Watershed

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Snake-Middle Rivers Watershed Restoration and Protection Strategy Report

Restoration and protection strategies for waterbodies in the Snake River Watershed in the Red River Basin

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique waterbody identifier for each river reach comprising the U.S. Geological Survey (USGS) 8 digit Hydrologic Unit Code (HUC) plus a 3-character code unique within each HUC.

Aquatic life use 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 use 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 and either chlorophyll-a or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Red River Basin is assigned a HUC-4 of 0902 and the Snake-Middle Rivers Watershed is assigned a HUC-8 of 09020309.

Impairment: Waterbodies 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 fish and invertebrates types found in the waterbody. The IBI is expressed as a numerical value between 0 (lowest quality) and 100 (highest quality).

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

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions to eventually 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 broad term includes pollutant sources and nonpollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum pollutant amount 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.

Executive summary

The Snake-Middle Rivers Watershed (SMRW) (Hydrologic Unit Code [HUC] 09020309) covers 779 square miles of the Red River of the North Basin in northwestern Minnesota. The SMRW lies largely within Marshall County, but also includes portions of Pennington and Polk Counties. Terrain within the SMRW is largely flat in the west owing to the SMRW's location in the lakebed of the former glacial Lake Agassiz. Terrain is relatively steeper in the former prairie wetland and oak savannah landscape of the eastern half of the watershed. Land cover is largely agricultural with cropland and hay/pasture covering 78.7% and 3% of the watershed, respectively. Other important land covers are wetlands (7.3%), forest (5.6%), and developed (4.9%). The land covers that comprise the remaining 0.5% are barren land, shrub/scrub, herbaceous, and open water.

Pre-European settlement vegetation was converted to agriculture by using open ditches. More recently, agricultural drainage has focused on subsurface tile drainage to reduce crop stress caused by excess water and simplify field operations by removing areas of standing water. The SMRW is prone to flooding because of its flat topography and fine-textured, heavy soils. Spring flooding is often particularly concerning, as a result of snowmelt and ice jams or frozen water downstream to the north.

A combined loss of native vegetation and artificial drainage has altered the hydrology and water quality within the SMRW, which has led to unstable stream channels and channel incision as a result of flashy hydrology (long periods of sustained low flow contrasted with short bursts of high flow following rain events). Cropland and streambank erosion have led to high sediment loads within the SMRW's streams, which combined with channel instability have degraded fish and macroinvertebrate habitat in many stream reaches. Sustained low flow periods also place stress on fish and macroinvertebrates as warm, slow moving water is depleted of dissolved oxygen (DO) needed for their survival.

The SMRW Watershed Restoration and Protection Strategies (WRAPS) project is part of Minnesota's watershed approach for evaluating surface waters. This ongoing process includes:

- Monitoring and assessment;
- Water resource characterization and problem investigation;
- **Restoration and protection strategy development (this document);**
- Comprehensive watershed management planning; and
- Ongoing local implementation.

The WRAPS project is the third step in this process as laid out above, although in reality the process is continuous and repeats on a 10 year monitoring cycle. The key components of a WRAPS project are:

- To synthesize background information, data, and findings from the characterization and problem investigation (including the monitoring and assessment report and stressor identification (SID) report);
- To conduct total maximum daily load (TMDL) studies to quantify reductions required to restore impaired waters to nonimpaired conditions;
- To develop restoration strategies for achieving TMDL reductions; and

- To develop protection strategies to prevent nonimpaired waterbodies from becoming impaired.

As part of the WRAPS project, TMDL studies were completed and compiled into the *Snake-Middle Rivers Watershed TMDL Report* (MPCA 2020d) to address a total of eight impairments (five caused by excessive total suspended solids [TSS] and three caused by excessive *Escherichia coli* [*E. coli*]) bacteria on seven distinct stream reaches listed on the approved 2018 303(d) Impaired Waters List (MPCA 2019a). Note that two of the TSS-caused impairments (Assessment Unit Identifiers [AUIDs] 540 and 541) were combined in a single TSS TMDL resulting in a total of 7 TMDLs. This document includes a brief overview of the TMDL studies. A total of 23 additional aquatic life use or aquatic recreation use impairments in 13 stream reaches on the approved 2018 303(d) list (MPCA 2019a) were not addressed by TMDL studies as part of the WRAPS process. No impairments caused by poor fish or macroinvertebrate communities (*n*= 9 and 7, respectively) were addressed, because while all of them are linked to stressors with numeric criteria to some extent, the impairments are primarily linked to stressors without numeric criteria (e.g., flow regime instability and poor habitat). The seven DO impairments were not addressed for various reasons ranging from lack of information to lack of reasonable assurance of success.

This WRAPS report includes a broad summary of background data, findings, and recommendations to characterize the SMRW as a whole, describe the SMRW's condition, and develop strategies for restoring impaired waterbodies and protecting nonimpaired waterbodies. The strategies table lays out possible approaches and best management practices (BMPs) for improving water quality within the SMRW. Strategies are largely focused on addressing sediment and phosphorus loading and altered hydrology and range from small-scale, agronomic practices such as nutrient management and cover crops to larger, engineered solutions such as stream restoration, wetland restoration, or impoundments. Many strategies can positively affect several pollutants or stressors simultaneously through soil protection, reducing runoff, restoring altered hydrology, and providing more stable conditions for stream channels. Addressing runoff, erosion, and altered hydrology will be key to restoring habitat by increasing DO concentrations and providing more suitable in-stream habitat.

Information in this report, including the strategies table, will provide the foundation for the next step of the watershed approach - comprehensive watershed management planning where more specific targeting (what? where?) and goals (how much of a reduction? how many BMPs do we need to implement to get there?) will be developed. The SMRW application was approved for One Watershed, One Plan funding in August 2020, enabling this planning effort to begin.

What is the WRAPS Report?

Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year monitoring cycle with follow-up planning and implementation that addresses both restoration and protection.

As part of the watershed approach, the Minnesota Pollution Control Agency (MPCA) developed a process to identify and address threats to water quality in each of these major watersheds. This process is called Watershed Restoration and Protection Strategy (WRAPS) development. WRAPS reports have 2 parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

Waters not meeting state standards are listed as impaired and Total Maximum Daily Load (TMDL) studies are developed for them. TMDLs are incorporated into WRAPS. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing 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 the basis for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help 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: • *Snake River Watershed Monitoring and Assessment - 2016* • *Snake River Watershed Biotic Stressor Identification - 2017* • *Snake River Watershed Total Maximum Daily Load - 2020*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams
Audience	•Local working groups (watershed districts, SWCDs, watershed groups, etc.) •State agencies (MPCA, MNDNR, BWSR, etc.)

1. Watershed background and description

The Snake-Middle Rivers Watershed[1] (SMRW) covers 498,609 acres (779 square miles) in northwestern Minnesota and is part of the Red River of the North Basin. The SMRW lies in the Red River Basin within the Lake Agassiz Plains Level III Ecoregion, which was formed as a part of the historical Lake Agassiz. The resulting topography is generally flat, particularity in the western SMRW.

The watershed lies largely within Marshall County, with smaller portions in Pennington and Polk Counties, and is entirely within the Middle-Snake-Tamarac Rivers Watershed District (MSTRWD). The largest city within the SMRW is Warren (2010 population of 1,563; [U.S. Department of Commerce 2012]); other municipalities include Argyle (population of 639), Newfolden (population of 368), Alvarado (population of 363), and Middle River (population of 303).

Major rivers in the watershed are the Snake and Middle Rivers, with the Snake River draining the southern portion of the watershed and the Middle River draining the northern portion of the watershed. The rivers generally flow from east to west with the lower portion of the Snake River flowing north toward its confluence with the Middle River and onward to its mouth at the Red River of the North. The Snake and Middle Rivers drain extensive networks of artificial drainage ditches.

As mapped in Figure 1, the National Land Cover Database (NLCD) 2011 (Homer et al. 2015) shows agricultural land cover dominates the SMRW with 78.7% of land in row crops and 3% in hay or pasture. Other key land covers are wetlands (7.3%), forests (5.6%), and developed areas (4.9%). The land covers that comprise the remaining 0.5% are barren land, shrub/scrub, herbaceous, and open water. Land cover is more varied in the eastern portion of the watershed, particularly in the upper portions of the Upper Snake and Middle River subwatersheds where most wetland, forest, and hay or pasture land covers are found.

Additional Snake-Middle Rivers Watershed resources

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Snake River Watershed: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022747.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework: http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/

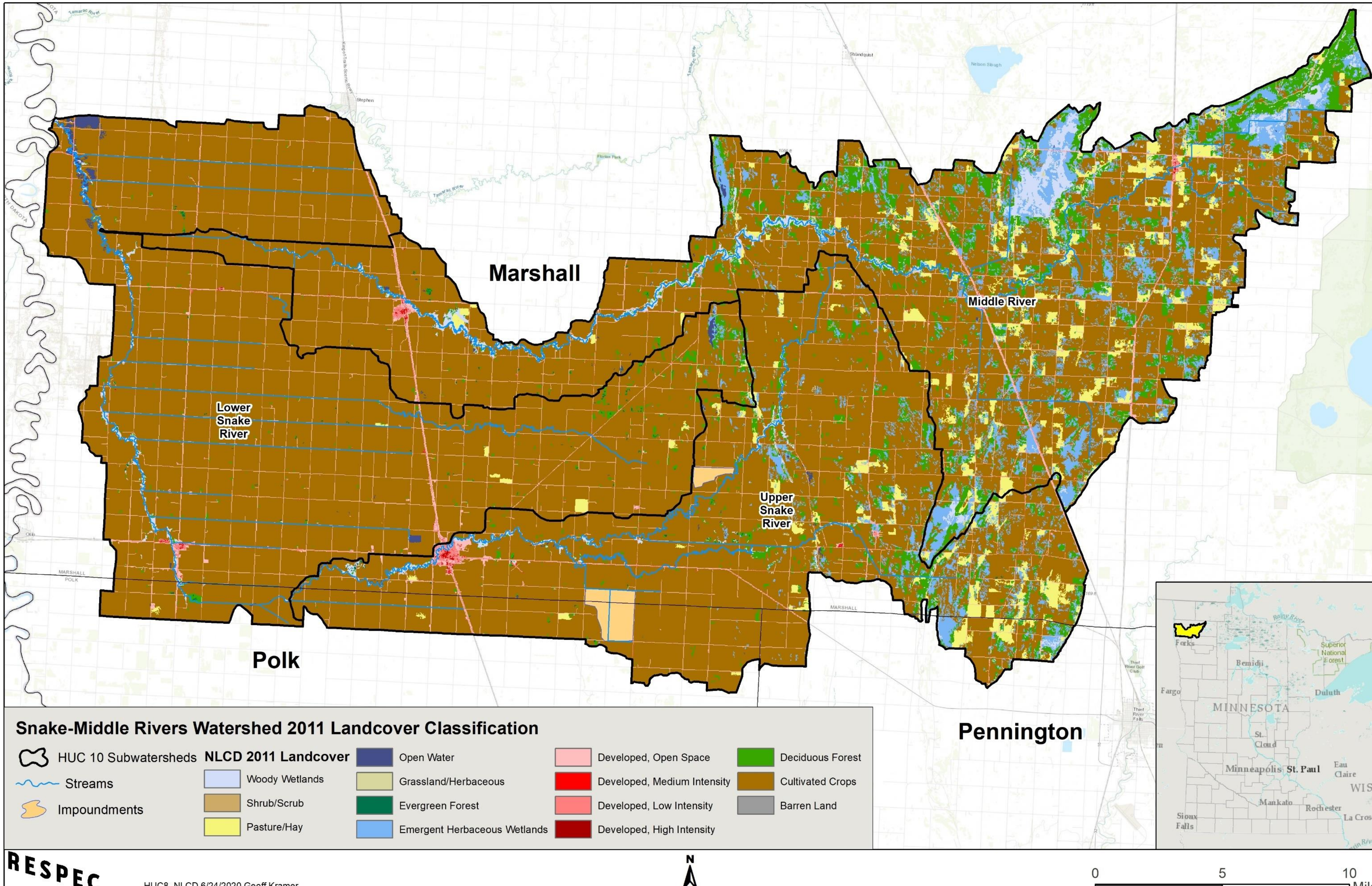
Minnesota Department of Natural Resources (DNR) Watershed Context Report for the Snake River (Red River) Watershed: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_68.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework Watershed Report Card for the Snake River (Red River) Watershed: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_68.pdf

Minnesota Pollution Control Agency (MPCA) Snake River – Red River Basin: https://www.pca.state.mn.us/water/watersheds/snake-river-red-river-basin

[1] Please note that while the MPCA's official name for the major watershed is the Snake River Watershed – Red River Basin, the locally-preferred name is the Snake-Middle Rivers Watershed. The name Snake-Middle Rivers Watershed and corresponding acronym (SMRW) are used in this report wherever possible.

Figure 1. Snake-Middle Rivers Watershed land cover from National Land Cover Database 2011 (Homer et al. 2015).



2. Watershed Conditions

The SMRW is situated in the Red River of the North Basin within the Lake Agassiz Plain ecoregion, which was formed as a part of glacial Lake Agassiz. The resulting topography of the western portion of the SMRW is flat, while the eastern portion is relatively steeper. The elevation drop from the headwaters of the Middle River to the mouth of the Snake River is nearly 400 feet, which corresponds to an average slope of approximately four feet per mile. Conversely, the portion of the Snake River downstream of Alvarado, which flows roughly parallel to the Red River, has a longitudinal slope of less than one foot per mile. With a flat terrain and fertile, loamy soils, the SMRW is a productive agricultural landscape. As a result of the flat landscape and relatively heavy soils, an extensive network of human-made ditches was constructed following the area's settlement to promote drainage and allow cultivation. Extensive pattern tiling has been adopted more recently to further increase agricultural yields by reducing excess water from the root zone.

Water quality and biological monitoring were conducted in the SMRW to determine if waterbodies were supportive of aquatic life and aquatic recreation; monitoring results were summarized in the *Snake River Watershed Monitoring and Assessment Report* (MPCA 2016). A total of 34 biological monitoring sites on 19 AUIDs were sampled and assessed for aquatic life. Only 4 streams of the 19 AUIDs monitored fully support aquatic life, 13 streams did not support aquatic life, and 2 lacked sufficient information to make a determination. A total of 10 AUIDs were assessed for aquatic recreation: 5 AUIDs were determined to fully support aquatic recreation, 3 AUIDs did not support aquatic recreation, and 1 lacked sufficient information to make a determination. Aquatic recreation impairments are caused by high bacteria levels. Impaired waterbodies are listed in Table 1 and shown in Figure 2. Florian Marsh did not meet criteria to be assessed as a lake and was not evaluated.

While this report does not cover toxic pollutants, it is worth noting that one waterbody (AUID 501) in the SMRW is impaired for aquatic consumption use due to high mercury levels in the water column. Mercury concentrations are above the threshold values for this impairment to be addressed by the *Minnesota statewide Mercury TMDL* (MPCA 2007a; MPCA 2020b), so it is scheduled to have a TMDL completed at a later date.

Table 1. Approved 2018 Impaired Waters List (MPCA 2019a) summary of waterbodies in the SMRW impaired for aquatic life use and/or aquatic recreation use.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach description	Impaired Use(s)	Impairment cause
Middle River (0902030902)	529	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	Aquatic life	MIBI
	538	Middle River	Headwaters to -96.171 48.4349	Aquatic life	FIBI
	539	Middle River	–96.171 48.4349 to Co Rd 114 bridge	Aquatic life	DO
	540	Middle River	Co Rd 114 to T156 R49W S3, north line	Aquatic life	Turbidity, MIBI, DO
	541	Middle River	T157 R49W S34, south line to Snake R	Aquatic life	Turbidity, DO
Upper Snake River (0902030901)	546	Snake River, South Branch (new channel)	Headwaters to Snake R	Aquatic life	FIBI
	544	Snake River, South Branch (old channel)	JD 25-1 [a] to Snake R	Aquatic life	FIBI, MIBI
	543	Snake River	Unnamed cr to S Br Snake R	Aquatic life, aquatic recreation	*E. coli*, FIBI, MIBI, DO
	504	Snake River	S Br Snake R to CD 7	Aquatic life, aquatic recreation	Turbidity, *E. coli*, FIBI, MIBI
Lower Snake River (0902030903)	519	Judicial Ditch 29	Headwaters to Snake R	Aquatic life	FIBI
	537	Snake River	T154 R49W S17, east line to CD 3	Aquatic life, aquatic recreation	*E. coli*, FIBI, MIBI, DO
	502	Snake River	CD 3 to Middle R	Aquatic life	Turbidity, FIBI, MIBI, DO
	501	Snake River	Middle R to Red R	Aquatic life	Turbidity, FIBI, DO

HUC = Hydrologic Unit Code

MIBI = macroinvertebrate index of biotic integrity

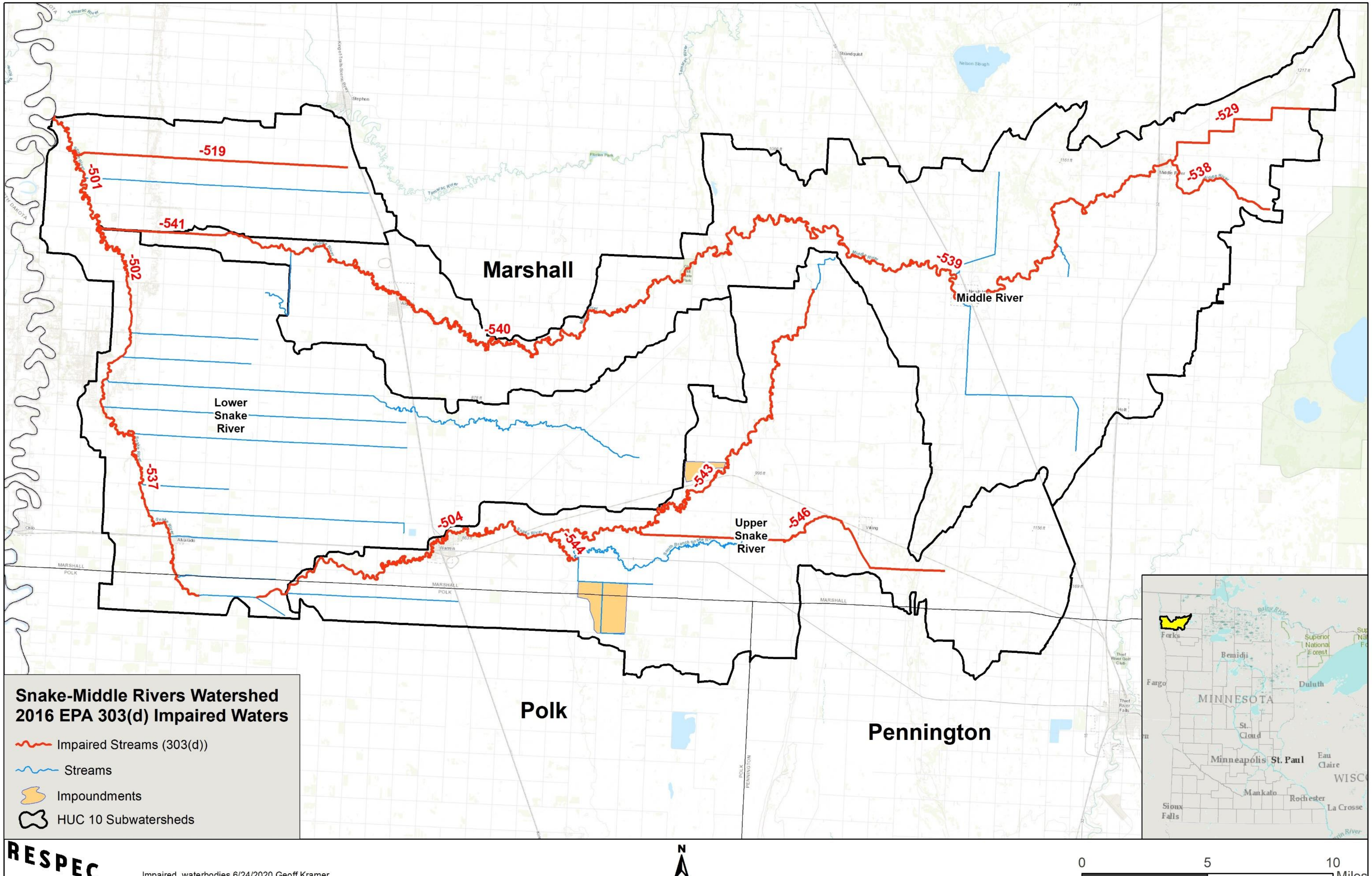
FIBI = fish index of biotic integrity

DO = dissolved oxygen

E. coli = *Escherichia coli*

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Figure 2. Impaired waterbodies in the Snake-Middle Rivers Watershed on the 2018 Impaired Waters List (MPCA 2019a).



2.1 Condition status

Water quality monitoring and assessment were conducted in the SMRW to determine the condition of the surface waterbodies. Monitoring was conducted by the MPCA as well as the MSTRWD and the International Water Institute (IWI). The MPCA conducted an intensive watershed monitoring (IWM) effort starting in 2013 to assess aquatic life and recreation. Following the IWM efforts, a Surface Water Assessment Grant (SWAG) was awarded to the IWI in partnership with the MSTRWD to collect water quality samples at the outlet of each HUC-11 subwatershed across the watershed.

Monitoring results are used to determine if waterbodies have impaired aquatic life or aquatic recreation. Waterbodies that are determined to be impaired may have TMDL studies prepared to develop a plan for bringing the waterbody into compliance with water quality standards. Impairments of aquatic recreation (caused by excessively high *E. coli* levels) may be determined directly from monitoring data, but impairments of aquatic life are subject to the SID process to determine if a parameter for which a TMDL can be developed (e.g., TSS, DO, phosphorus) is causing the waterbody to not fully support aquatic life.

In addition to a summary of monitoring findings, this section includes an overview of several additional reports, including a sediment source assessment, water quality conditions report, and geomorphology report. The findings and outcomes of these analyses and reports are included in the following sections.

Waters determined to be impaired have *restoration strategies* written as part of this report, while waters that are not impaired have *protection strategies* written as part of this report. While the goal of restoration strategies is to bring a waterbody into compliance with water quality standards, protection strategies aim to prevent a nonimpaired waterbody from becoming impaired. Protection considerations, which are discussed in Section 2.5, are used to determine priority protection waterbodies and strategies to achieve protection.

Streams

The MPCA conducted an IWM investigation of the SMRW in 2013 and 2014, with complete results presented in the *Snake River Watershed Monitoring and Assessment Report* (MPCA 2016). Biological monitoring was conducted at 34 sites during the summer of 2013, and 7 of the 34 biological monitoring sites were revisited in the summer of 2014. Biological monitoring stations were located near the outlets of most minor HUC-14 subwatersheds. To determine the health of aquatic life at each of these monitoring sites, FIBI and MIBI scores were calculated based on sampling each community. The calculated scores are compared to impairment thresholds to determine if the stream reach is supporting, or has impaired, aquatic life. The biological monitoring efforts resulted in a total of 19 AUIDs assessed for aquatic life. Of the 19 AUIDs assessed, 13 AUIDs were identified as having impaired aquatic life, 4 AUIDs were found to support aquatic life, and 2 AUIDs did not have sufficient biological data to determine if they were impaired. Another part of IWM monitoring efforts was evaluating water chemistry parameters that can affect the quality of biological communities. Water samples were collected to evaluate DO, TSS, chloride, pH, and NH_3. The results from the water quality sampling efforts were used during the SID process to determine likely stressors to the local biological communities.

Water quality conditions to support aquatic recreation were also assessed on nine stream reaches based on measured *E. coli* levels. Results showed that five reaches support aquatic recreation, three have impaired aquatic recreation, and one reach lacked sufficient data to make a determination.

The complete results of the IWM efforts for the assessed reaches are shown in Table 2. Following the IWM efforts, water chemistry stations were placed at the outlet of each HUC-11 subwatershed and ranged in drainage area from 75 to 150 square miles.

Water quality data were further analyzed in the *Snake River Watershed Conditions Report* (RESPEC 2016a). This report provided additional context for water quality conditions relating to water resources, landscape characteristics, climate, and human influences. The report provides a detailed analysis of various water quality constituents and continuous flow data for the time period of 2006 to 2015. The results of the analysis support the MPCA's impairment listings in the SMRW and can be used to track water quality trends over time and determine if restoration efforts are effective in their goal of improving water quality in the SMRW.

Table 2. Assessment status of stream reaches in the Snake-Middle Rivers Watershed.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach description	Aquatic Life								Aquatic Recreation		Aquatic Life	Aquatic Recreation
				FIBI	MIBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		
Middle River (0902030902)	529	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	MTS	EXS	IF	IF	-	IF	IF	-	-	-	IMP	NA
	534	Unnamed creek	Unnamed ditch to Middle R	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
	515	County Ditch 15 Branch [a]	Headwaters to CD 15	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
	530	Judicial Ditch 21	380th St to Middle R	MTS	MTS	IF	IF	-	IF	IF	-	-	-	SUP	NA
	538	Middle River	Headwaters to -96.171 48.4349	EXS	-	IF	IF	-	IF	IF	-	-	-	IMP	NA
	539	Middle River	–96.171 48.4349 to Co Rd 114 bridge	MTS	MTS	IF	IF [b]	MTS	MTS	MTS	-	MTS	-	IMP	SUP
	540	Middle River	Co Rd 114 to T156 R49W S3, north line	MTS	EXS	IF	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
	541	Middle River	T157 R49W S34, south line to Snake R	MTS	-	IF	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
Upper Snake River (0902030901)	546	Snake River, South Branch (new channel)	Headwaters to Snake R	EXS	MTS	IF	IF	-	IF	IF	-	-	-	IMP	NA
	518	Judicial Ditch 25-1 [a]	Unnamed ditch to Unnamed ditch	-	MTS	IF	IF	IF	IF	IF	-	-	-	SUP	NA
	514	Judicial Ditch 25-1 [a]	Unnamed ditch to S Br Snake R	-	-	MTS	MTS	-	MTS	-	-	-	-	NA	NA
	544	Snake River, South Branch (old channel)	JD 25-1 [a] to Snake R	EXS	EXS	IF	IF	-	IF	IF	-	-	-	IMP	NA
	543	Snake River	Unnamed cr to S Br Snake R	EXS	EXS	IF	IF	MTS	MTS	MTS	-	EXS	-	IMP	IMP
	504	Snake River	S Br Snake R to CD 7	EXS	EXS	IF	EXS	MTS	MTS	MTS	-	EXS	-	IMP	IMP
Lower Snake River (0902030903)	511	Swift Coulee (County Ditch 3)	Headwaters to Snake R	-	-	IF	MTS	-	IF	IF	-	-	-	IF	NA
	519	Judicial Ditch 29	Headwaters to Snake R	EXS	-	IF	IF	IF	IF	IF	-	IF	-	IMP	IF
	537	Snake River	T154 R49W S17, east line to CD 3	EXS	EXS	IF	IF	MTS	MTS	MTS	-	EXS	-	IMP	IMP
	502	Snake River	CD 3 to Middle R	EXS	EXS	EXS	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP
	501	Snake River	Middle R to Red R	EXS	-	EXS	EXS	MTS	MTS	MTS	-	MTS	-	IMP	SUP

Abbreviations for Indicator Evaluations: **-** = no data; **MTS** = meets standard; **EXS** = fails standard; **IF** = insufficient information

Abbreviations for Use Support Determinations; **NA** = not assessed; **IF** = insufficient information, **SUP** = full support (meets standards); **IMP** = impaired (fails standard)

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach description	Aquatic Life								Aquatic Recreation		Aquatic Life	Aquatic Recreation
				FIBI	MIBI	DO	TSS	Chloride	pH	NH_3	Pesticides	Bacteria	Nutrients		

Key for cell shading:		existing impairment listed before 2015 reporting cycle		new impairment		full support of designated use		insufficient information

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

[b] The impairment caused by turbidity on AUID 539 has been removed as of the 2016 303(d) list as a correction.

Lakes

No lakes in the SMRW were sampled as part of the MPCA's IWM. All of the open water basins in the watershed are classified as wetlands, intermittent lakes, or short-term water storage impoundments and do not meet the criteria to be assessed as lakes.

Geomorphology

Stream channel stability was evaluated as a part of the IWM to determine the Channel Condition and Stability Index (CCSI) (MPCA 2016). The CCSI rates the geomorphic stability of the stream reach and rates three portions of a stream channel cross section: the upper banks, lower banks, and bottom. The results indicate stream channel geomorphic changes and loss of habitat that may be tied to changes in watershed hydrology, stream gradient, sediment supply, or sediment transport capacity. CCSI ratings are categorized into five channel stability ratings: stable, fairly stable, moderately unstable, severely unstable, and extremely unstable. A total of four sites were monitored for their CCSI scores, with two scoring as fairly stable, one moderately unstable, and one severely unstable (Table 3).

A separate effort was performed by the Minnesota Department of Natural Resources (DNR) to analyze the channel stability of the Middle and Snake Rivers in the SMRW using the modified Pfankuch stability rating which was then compiled into the *Snake River Watershed Geomorphology Report* (DNR 2017). Analyzing fluvial morphology is one of five components DNR uses to describe watersheds and their survey of the SMRW was timed with that of MPCA's stressor ID, in part, so that DNR's fluvial geomorphology results from relevant sites could be referenced in the Snake River Watershed Stressor Identification Report (MPCA 2017). DNR's survey results indicate the Middle and Snake Rivers are largely unstable with evidence of incised (down-cut) and entrenched channels in many locations. Incised channels do not allow bankfull flows to reach the floodplain, which results in excessive stress to stream channel banks and results in increased erosion. The headwaters of the Middle and Snake Rivers were stable and not incised, but the next downstream sites for each river exhibited signs of instability such as incision and widening. Restoring the channels to allow flows to access the floodplain for one to two year recurrence events can provide several benefits, including reducing peak flow rates by providing floodplain connectivity, reducing channel incision, and reducing both sediment transport and channel erosion as a result. Ancillary benefits of stream restoration can result in improved stream habitat from reduced sediment loading and improved channel substrate.

Sediment Source Assessment

The *Snake River Watershed Sediment Source Assessment* (RESPEC 2016b) included: a GIS-based, sediment source analysis; identifying critical monitoring locations; the DNR streambank monitoring results; and Hydrological Simulation Program-Fortran (HSPF) model-based, sediment source assessments. The sediment source assessment was conducted to determine areas likely to be sediment sources and areas ideal for sediment-trapping BMPs. Light Detection and Ranging- (LiDAR-) derived 1-meter digital elevation models (DEMs) were used to develop Stream Power Index (SPI) and Compound Topographic Index (CTI) values to identify these target areas. The SPI identifies areas of high-erosive potential that tend to occur with higher-drainage areas (more water) and steeper slopes (higher-water velocity). High CTI values identify areas with larger-drainage areas (more water) and lower slopes (increased ability to pond and store water, which may be suitable for restored or constructed wetlands).

Potential treatment areas were first determined by considering only the 5% of raster values within both the SPI and CTI rasters, which identifies those areas most susceptible to erosion and most suited for surface water storage, respectively. Those areas were then overlaid with Hydrologic Soil Groups C and D, which are typically higher in clay and silt content, have a higher runoff potential (because of low infiltration rates), and are more suitable for surface storage practices like wetland restoration. Only areas within a certain distance of modeled streams and ditches were considered to identify areas of concern and opportunity that are close to stream channels. Figure 3 shows the percentage of each subwatershed having high upland erosion potential (top 5% of SPI values) and also within 1,000 feet of a stream or ditch; subwatersheds with higher concentrations may be more suitable for BMPs (e.g., Water and Sediment Control Basins [WASCOBs] or grassed waterways) that can address overland flow with high erosive potential. Figure 4 shows results of a similar analysis focused only on high erosion potential areas (top 5% of SPI values) that are also within 150 feet of a stream or ditch. Subwatersheds with higher concentrations of these areas may benefit from upland (e.g., WASCOBs or grassed waterways) or additional edge of field trapping practices such as water quality side inlets. Finally, the analysis was repeated with the CTI raster (top 5% of values) to identify areas within 1,000 feet of streams or ditches that may be suitable for upland storage (e.g., restored wetlands). Each subwatershed's concentration of these areas is shown in Figure 5.

To help guide future monitoring efforts, the results from the sediment source assessment were combined with local knowledge from DNR and MSTRWD staff and the HSPF model to identify high-potential locations. A total of 29 sites were identified as potentially critical locations for additional data collection. Monitoring was conducted at 8 of the 29 sites, and results and analyses were reported in the *Snake River Watershed Sediment Source Assessment* (RESPEC 2016b). These 8 monitoring sites are shown in Figure 6. At each of the 8 sites, characteristics were measured to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), which were used for the annual streambank, retreat rate calculations following Rosgen's methods. Annual streambank retreat rates were multiplied by the mean bank height and bank length to estimate the sediment loading rates for each monitored site. Results of this analysis are shown in Table 4.

The calibrated HSPF model was also used to identify areas contributing high sediment loading in the SMRW. In-channel sediment loading (from bed scour and bank erosion) was evaluated, and long-term mean loading rates (for scour reaches) and deposition rates (for example, for deposition reaches coinciding with impoundments) are shown in Figure 7. Channel scour generally increases from upstream to downstream throughout the watershed with deposition occurring only at impoundments. Land cover type analysis was also done with a summary of loading by land cover summarized in Table 5. More information about upland sediment and nutrient loading is provided in Section 2.3, and upland sediment loading rates by subwatershed are shown in Figure 14.

Table 3. Channel Condition and Stability Index (CCSI) scores (MPCA 2016).

HUC-11	# of Visits	Biological Station ID	Stream Name	Upper Banks (43-4)	Lower Banks (46-5)	Substrate (37-3)	Channel Evolution (11-1)	CCSI Score (137-13)	CCSI Rating [a]
09020309010	1	13RD104	Snake River	32	27	21	3	83	Severely Unstable
	1	13RD108	Snake River	21	19	8	3	51	Moderately Unstable
	1	13RD106	Snake River, South Branch	6	16	4	3	29	Fairly Stable
	Average stream stability results: Snake River Subwatershed			19.67	20.67	11	3	54.33	Moderately Unstable
09020309040	1	13RD080	Snake River	13	12	11	2	38	Fairly Stable
	Average stream stability results: Vega Subwatershed			13	12	11	2	38	Fairly Stable

[a] There are 5 possible CCSI ratings (listed from best to worst condition): stable, fairly stable, moderately unstable, severely unstable, and extremely unstable.

Table 4. Estimated average annual sediment loads attributed to streambank erosion (RESPEC 2016b).

Reach	Stream	Monitoring Site Length (feet)	Mean Bankfull Width (feet)	Eroding Streambank Length (feet)	Percent of Monitoring Site with Eroding Streambank (%)	Monitoring Site Streambank Erosion Sediment Load (U.S. tons/year)	Sediment Load per 1,000 Feet (U.S. tons/year)	Sediment Load per Mile (U.S. tons/year)
SNK02	Snake River	610	17.7	356	29.2	16.9	27.7	146.3
SNK04		752	not measured	0.0	0.0	0.0	0.0	0.0
SNK30		904	33.9	593	32.8	45.4	50.2	265.1
SNK09		1,300	33.2	861	33.1	59.3	45.6	241.0
SNK17		2,361	55.3	153	3.2	7.7	3.3	17.3
SNK31	South Branch Snake River	901	16.0	173	9.6	6.2	6.9	36.2
S26	Melgaard Coulee	487	not measured	0	0.0	0.0	0.0	0.0
SN27	Swift Coulee	692	not measured	0	0.0	0.0	0.0	0.0

Table 5. HSPF-simulated upland runoff and sediment-load contributions by land cover.

Source Category	Area (acre)	Percent Area (%)	Total Suspended Solids: Unit Load (U.S. ton/ac-yr)	Total Suspended Solids: Average Annual Load (U.S. ton/yr)	Total Suspended Solids: Percent of Annual Upland Load	Runoff: Unit Runoff (in/yr)	Runoff: Average Annual Runoff (ac-ft/yr)	Runoff: Percent of Annual Watershed Runoff
Developed	24,044	5	0.16	3,875	8.1	9.7	19,477	6
Cropland Low Till	61,395	12	0.09	5,256	11	8.3	42,590	12
Cropland High Till	322,322	65	0.12	38,217	80	8.3	224,068	65
Forest	28,004	6	0.01	121	0.25	8.0	18,636	5
Grassland	1,203	0.24	0.03	33	0.07	9.3	936	0.27
Pasture	14,837	3.0	0.01	186	0.39	9.4	11,563	3
Wetland	38,252	8	0.00	15	0.03	7.9	25,182	7
Feedlot	32	0.01	0.29	9	0.02	9.7	26	0.01
Point Sources	N/A			57	0.12	N/A	2,102	1
Totals	**490,088**		**0.097**	**47,769**		**8.4**	**344,579**	

Figure 3. Concentration of high upland erosion potential areas by subwatershed in the Snake-Middle Rivers Watershed (adapted from RESPEC 2016b).

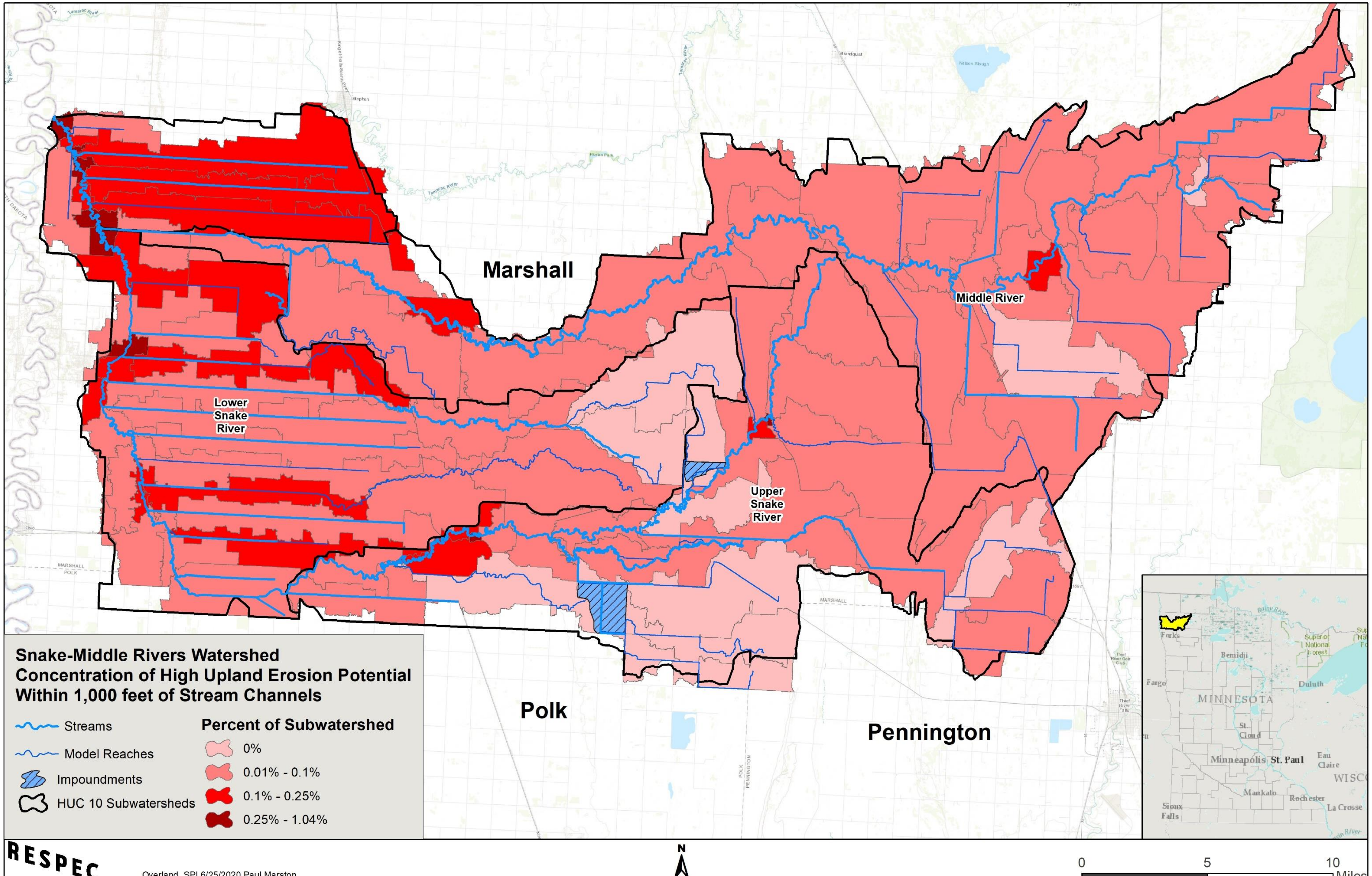


Figure 4. Concentration of high erosion potential areas within 150 feet of stream channels in the Snake-Middle Rivers Watershed (adapted from RESPEC 2016b).

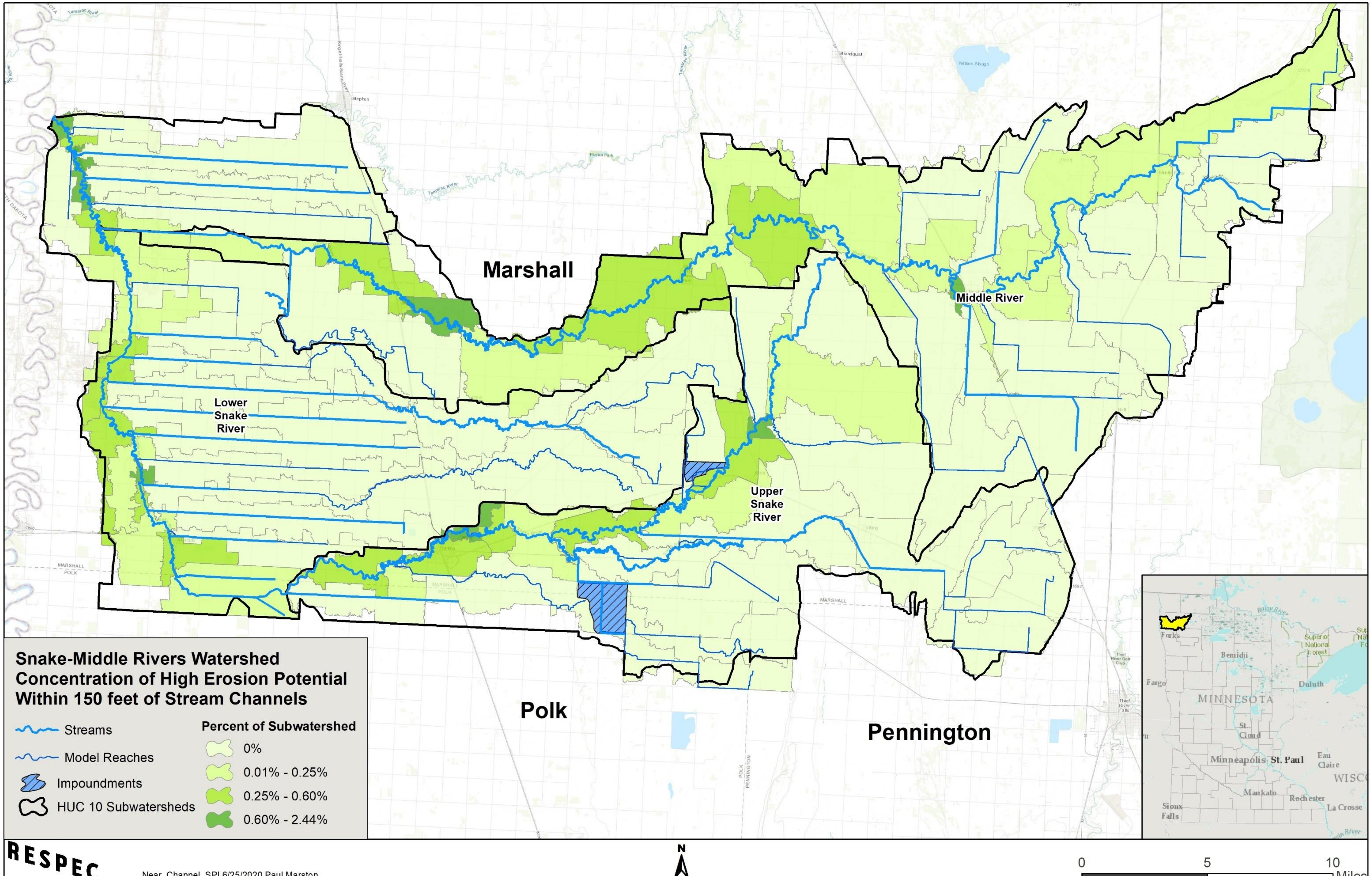


Figure 5. Wetland restoration potential in the Snake-Middle Rivers Watershed (adapted from RESPEC 2016b).

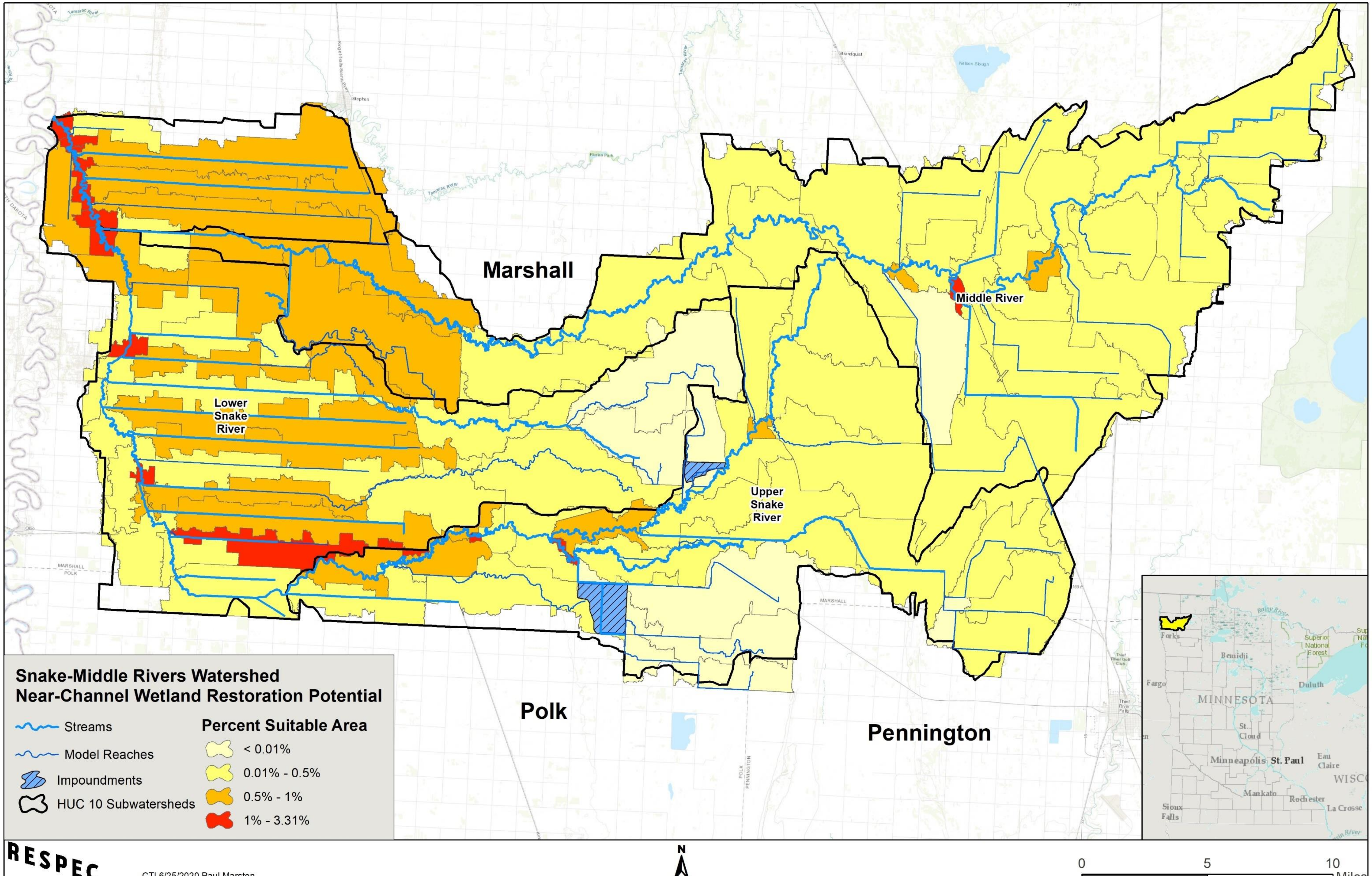


Figure 6. Snake-Middle Rivers Watershed streambank erosion monitoring sites (adapted from RESPEC 2016b).

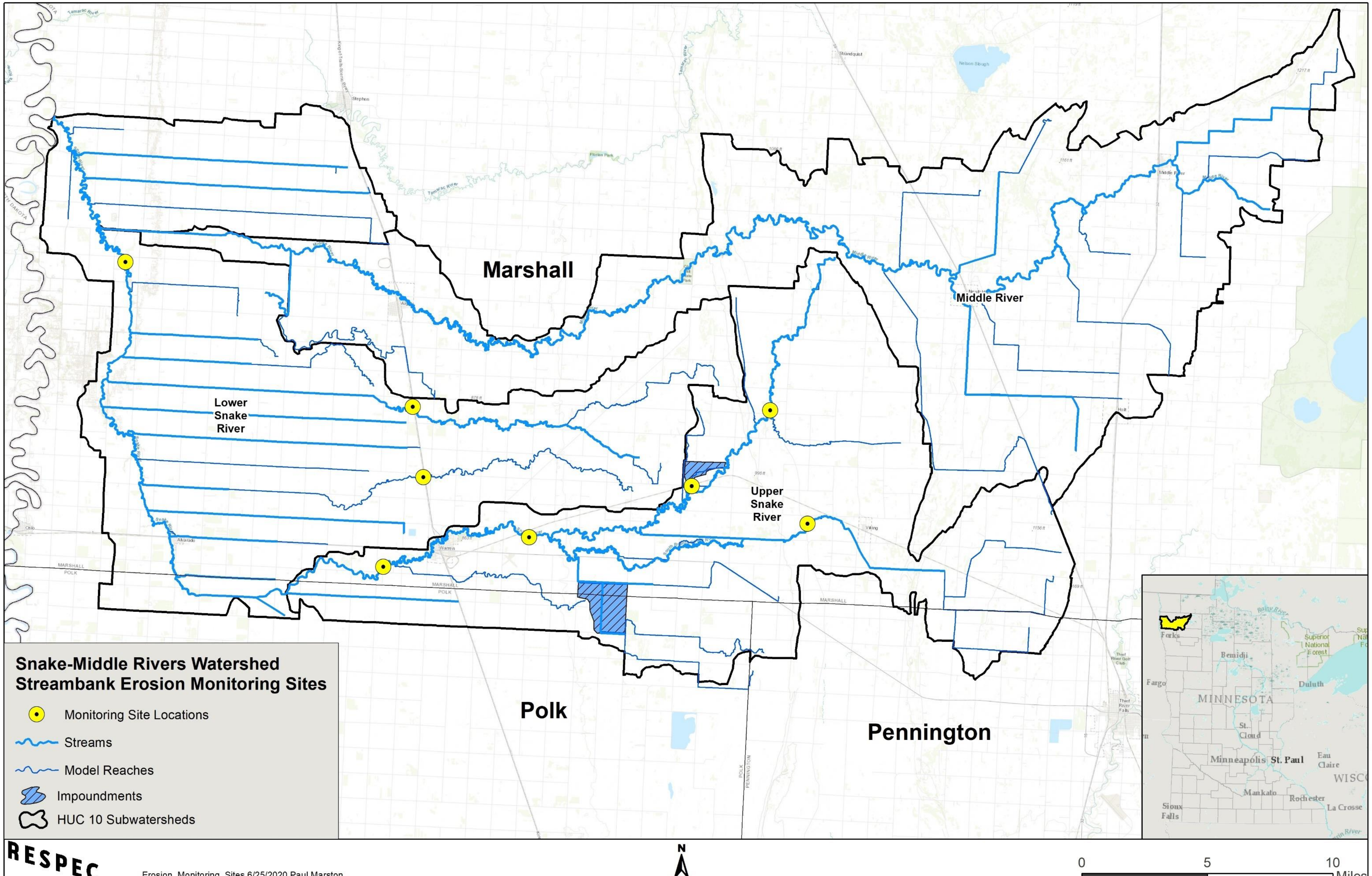
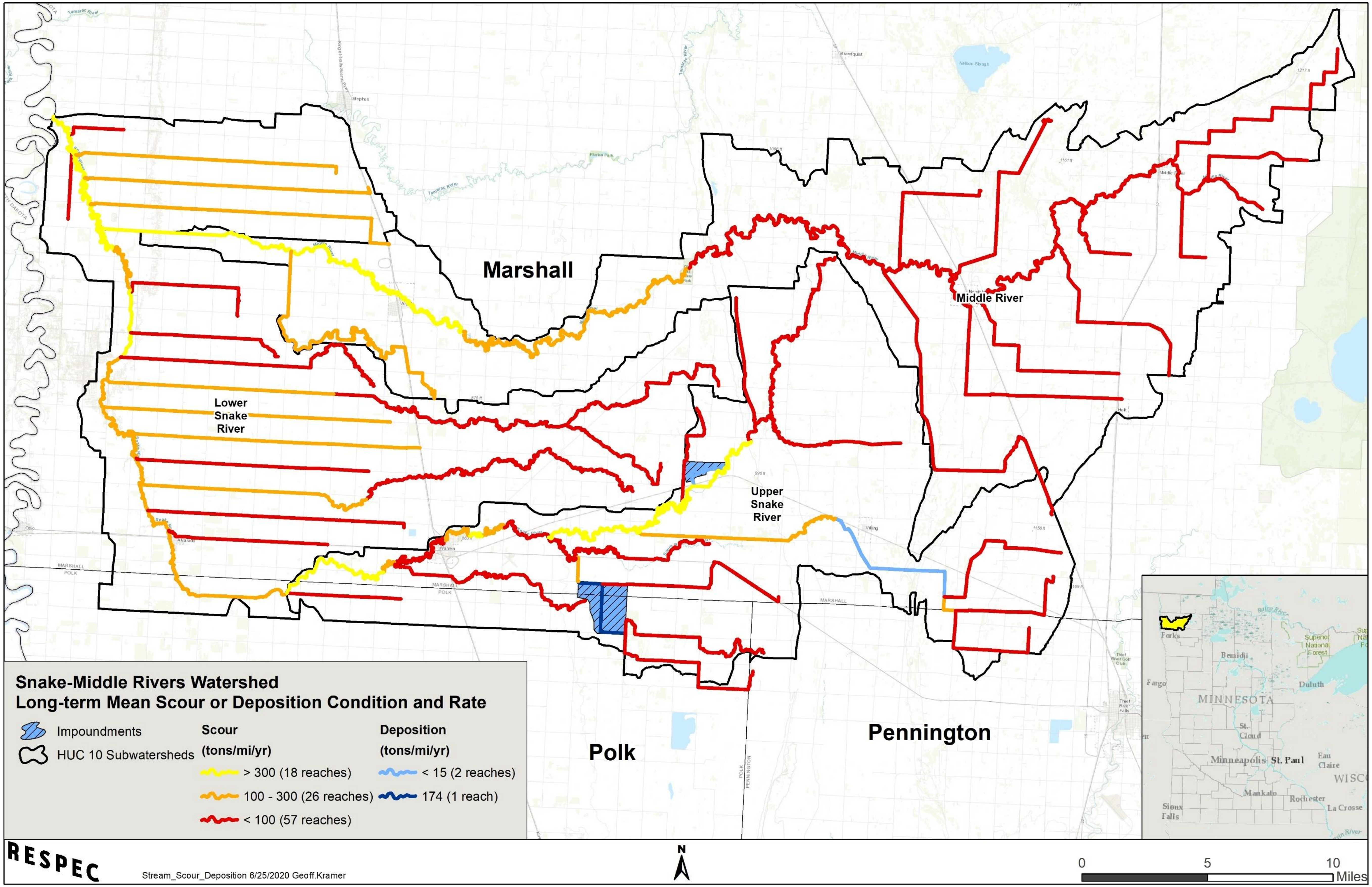


Figure 7. Long-term stream scour or deposition condition in the Snake-Middle Rivers Watershed (adapted from RESPEC 2016b).



2.2 Water quality trends

Long-term water quality trends were determined by the MPCA for major watershed sites as part of the Minnesota Milestone Monitoring Program. Long-term data (1971 to 2010) were collected for the SMRW at Station H68011001 at the Minnesota State Highway 220 (MN-220) bridge over the Snake River, which is three river miles upstream from the Snake River's confluence with the Red River of the North (MPCA 2014a); the location of this gage is shown in Figure 11. Table 6 summarizes trends in several pollutants' concentrations over the entire period of record and the period from 1995 to 2010. Historical trends show decreases of 49% and 24% for biochemical oxygen demand and total phosphorus (TP), respectively. Recent trends show reductions of 22% and 60% for TP and chloride, respectively. No trends were detected for TSS or nitrite/nitrate concentrations for either period.

Table 6. Water quality trends of the Snake River based on data from Station H68011001 (at the crossing of MN-220 and the Snake River) (MPCA 2014a); green values indicate improving trends.

Parameter	Historical trend (1971–2010)	Recent trend (1995–2010)
Total Suspended Solids	no trend	no trend
Biochemical Oxygen Demand	-49%	no trend
Total Phosphorus	-24%	-22%
Nitrite/Nitrate	no trend	no trend
Chloride	no trend	-60%

2.3 Stressors and sources

To develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening the waterbodies must be identified and evaluated. Biological SID is conducted for streams with either fish or macroinvertebrate biota impairments, and encompasses evaluating pollutant- and nonpollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. 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. More detailed information on the SID process can be found on the EPA website at https://www.epa.gov/caddis.

The *Snake River Watershed SID Report* (MPCA 2017) documents the efforts that were taken to identify the causes and, to some degree, the source(s) of impairments of aquatic biological communities in the SMRW. Eleven AUID reaches (Table 7) were evaluated during the SID process because they had one or both of the sampled biological communities scoring below the impairment thresholds per the Watershed Monitoring and Assessment Report (MPCA 2016). The locations of the biologically impaired reaches assessed in the SID process are shown in Figure 8.

Table 7. Biological impairments for stream reaches addressed in the SID report.

AUID (Last 3 digits)	Reach Name	Reach Description	Reach Length (mi)	Biological Impairment(s)
501	Snake River	Middle R to Red R	10	FIBI
502	Snake River	CD 3 to Middle R	11	FIBI, MIBI
504	Snake River	S Br Snake R to CD 7	23	FIBI, MIBI
519	Judicial Ditch 29	Headwaters to Snake R	11	FIBI
529	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	8	MIBI
537	Snake River	T154 R49W S17, east line to CD 3	17	FIBI, MIBI
538	Middle River	Headwaters to -96.171 48.4349	7	FIBI
540	Middle River	Co Rd 114 to T156 R49W S3, north line	46	MIBI
543	Snake River	Unnamed cr to S Br Snake R	29	FIBI, MIBI
544	Snake River, South Branch (old channel)	JD 25-1 [a] to Snake R	3	FIBI, MIBI
546	Snake River, South Branch (new channel)	Headwaters to Snake R	14	FIBI

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Stressors of biologically impaired stream reaches

The SID process identified four stressors (low DO, high TSS, altered hydrology, and lack of habitat) contributing to biological impairments for each biologically impaired reach. For all of the Fish-Index of Biological Integrity (FIBI) impairments, evidence neither supported nor weakened the case for fish passage as a stressor. Based on the biological community structure, collected water chemistry samples, and HSPF model outputs, a strength of evidence to support the specific stressor was developed by the SID analysis. The strength of evidence for each stressor by reach is listed in Table 8. All of the biologically impaired stream reaches are flashy systems with high peak flows that are followed by prolonged periods of low or no discharge. The SID analysis concluded that historical changes to land cover (e.g., native vegetation to cropland) and drainage patterns (e.g., ditching and channelization) are the primary anthropogenic factors contributing to the instability in flows that are increasing the stressor severities. Excess sediment issues are caused by in-stream erosion resulting from the high peak flows, and low DO issues are a result of prolonged periods of low or no flows.

Figure 8. Biologically impaired reaches addressed in the SID report.

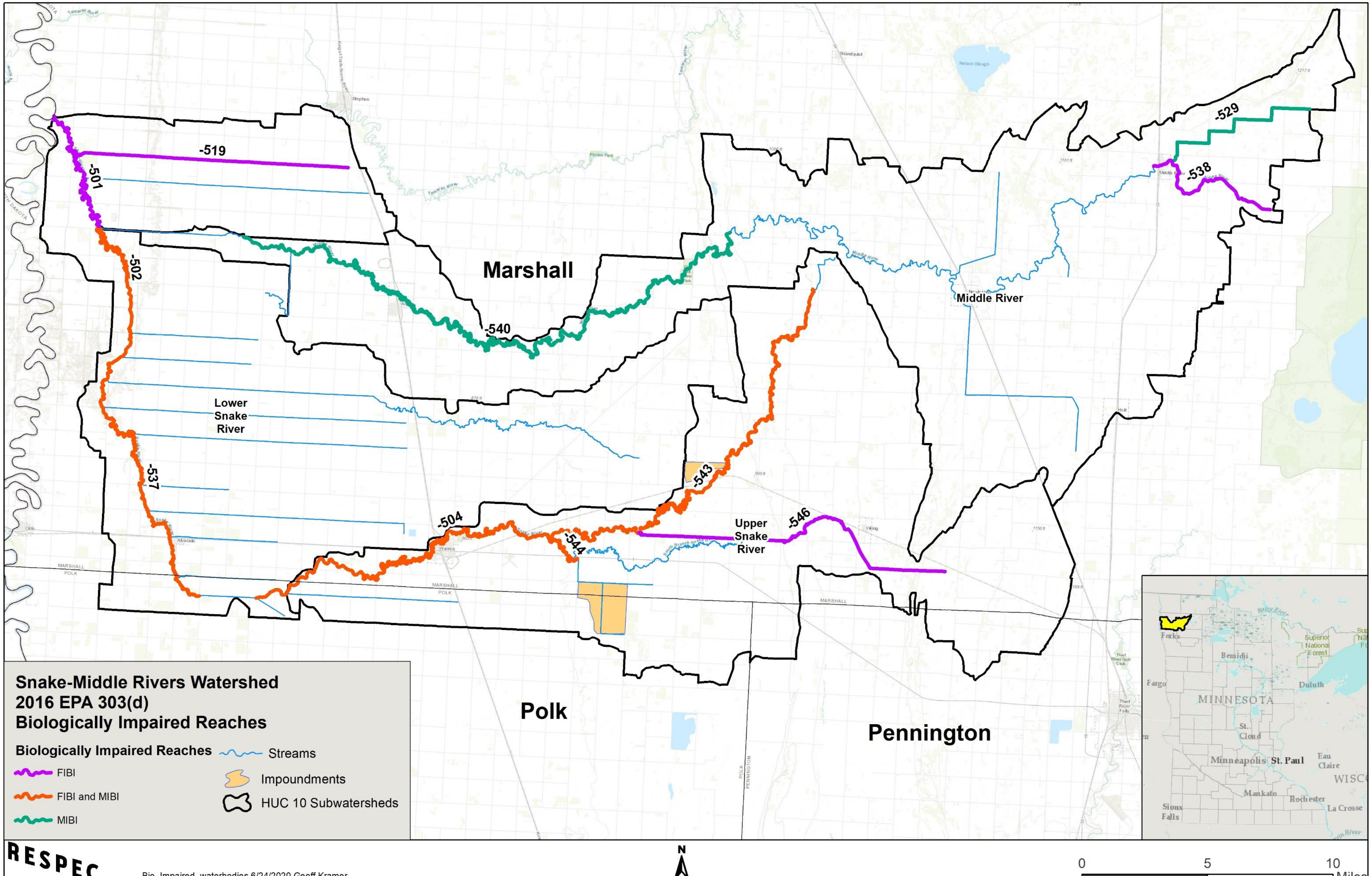


Table 8. Primary stressors to aquatic life in biologically impaired reaches in the Snake-Middle Rivers Watershed (MPCA 2017).

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach description	Biological Impairment	Candidate Causes [a]				
					Dissolved Oxygen	Turbidity	Fish Passage	Altered Hydrology	Habitat
Middle River (0902030902)	529	Judicial Ditch 28 [b]	Unnamed ditch to Middle R	MIBI	+	+	NE	++	++
	538	Middle River	Headwaters to -96.171 48.4349 (AUID 539)	FIBI	++	+	0	+	++
	540	Middle River	Co Ro 114 to T156 R49W S3, north line (AUID 541)	MIBI	+	++	NE	++	++
Upper Snake River (0902030901)	546	Snake River, South Branch (new channel)	Headwaters to Snake R	FIBI	++	+	0	++	++
	544	Snake River, South Branch (old channel)	JD 25-1 [b] to Snake R	FIBI	+	++	0	++	++
				MIBI	++	+	NE	++	+
	543	Snake River	Unnamed cr to S Br Snake R	FIBI	+++	++	0	++	++
				MIBI	+++	+	NE	++	++
	504	Snake River	S Br Snake R to CD 7	FIBI	+	++	0	++	++
				MIBI	+	+	NE	++	++
Lower Snake River (0902030903)	519	Judicial Ditch 29	Headwaters to Snake R	FIBI	+	++	0	+++	+++
	537	Snake River	T154 R49W S17, east line to CD 3	FIBI	++	++	0	++	++
				MIBI	++	++	NE	++	++
	502	Snake River	CD 3 to Middle R	FIBI	++	+	0	++	+++
				MIBI	++	+	NE	++	++
	501	Snake River	Middle R to Red R	FIBI	++	+	0	++	+++

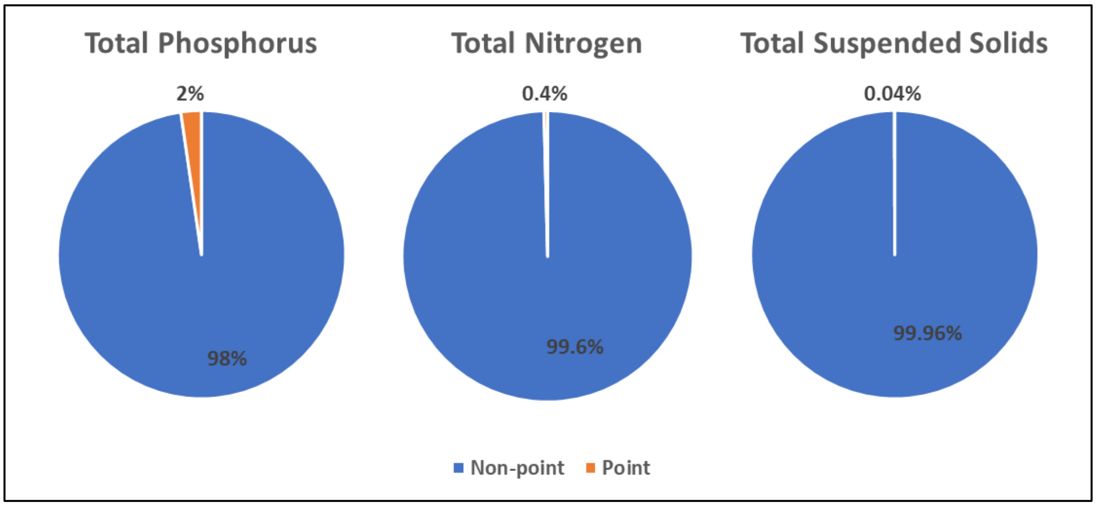
[a] Key:
+++ The available evidence convincingly supports the case for the candidate cause as a stressor;
++ The available evidence strongly supports the case for the candidate cause as a stressor;
+ The available evidence somewhat supports the case for the candidate cause as a stressor;
0 The available evidence neither supports nor weakens the case for the candidate cause as a stressor; and
NE no evidence is available.

[b] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Pollutant sources

This section summarizes the sources of pollutants (e.g., phosphorus, bacteria, or sediment) to surface waters in the SMRW, including point sources (such as wastewater treatment plants [WWTPs]) or nonpoint sources (e.g., runoff from the land). By using the calibrated HSPF model, loading from all of the nonpoint sources was compared to loading from point sources for TP, total nitrogen (TN), and TSS, which indicates that nonpoint source pollution is the major concern in the SMRW (Figure 9).

Figure 9. Overall breakdown of nonpoint source vs. point source pollution in the SMRW for TP, TN, and TSS.



Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a surface water and have a National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) permit.

Municipal/industrial wastewater – There are six municipal wastewater facilities and one industrial wastewater facility in the SMRW, as described in Table 9 and mapped in Figure 11. Per the TMDL studies described in Section 2.4, no reductions are required beyond the current permitted loads for these seven NPDES/SDS permitted point sources.

Table 9. Municipal/industrial wastewater point sources in the Snake-Middle Rivers Watershed.

HUC-10 Subwatershed	Point source			Pollutant reduction needed beyond current permit conditions/limits?
	Name	Permit #	Type	
Middle River	Argyle WWTP	MNG585140	Municipal wastewater	No
Middle River	Hawkes Co Inc	MN0062715	Industrial wastewater	No
Middle River	Middle River WWTP	MNG585163	Municipal wastewater	No
Middle River	Newfolden WWTP	MNG585145	Municipal wastewater	No
Upper Snake River	Viking WWTP	MNG585370	Municipal wastewater	No
Lower Snake River	Alvarado WWTP	MNG585171	Municipal wastewater	No
Lower Snake River	Warren WWTP	MNG585073	Municipal wastewater	No

Construction/Industrial Stormwater - Construction stormwater is regulated by NPDES permits for any construction activity that disturbs (1) one acre or more of soil; (2) less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or (3) less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A construction site owner/operator must meet the conditions of the Construction General Permit and properly select, install, and maintain all BMPs required under the permit, including any applicable additional BMPs required in Section 23 of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

Industrial activities require permit coverage under the state's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000) if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. A facility owner/operator with stormwater coverage under the appropriate NPDES/SDS permit must properly select, install, and maintain BMPs sufficient to meet the benchmark values in the permit.

Municipal Stormwater - There are no municipal separate storm sewer systems (MS4s) in the SMRW, so unregulated smaller-scale municipal stormwater is covered under urban stormwater runoff in the nonpoint sources section below.

Animal feedlots - Concentrated animal feeding operations (CAFOs) are defined by the EPA based on the number and type of animals. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an animal unit (AU). An AU is a unit used to provide a common basis to account for the differences in manure production across different species of livestock. In Minnesota, the following types of livestock facilities are required to operate under an NPDES permit or a state issued SDS permit: a) all federally defined CAFOs, some of which are under 1,000 AUs in size; and b) all CAFOs and nonCAFOs that have 1,000 or more AUs. All NPDES and SDS permitted feedlots are designed to have zero discharge, and as such they are not considered a significant source of pollutants.

Of the approximately 32 animal feedlots in the SMRW that are registered, active, and have more than zero AUs, there are two CAFOs; one with fewer than 1,000 AUs and the other with more than 1,000 AUs. However, neither of the two CAFOs in the SMRW have an NPDES or SDS permit, so the CAFOS, along with all other feedlots are accounted for as nonpermitted/nonpoint sources. An animal feedlot with 300 to 999 AUs that is a CAFO but does not have an NPDES or SDS permit is called a “gap site”, so the smaller CAFO in the SMRW is a gap site. The larger CAFO surpassed the 1,000 AU threshold as of its most recent registration, so it may require future NPDES or SDS permit coverage; additional follow up is needed regarding this CAFO. The land application of all manure, regardless of whether the source of the manure originated from permitted (e.g., CAFOs) or nonpermitted animal feedlots, is typically subject to manure management plans and is also accounted for as a nonpermitted/nonpoint source.

Nonpoint Sources

Nonpoint pollution, unlike pollution from industrial and sewage treatment plants, comes from many different sources. Nonpoint source pollution is caused by rainfall or snowmelt striking and moving over and through the ground and carrying natural and anthropogenic pollutants to surface waters.

In the SMRW, nutrient runoff from cropland and channel erosion are identified as the main nonpoint pollutant sources. Figure 10 shows the breakdown of phosphorus, nitrogen, and sediment (TSS) loading by land cover type in the SMRW. The loading rates for these pollutants are shown in Figure 12 (phosphorus), Figure 13 (nitrogen), and Figure 14 (TSS). Nutrient loading from cropland is delivered to streams and transported downstream. Flashy hydrographs caused by altered hydrology (tile drainage, ditching, and land cover change) create large sediment loads associated with bank erosion.

Other potential pollutant mechanisms include:

- **Fertilizer and/or manure runoff**: Fertilizer and manure contain high concentrations of phosphorus, nitrogen, and bacteria that can run off into surface waters when not properly managed.
- **Feedlots**: While only larger animal feedlots are regulated and permitted, Minnesota law requires most feedlot owners to register their feedlot with the MPCA. Feedlots located in shoreland (within 300 feet of a stream or river or within 1,000 feet of a lake) that maintain 10 AUs or more and those located outside of shoreland that maintain 50 AUs or more are required to register.

  Table 10 shows the number of active feedlots in the SMRW that are registered, active, and have more than 0 AUs (n = 32); they are grouped by HUC-10 subwatershed and by size (AUs). The feedlots within this watershed are mostly under 300 AUs, and their operating requirements are to maintain current registration and notify the MPCA of any construction activities taking place. There are two active CAFOs in the SMRW, one with approximately 1,035 AUs (turkey) and another with approximately 958.5 AUs (beef). Since neither of the two CAFOs have an NPDES or SDS permit, they, along with all other feedlots, are accounted for as nonpermitted sources. The land application of all manure, regardless of whether the source of the manure originated from permitted (e.g., CAFOs) or nonpermitted animal feedlots, is also accounted for as a nonpermitted source.

Table 10. Summary of animal feedlots in the SMRW that are registered, active, and have more than 0 AUs, grouped by HUC-10 subwatershed and size (AUs) (MPCA 2020c).

Feedlot animal units (AUs)	Middle River HUC-10 Subwatershed	Upper Snake River HUC-10 Subwatershed	Lower Snake River HUC-10 Subwatershed	Total
< 300[a]	12[a]	14[a]	3[a]	29[a]
300-499	0	0	0	0
500-999	2[b]	0	0	2
>999	0	1[b]	0	1
Total	**16**	**11**	**2**	**32**

[a] Four animal feedlots are within shoreland: 1 each in the Lower Snake River and Middle River HUC-10 Subwatersheds and 2 in the Upper Snake River HUC-10 Subwatershed, and each have < 300 AUs.

[b] One CAFO < 1,000 AUs is in the Middle River HUC-10, and another CAFO with > 1,000 AUs is in the Upper Snake River HUC-10.

- **Urban stormwater runoff**: Stormwater collects and transports pollutants deposited on impervious surfaces, such as sidewalks, streets, and rooftops, directly to local waterbodies if not properly managed.
- **Noncompliant septic systems**: Two types of noncompliant septic systems exist: those that *fail to protect groundwater* and those that pose an *imminent public health threat*. The latter is defined

in Minnesota Rules (Minn. R. Ch. 7080.1500, subp. 4) as having at least one of the following characteristics:

  - Discharge of sewage or sewage effluent to the ground surface, drainage systems, ditches, or storm water drains or directly to surface water;
  - Systems that cause a reoccurring sewage backup into a dwelling or other establishment;
  - Systems with electrical hazards; or
  - Sewage tanks with unsecured, damaged, or weak maintenance hole covers.

  Systems posing an imminent health threat are the most concerning for protecting surface waters because of potential nutrient and bacterial loading.

- **Peatlands/wetlands**: Peatlands and wetlands may have high levels of phosphorus and low levels of DO, which that can contribute to excessive phosphorus or low-DO levels in downstream streams and lakes.
- **Internal loading**: Lake or stream sediments may contain large amounts of phosphorus that can be released to the water column through physical mixing or under certain chemical and temperature conditions.
- **Livestock overgrazing in the stream**: Livestock grazing/watering in the riparian zone can cause localized streambank erosion, which contributes sediment and phosphorus to the stream; manure falling in or near the water will contribute higher nutrient and bacterial loads than manure falling on upland pastures.
- **Wildlife or pet fecal contamination**: Dense or localized wildlife populations, such as beavers or geese, can contribute phosphorus and bacteria pollutants to surface water either directly or through runoff. Pets can also contribute nutrients and bacteria to surface waters.

Figure 10. Breakdown of nonpoint source TP, TN, and TSS loading in the Snake-Middle Rivers Watershed.

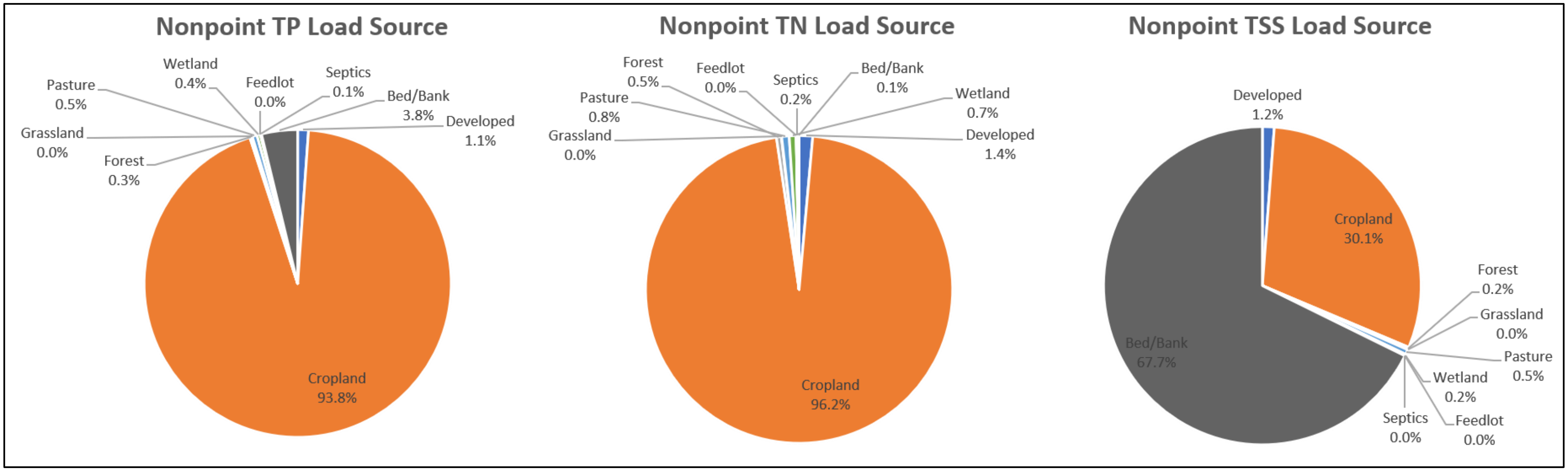


Figure 11. Point sources and animal feedlots (MPCA 2020c) in the Snake-Middle Rivers Watershed.

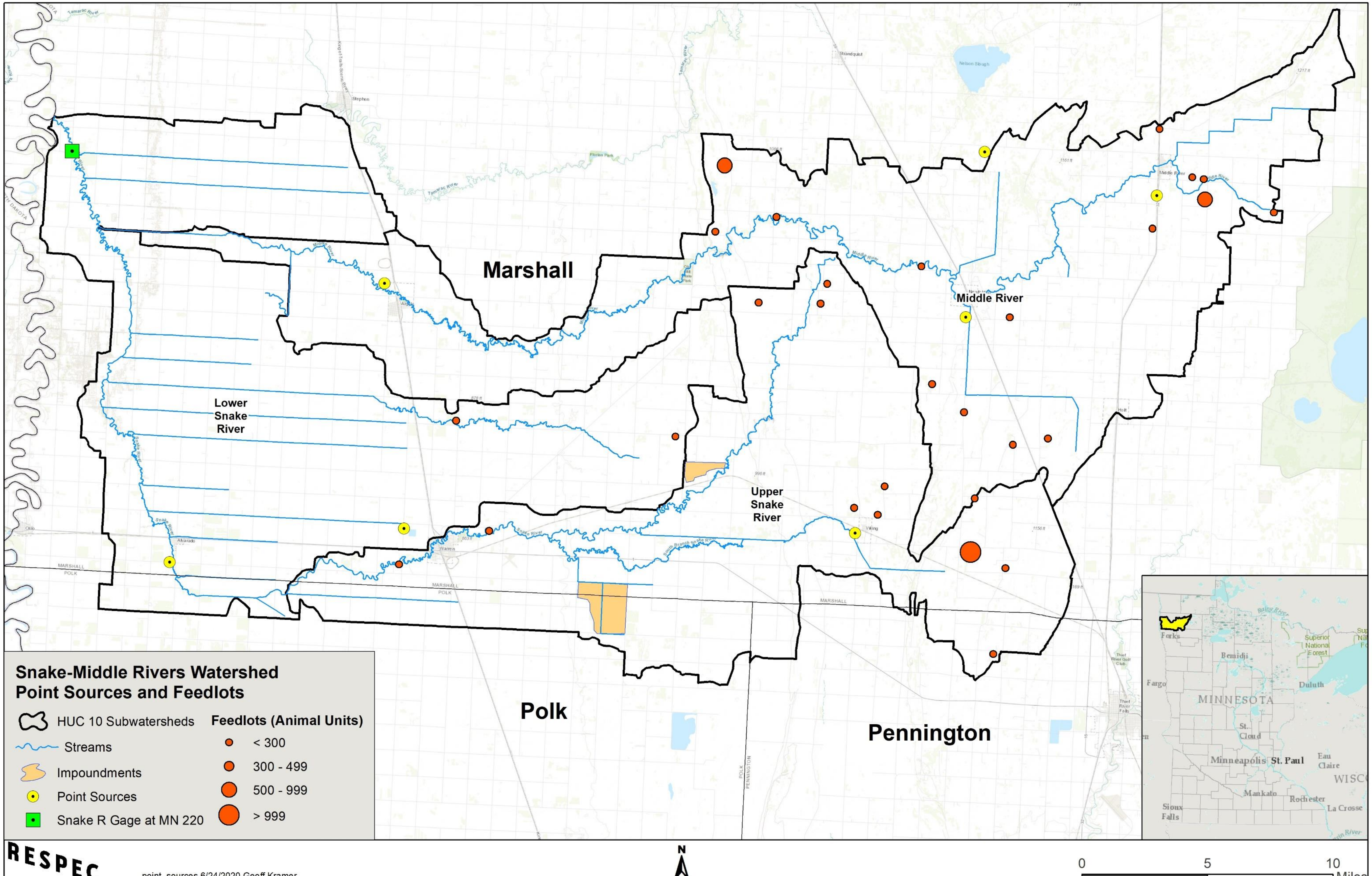


Figure 12. Mean annual total phosphorus loading rates by subwatershed in the Snake-Middle Rivers Watershed.

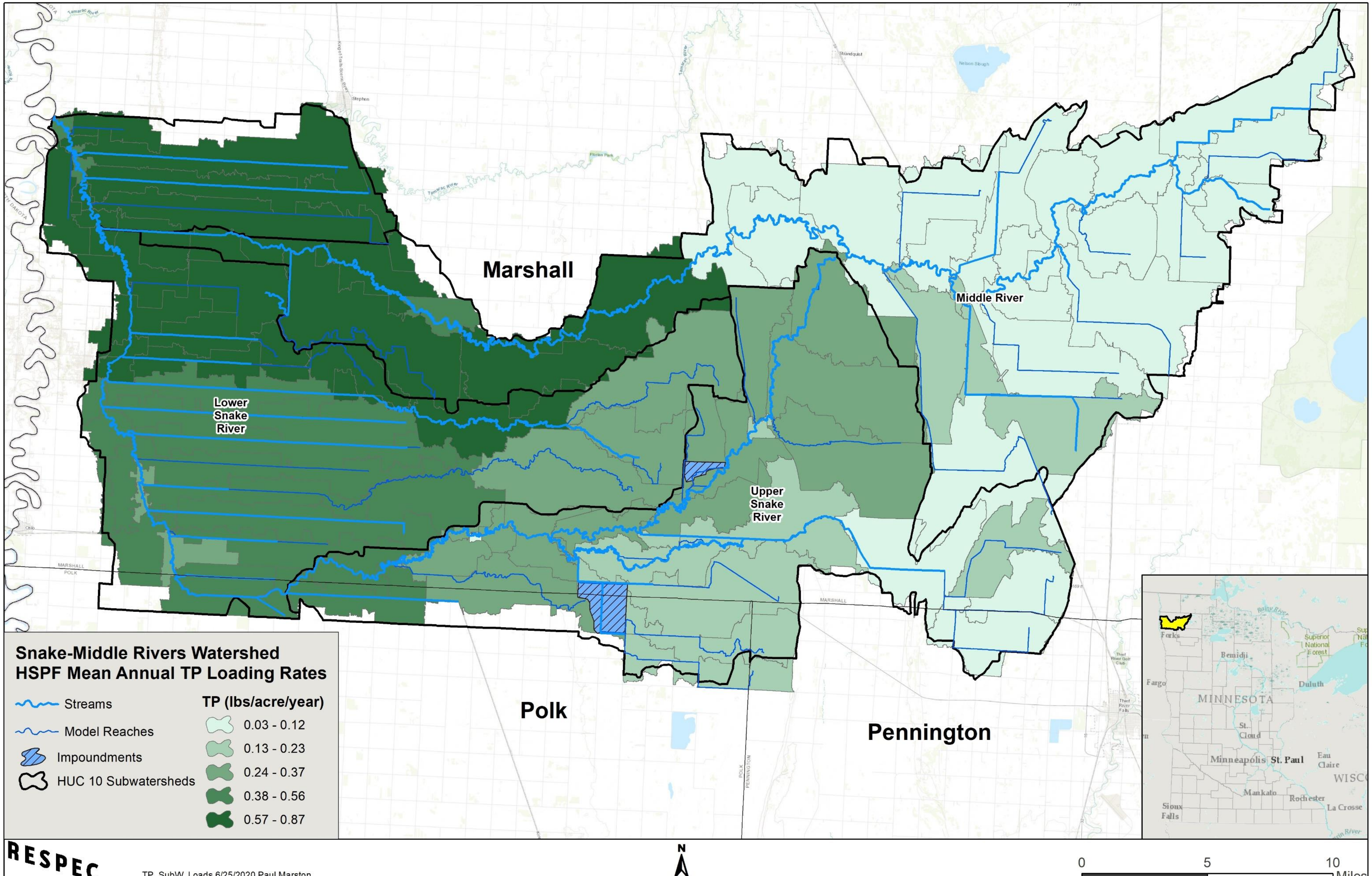


Figure 13. Mean annual total nitrogen loading rates by subwatershed in the Snake-Middle Rivers Watershed.

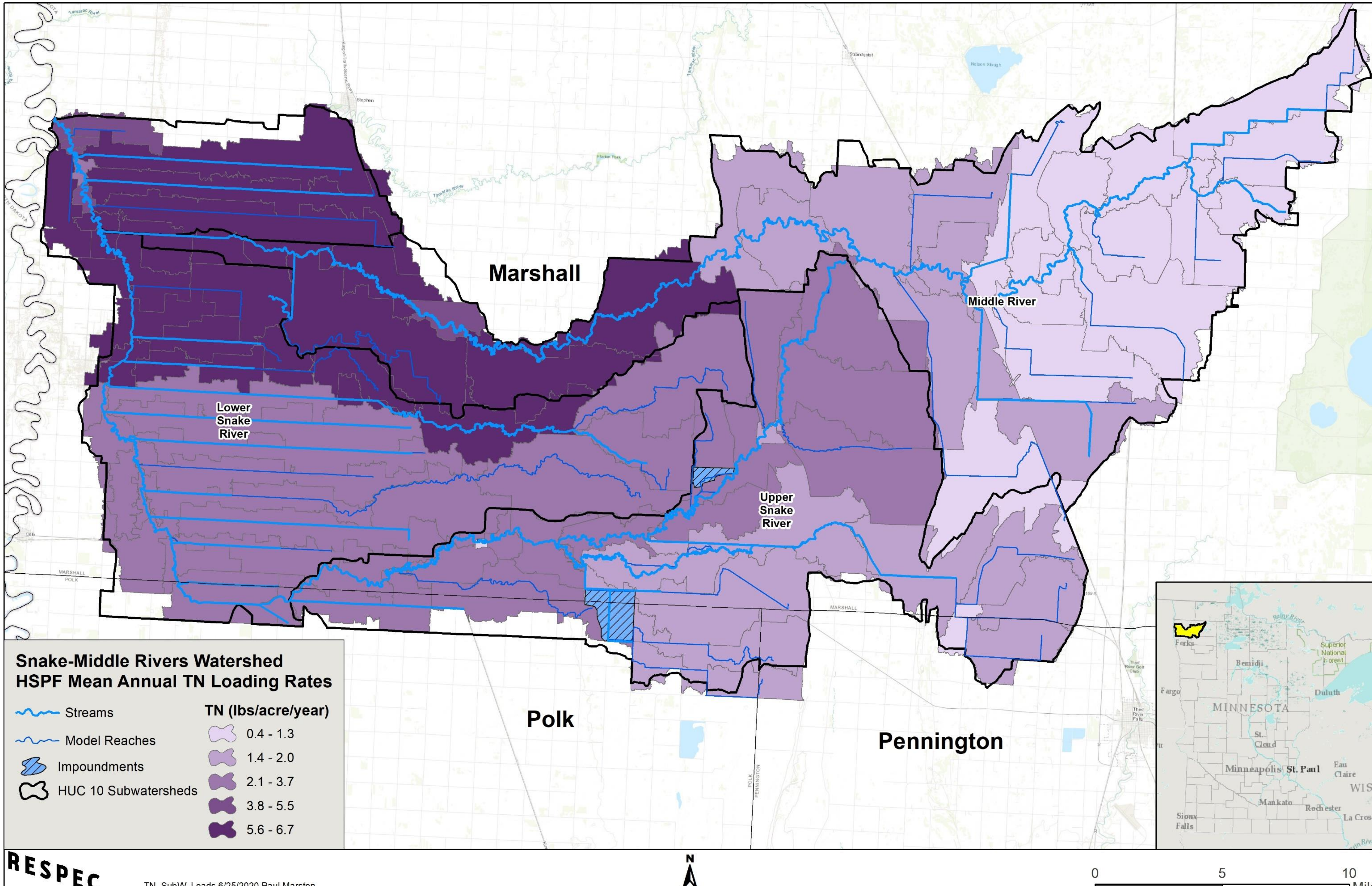
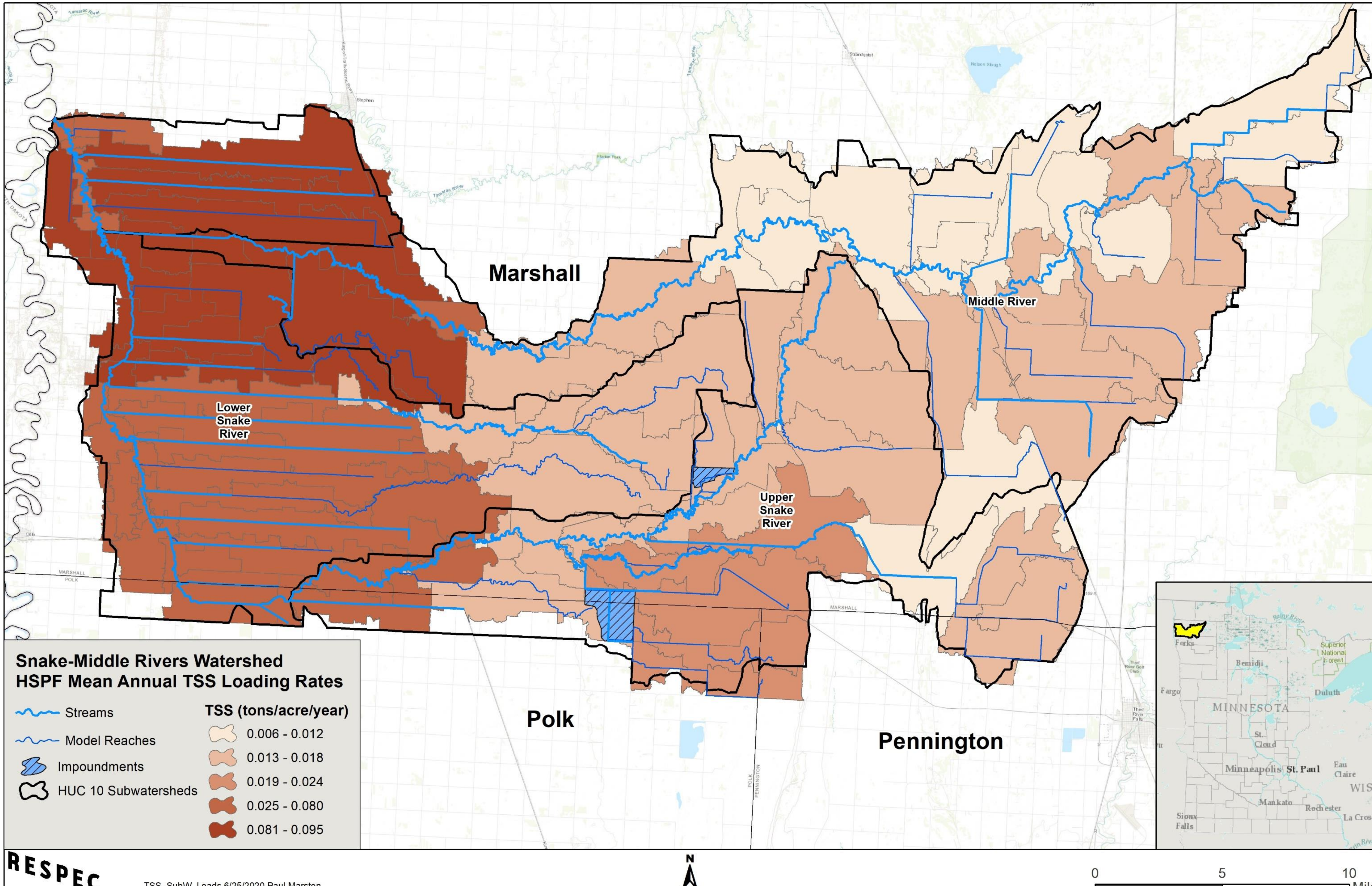


Figure 14. Mean annual total suspended solids loading rates by subwatershed in the Snake-Middle Rivers Watershed.



2.4 TMDL Summary

Thirteen stream reaches (AUIDs) in the SMRW have a total of 31 water quality impairments of aquatic life use and/or aquatic recreation use. TMDL studies for eight impairments were carried out on seven AUIDs: five reaches of the Snake River and two reaches of the Middle River. These studies were compiled in the *Snake and Middle Rivers TMDL Report* (MPCA 2020d). The seven AUIDs and corresponding eight impairments (five turbidity and three *E. coli*) addressed with the TMDL studies are listed in Table 11. Note that turbidity impairments were addressed with TSS TMDL studies because of the adoption of a TSS standard to replace the turbidity standard in January 2015. Per the EPA, "a TMDL establishes the maximum amount of a pollutant allowed in a waterbody while still achieving water quality standards, and serves as the starting point or planning tool for restoring water quality." TMDL load allocation tables for the completed TMDLs listed in Table 11 are included in Appendix A.

Table 11. Water quality impairments on the approved 2018 303(d) list (MPCA 2019a) that are addressed in the TMDL report.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Proposed Use Class [a]	Impairment Causes
Middle River (0902030902)	540	Middle River	Co Rd 114 to T156 R49W S3, north line	2Bg, 3C	Turbidity
	541	Middle River	T157 R49W S34, south line to Snake R	2Bm, 3C	Turbidity
Upper Snake River (0902030901)	543	Snake River	Unnamed cr to S Br Snake R	2Bg, 3C	*E. coli*
	504	Snake River	S Br Snake R to CD 7	2Bg, 3C	Turbidity, *E. coli*
Lower Snake River (0902030903)	537	Snake River	T154 R49W S17, east line to CD 3	2Bg, 3C	*E. coli*
	502	Snake River	CD 3 to Middle R	2Bg, 3C	Turbidity
	501	Snake River	Middle R to Red R	2Bg, 3C	Turbidity

[a] Lowercase letters are tiered aquatic life use (TALU) designations: e = Exceptional, g = General, m = Modified.

Twenty-three of the 31 aquatic life use and aquatic recreation use impairments were not addressed with TMDL studies; these impairments are listed in Table 12. Impairments that were not addressed in the TMDL studies include those caused by low DO and poor biological communities. No impairments caused by poor fish or macroinvertebrate communities (*n*= 9 and 7, respectively) were addressed, because while all of them are linked to stressors with numeric criteria to some extent, the impairments are primarily linked to stressors without numeric criteria (e.g., flow regime instability and poor habitat). However, addressing the impairments caused by TSS will also provide improvements to the fish and macroinvertebrate communities. The 6 DO impairments were not addressed for the following reasons:

- Snake River Reach 501 because of backwater effects at the Red River of the North;
- Snake River Reach 502 because of lack of reasonable assurance to meet the standard;
- Snake River Reach 537 because of a need for further assessment;
- Middle River Reach 539 because of two large wetland complexes in its drainage area;

- Middle River Reach 540 and 541 because of a lack of reasonable assurance to meet the standard; and
- Snake River Reach 543 because of a large impoundment in its drainage area that requires further evaluation.

The DO impairments not addressed in the *Snake and Middle Rivers TMDL Report* (MPCA 2020d) may be addressed in future listing cycles if impairments are found to remain after additional assessments or evaluations.

The Snake River Reach 501 aquatic consumption use impairment is caused by high mercury in the water column. This WRAPS report and associated TMDL report do not cover toxic pollutants and mercury concentrations are above the threshold values for this impairment to be addressed by the *Minnesota Statewide Mercury TMDL* (MPCA 2007a; MPCA 2020b). As a result, this impairment is scheduled to have a TMDL study completed at a later date.

Table 12. Aquatic life use and aquatic recreation use impairments on the approved 2018 303(d) list (MPCA 2019a) that are not addressed in the TMDL report.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach description	Proposed Use Subclass	Impairment Causes
Middle River (0902030902)	529	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	2B, 3C	MIBI
	538	Middle River	Headwaters to –96.171 48.4349	2B, 3C	FIBI
	539	Middle River	–96.171 48.4349 to Co Rd 114 bridge	2B, 3C	DO
	540	Middle River	Co Rd 114 to T156 R49W S3, north line	2B, 3C	MIBI, DO
	541	Middle River	T157 R49W S34, south line to Snake R	2B, 3C	DO
Upper Snake River (0902030901)	546	Snake River, South Branch (new channel)	Headwaters to Snake R	2B, 3C	FIBI
	544	Snake River, South Branch (old channel)	JD 25-1 [a] to Snake R	2B, 3C	FIBI, MIBI
	543	Snake River	Unnamed cr to S Br Snake R	2B, 3C	FIBI, MIBI, DO
	504	Snake River	S Br Snake R to CD 7	2B, 3C	FIBI, MIBI
Lower Snake River (0902030903)	519	Judicial Ditch 29	Headwaters to Snake R	2B, 3C	FIBI
	537	Snake River	T154 R49W S17, east line to CD 3	2B, 3C	FIBI, MIBI, DO
	502	Snake River	CD 3 to Middle R	2B, 3C	FIBI, MIBI, DO
	501	Snake River	Middle R to Red R	2B, 3C	FIBI, DO

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

E. coli TMDLs

The three *E. coli* impairments (Snake River Reaches 504, 537, and 543) were addressed as part of the TMDL studies. Reductions across the 5 flow zones for each reach are presented in Table 13.

Table 13. Required *E. coli* reductions by flow zone as determined from the TMDL studies.

Name	Stream ID	Flow Zone				
		Very High	High	Mid	Low	Very Low
Snake River	09020309-504	0%	38%	0%	0%	*
	09020309-537	74%	0%	0%	48%	83%
	09020309-543	0%	0%	0%	0%	*

* The data available are insufficient to calculate load reduction.

Dissolved Oxygen TMDLs

Three DO TMDL calculations were initially conducted for reaches 502, 540, and 541; however, after additional analysis using the HSPF model, the 90+ percent reduction in nutrient loading necessary to achieve the DO standard 100% of the time was determined to be impossible to attain on a primarily agricultural landscape where nutrient application is commonplace for crop production. As a result, the MPCA could not provide reasonable assurance that nutrient loading could be reduced by 90+ percent to meet the DO TMDLs, and they were removed from the TMDL report. However, strategies are listed in Section 3.3 of this WRAPS report that can be implemented to improved DO conditions in impaired streams.

Total Suspended Solids TMDLs

The five turbidity impairments (Snake River Reaches 501, 502, and 504 and Middle River Reaches 540 and 541) were addressed in the TMDL report as TSS TMDL studies, following the replacing of the turbidity standard with the TSS standard in January 2015. Required reductions are presented in Table 14 for each of the five flow zones and for the overall reduction. Because Reach 540 has a 286 square mile drainage area and is located directly above Reach 541, which has an additional drainage area of only 6.5 square miles, the two TMDLs were combined to represent the full drainage area.

Table 14. Required total suspended solids reductions by flow zone as determined from the TMDL studies.

Name	Stream ID	Flow Zone					Overall Reduction Required
		Very High	High	Mid	Low	Very Low	
Snake River	09020309-501	98%	92%	89%	78%	0%	93%
	09020309-502	86%	83%	86%	85%	0%	84%
	09020309-504	75%	23%	39%	0%	0%	50%
Middle River	09020309-540/541 [a]	81% [a]	52% [a]	51% [a]	53% [a]	0% [a]	76% [a]

[a] A combined TMDL was determined for Reaches 540 and 541 because the reductions required for Reach 541, when calculated separately, were very high because of the relatively low direct drainage area to Reach 541.

2.5 Protection considerations

Because of the large number of impairments identified in the SMRW, the efforts outlined in this report largely focus on restoring impaired waterbodies; however, protection goals are also addressed to ensure that nonimpaired waterbodies do not become impaired. Initial goals were identified in the MSTRWD's *Final Ten Year Watershed Management Plan* (MSTRWD 2011). The natural resources goals indicate protection is a priority in the SMRW to protect wetland and grassland areas from future impacts. Specific goals include:

- Maintain the existing Conservation Reserve Program (CRP) base in the beach ridge and eastern portions of the SMRW, particularly discouraging marginal land conversion to cropland in areas of high wind erosion potential;
- Protect native plant communities and key habitats;
- Actively manage vegetation on public and private conservation lands to maintain an aspen parkland and oak savannah type habitat on the top of the beach ridges;
- Protect nonchannelized reaches from alteration;
- Protect riparian wetlands and perennial vegetation within the meander belt width of streams;
- Protect native prairie lands.

In addition to the priority protection considerations identified in the MSTRWD's 2011 plan, stream reaches that fully or partially support aquatic life use should be considered for protection strategies. Stream reaches that fully support aquatic life and meet the IBI thresholds for fish and macroinvertebrates are listed in Table 15, while stream reaches partially supporting aquatic life (support fish, macroinvertebrates, or both, but are impaired for at least one pollutant constituent or aquatic life community) are listed in Table 16.

Table 15. List of streams fully supporting aquatic life use parameters.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life Communities Supported
Middle River (0902030902)	534	Unnamed creek	Unnamed ditch to Middle R	FIBI, MIBI
	515	County Ditch 15 Branch [a]	Headwaters to CD 15	FIBI, MIBI
	530	Judicial Ditch 21	380th St to Middle R	FIBI, MIBI
Upper Snake River (0902030901)	518	Judicial Ditch 25-1 [a]	Unnamed ditch to Unnamed ditch	MIBI

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Table 16. List of streams partially supporting aquatic life use parameters.

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life Communities Supported
Middle River (0902030902)	529	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	FIBI
	539	Middle River	–96.171 48.4349 to Co Rd 114 bridge	FIBI, MIBI
	540	Middle River	Co Rd 114 to T156 R49W S3, north line	FIBI
	541	Middle River	T157 R49W S34, south line to Snake R	FIBI
Upper Snake River (0902030901)	546	Snake River, South Branch (new channel)	Headwaters to Snake R	MIBI

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

3. Prioritizing and implementing restoration and protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize watershed modeling outputs, and identify areas with high pollutant-loading rates. In addition, the CWLA requires including strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint pollutant sources. This information is to be used to inform local water planning and implementation.

This report section provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and SMRW residents, creating social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement BMPs is imperative; thus, effective ongoing public participation is a full part of the overall plan for moving forward.

The implementation strategies provided in this section, including associated scales of adoption and timelines, are the result of watershed modeling efforts 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. The proposed actions outlined are, therefore, subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

Certain issues are not addressed in the strategies tables, including the limited local project management capacity and funding that could greatly affect the outcomes of this report's recommendations. If resources (e.g., staffing or funding) are limited or nonexistent in the project area, the strategies and goals laid out in this report will likely take longer to achieve, if they are achieved at all. This work mostly relies on reductions from nonregulated actions in the watershed and, to achieve those goals, local relationships and trust need to be built where they may not currently exist. Therefore, as these actions are undertaken, all levels of government and landowners must continue to find ways to support local entities and individuals to ensure that the waterbodies in the SMRW are restored and protected. If this support does not happen, achieving the TMDL reductions and strategies in this report is very unlikely.

3.1 Targeting of geographic areas

Implementation efforts on nonimpaired waterbodies should be targeted based on prioritization, which helps to identify those waterbodies to focus protection efforts on preventing future impairments. To determine the stream reaches in the SMRW that have the greatest potential, or are at the greatest risk, of future impairment, an analysis of the IBI scores in relation to their impairment thresholds and drainage area was completed. Table 17 includes all nonimpaired reaches, their IBI scores for the nonimpaired biologic community, and their drainage areas. Metrics were developed by calculating the percent change from the impairment threshold, and converting the result to a score that ranks the reaches with IBI scores closest to their impairment thresholds higher than reaches with IBI scores further above (meeting) their impairment thresholds; for example, a stream reach that has an FIBI score that surpasses the impairment threshold by only 10 points would be prioritized over a reach that scores 20 points above the impairment threshold. For this calculation, the percent change from the impairment threshold is calculated to determine the "percent from threshold" value. Because values further away from the threshold will have a higher percent change, values were subtracted from one to develop the metric score, which results in higher scores for reaches closer to the threshold. For stream reaches with multiple IBI scores and threshold values, the average IBI scores for a given threshold are averaged and then divided by the impairment threshold; these values are averaged to determine one value for "percent from threshold." This calculation is done for the FIBI and MIBI scores. The drainage area value is calculated by doing an inverse, percent rank calculation to give the smallest drainage areas higher scores than the largest drainage areas, because smaller drainage areas likely being impacted by fewer factors and, therefore, are likely to require less effort to protect. The final combined score is calculated by averaging the FIBI, MIBI, and drainage area scores with a two times weight being applied to the IBI score averages for reaches that meet both FIBI and MIBI thresholds. This calculation is done to prioritize reaches that currently meet standards for both of the biological communities versus reaches that meet standards for only 1. The final scores are ranked from the largest to smallest values and provide prioritization for nonimpaired reaches. Additional tools available to assist in geographic targeting are listed in Table 18.

No prioritization of impaired waterbodies was conducted as part of this report; rather, restoring all impaired waterbodies should carry equal priority as their inclusion on the EPA's 303(d) impaired waters list already reflects Minnesota's priority ranking.

The MSTRWD's 10-year management plan identified 3 priority concerns: flood control/water retention; water quality; and river channel and ditch maintenance (MSTRWD 2011). The DNR worked with the MSTRWD to design a monitoring program to assess the impacts of the off-channel storage project near Radium, Minnesota. The site upstream of the inlet to the off-channel storage area showed erosion and channel widening, which indicated instability, while all of the sites downstream of the off-channel impoundment decreased in cross-sectional area following construction (Topp 2015).

Table 17. Stream prioritization metrics and rankings.

AUID (Last 3 digits)	HUC-10 Subwatershed	Stream	Reach Description	Aquatic Life Communities Supported	FIBI Score	FIBI Threshold	Percent From Standard	FIBI Rank Score	MIBI Score	MIBI Threshold	Percent From MIBI Threshold	MIBI Rank Score	Drainage Area (acres)	Drainage Area Score	Combined Score	Priority Rank
530	Middle River	Judicial Ditch 21	380^{th} St to Middle R	FIBI, MIBI	60.6	42	44%	0.56	36	37	-3%	1.03	7538	0.88	1.35	1
539	Middle River	Middle River	–96.171 48.4349 to Co Rd 114 bridge	FIBI, MIBI	51.5	47	32%	0.68	41.5	37	12%	0.88	133390	0.25	1.12	2
					65	42			46	41						
515	Middle River	County Ditch 15 Branch [a]	Headwaters to CD 15	FIBI, MIBI	38	23	65%	0.35	29	22	32%	0.68	1874	1.00	1.02	3
534	Middle River	Unnamed creek	Unnamed ditch to Middle R	FIBI, MIBI	66	42	57%	0.43	43	37	16%	0.84	11802	0.50	1.01	4
518	Upper Snake River	Judicial Ditch 25-1 [a]	Unnamed ditch to Unnamed ditch	MIBI	-	-	-	-	24	22	9%	0.91	11709	0.63	0.77	5
546	Upper Snake River	Snake River, South Branch (new channel)	Headwaters to Snake R	MIBI	-	-	-	-	43.5	37	18%	0.82	38518	0.38	0.60	6
540	Middle River	Middle River	Co Rd 114 to T156 R49W S3, north line	FIBI	53	47	12%	0.88	-	-	-	-	181599	0.13	0.50	7
					56	50										
541	Middle River	Middle River	T157 R49W S34, south line to Snake R	FIBI	54	35	54%	0.46	-	-	-	-	185243	0.00	0.23	8
529	Middle River	Judicial Ditch 28 [a]	Unnamed ditch to Middle R	FIBI	59	23	157%	-0.57	-	-	-	-	9007	0.75	0.09	9

[a] Note that while MPCA’s name for this waterbody is “Unnamed ditch”, it was changed to represent the local name.

Table 18. Additional tools to guide targeting of geographical areas.

Tools	Description	How can the tool be used?	Notes	Link to information and data
Board of Water and Soil Resources (BWSR) Landscape Resiliency Strategies	These webpages describe strategies for integrated water resources management to address soil and water resource issues at the watershed scale, and to increase landscape and hydrological resiliency in agricultural areas.	In addition to providing key strategies, the webpages provide links to planning programs and tools such as SPI, PTMApp, Nonpoint Priority Funding Plan, and local water management plans.	These data layers are available on the Board of Water and Soil Resources (BWSR) website. The MPCA download link offers spatial data that can be used with GIS software to make maps or perform other geography-based functions.	Landscape Resiliency - Water Planning Landscape Resiliency - Agricultural Landscapes MPCA download
Ecological ranking tool (Environmental Benefit Index - EBI)	This dataset consists of 3 Geographic Information System (GIS) raster data layers including soil erosion risk, water quality risk, and habitat quality. The 30-meter grid cells in each layer contain scores from 0-100. The sum of all 3 scores is the EBI score (max of 300). A higher score indicates a higher priority for restoration or protection.	The 3 layers can be used separately, or the sum of the layers (EBI) can be used to identify priority areas for restoration or protection projects. The layers can be weighted or combined with other layers to better reflect local values.	These data layers are available on the Board of Water and Soil Resources (BWSR) website. In addition, a GIS data layer that shows the 5% of each 8-digit watershed in Minnesota with the highest EBI scores is available for viewing in the MPCA 'water quality targeting' web map, and download from MPCA.	BWSR MPCA Web Map MPCA download
Zonation	This tool serves as a framework and software for large-scale spatial conservation prioritization, and a decision support tool for conservation planning. The tool incorporates values-based priorities to help 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.)	Software Examples
Restorable wetland inventory	A GIS data layer that shows potential wetland restoration sites across Minnesota. Created using a CTI (10-meter resolution) to identify areas of ponding, and U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soils with a soil drainage class of poorly drained or very poorly drained.	Identifies potential wetland restoration sites with an emphasis on wildlife habitat, surface and ground water quality, and reducing flood damage risk.	The GIS data layer is available for viewing and download on the Minnesota 'Restorable Wetland Prioritization Tool' website.	Restorable Wetlands
National Hydrography Dataset (NHD) and 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 have been used for fisheries management, hydrologic modeling, environmental protection, and resource management. A specific application of this data set is to identify riparian buffers around rivers.	The layers are available on the USGS website.	USGS
Light Detection and Ranging (LiDAR)	Elevation data in a 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 Office (MGIO) website.	MGIO
Hydrological Simulation Program – FORTRAN (HSPF) Model and HSPF Scenario Application Manager (SAM)	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). SAM harvests data from HSPF and provides predictions of reductions tied to various levels of multiple BMP adoption or installation.	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.	EPA Models USGS

3.2 Public Participation

Efforts to facilitate public education, review, and comment when developing the WRAPS report included meetings with local groups in the watershed on the assessment findings, and a 30-day public notice period for public review of and comment on the draft WRAPS report. All of the input, comments, responses, and suggestions from public meetings and the public notice period were addressed or taken into consideration in developing the WRAPS report. Regular updates regarding the WRAPS process with the WRAPS team for the SMRW included meetings to discuss WRAPS processes and results. Public and team meetings are listed as follows:

- A project kickoff meeting was held with the project team on April 25, 2017.
- Project team meetings were held on June 1, 2017, June 14, 2017, August 16, 2017, December 19, 2017, February 1, 2018, June 25, 2018, January 10, 2019, February 6, 2019, April 23, 2019, and October 31, 2019, to discuss the project timeline, methods, TMDL segments to be addressed, TMDL approaches, and WRAPS strategies.
- A public meeting was held in Argyle, Minnesota, on July 27, 2017, to provide an overview of the WRAPS and TMDL process.
- Because of the COVID-19 pandemic, it was not possible to hold an in-person public meeting to present the draft TMDL and WRAPS reports. A two-page flyer was developed instead with information and web addresses to prerecorded, on-demand presentations available to the public with material that would normally be discussed at an in-person meeting. The MSTRWD mailed the flyer and a cover letter to 110 contacts and organizations (including township clerks, county commissioners, county engineers, city clerks, Minnesota Department of Transportation, SWCDs, National Resources Conservation Service, BWSR, etc) shortly after the beginning of public notice. The flyer also listed one contact person from each state and local organization that the public can contact with any feedback, concerns, or questions.

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 September 21, 2020 through October 21, 2020. There was one comment letter received and responded to as a result of the public comment period.

3.3 Restoration and protection strategies

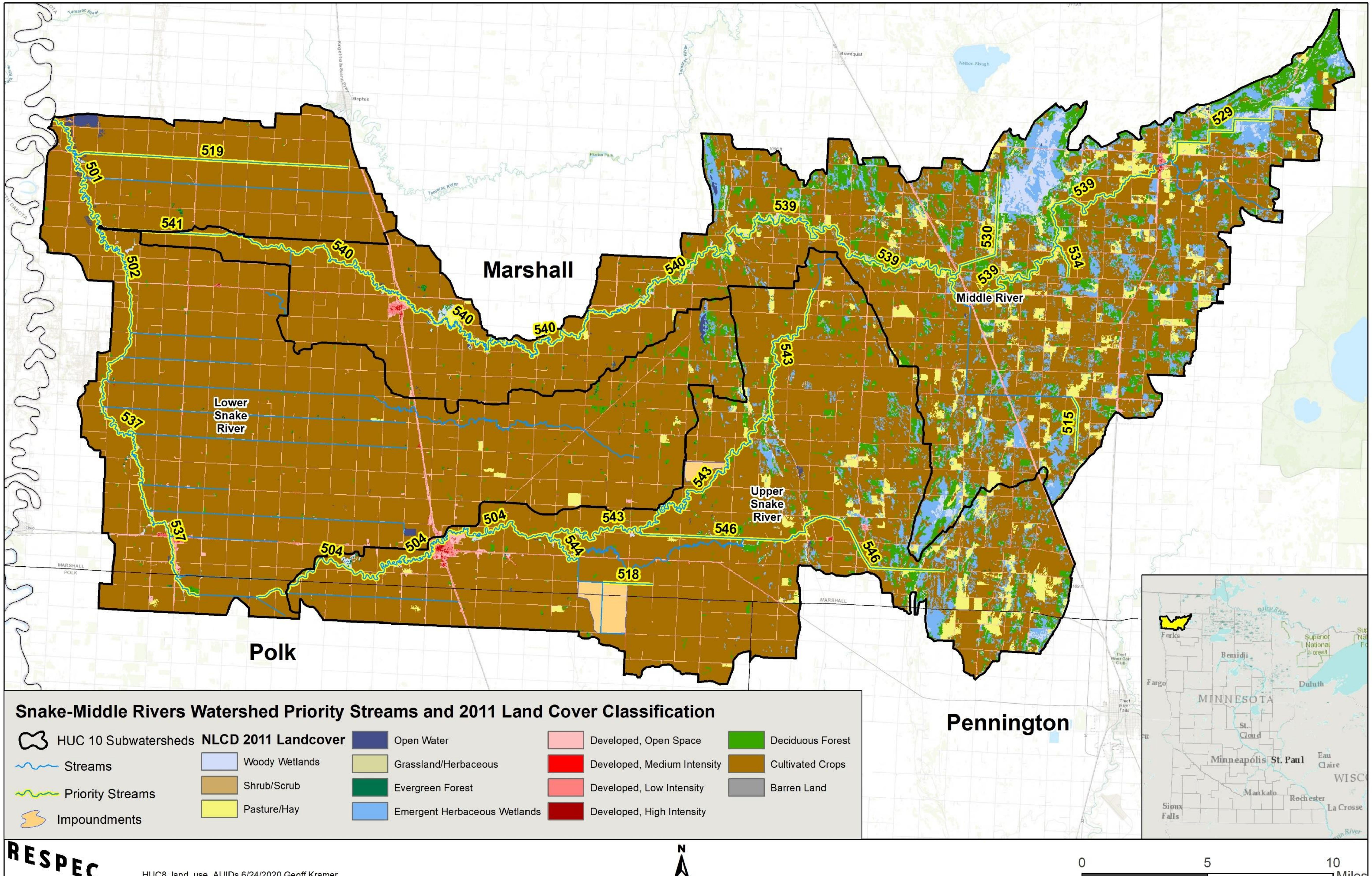
This section outlines restoration and protection strategies that can be used to address water quality and habitat impairments in the SMRW. Strategies were developed in concert with local government and state agency partners and are presented in several tables below. Table 19 provides an overview of the structure and content within each strategies table. Figure 15 shows assessed streams and land cover in the entire SMRW. Table 20 lists protection strategies for various pollutants and stressors that are broadly applicable throughout the SMRW. No restoration strategies (for impaired streams) are included at the HUC-8 level (in Table 20) as those strategies are presented in the appropriate HUC-10 subwatershed table corresponding to each individual impaired reach. Figure 16 and Table 21 show priority stream reaches and corresponding restoration protection strategies for the Middle River HUC-10 subwatershed; Figure 17 and Table 22 correspond to the Upper Snake River HUC-10 subwatershed; and Figure 18 and Table 23 correspond to the Lower Snake River HUC-10 subwatershed. Within the strategies tables, cells corresponding to restoration strategies are shaded in red and protection strategies are shown in white.

The goal of the strategies tables is to identify strategies and BMPs that can be used to restore impaired waterbodies and protect nonimpaired waterbodies. A comprehensive list of BMPs that were considered for the strategies tables is included in Appendix B. Strategies included in this section were chosen as most likely for implementation and success based on the experience of project partners and in consideration of the unique characteristics of the SMRW. Future watershed planning efforts will use the strategies identified to develop waterbody specific implementation goals and timelines.

Table 19. Strategies table category descriptions.

Strategy Table Category	Category Description
Waterbody (ID)	The name and ID of the priority waterbody.
Location Description	A general description of the stream reach segment.
Pollutant/ Stressor	The pollutant or stressor that strategies and BMPs address.
Current Water Quality (WQ) Conditions	The current observed water quality conditions for the pollutant/stressor. Water quality data are from the MPCA and represent the years 2006–2015. The “n/a" is used to denote waterbodies with no data or larger-scale areas (e.g., an entire HUC-10 or the entire SMRW) where providing a single value is not possible.
10-year WQ milestone Year:	The 10-year WQ milestone goal is based on a general target of reducing the pollutant by 1% each year or 10% total. In cases where the current WQ conditions are within 10% of the final WQ goal, the 10-year WQ milestone was set equal to the long-term WQ goal.
Final WQ Goal Year:	The final WQ goal was set equal to the water quality standard. For streams with 10-year milestones that meet the water quality standard, the final water quality goal is "maintain or improve upon the 10-year milestone.”
Strategy Type	General strategy classification (see Appendix B for further description of strategies).
BMP Scenario	Specific BMP associated with the strategy to address pollutant/stressor and achieve the water quality goals (see Appendix B for further details).

Figure 15. Snake-Middle Rivers Watershed land cover and priority streams.



The format of Table 20 has been modified to reflect the fact that all strategies presented in this table apply to all waterbodies and areas within the SMRW.

Table 20: Strategies and actions proposed for the Snake-Middle Rivers Watershed.

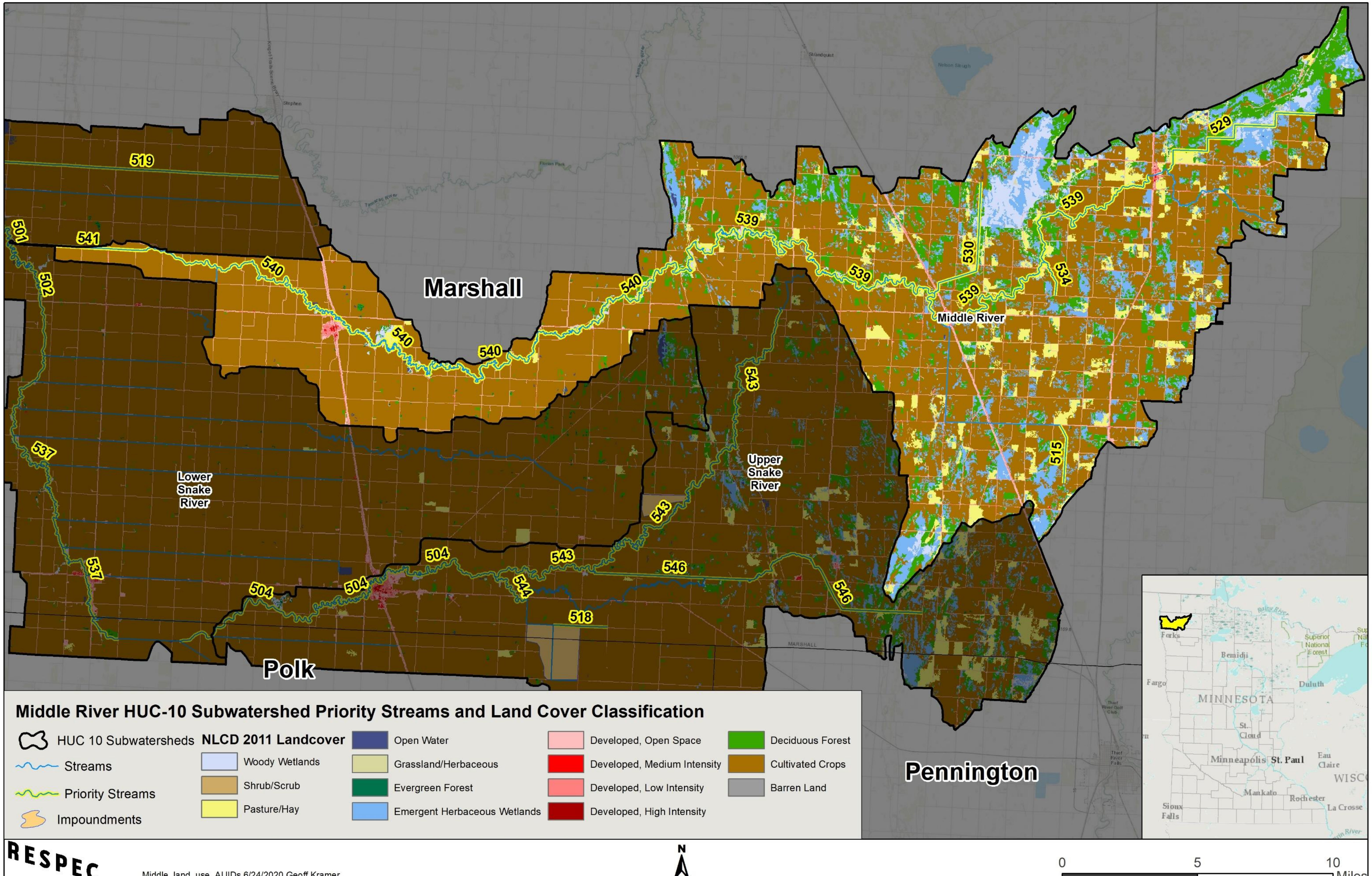
Pollutant/Stressor	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Sediment/TSS	n/a	n/a	n/a	Add cover crops for living cover in fall/spring	Cover Crops with Corn & Soybeans [340]
					Cover crops after early-harvest crops [340]
				Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
				Buffers and filters, field edge	Riparian Buffers, 16+ ft (perennials replace tilled) [390, 391, 327]
					Riparian Buffers, 50+ ft (perennials replace tilled) [390, 391, 327]
				Changing rotations to less erosive crops	Conservation Crop Rotation - adding small grains [328]
					Conservation Crop Rotation - add more perennials [328]
				Converting land to perennials	Conservation Cover Perennials [327, 327M, 342, 612]
					Perennial crops for regular harvest
				Designed erosion control and trapping	Filter Strips [386]
					Sediment Basin [350]
					Water and Sediment Control Basin (cropland) [638]
				Drainage ditch modifications	Minimize ditch repair/realignment projects
					Proper erosion control management for ditch projects
					Proper grading of unstable sideslopes
					Two stage ditch - open channel [582]
					Grade stabilization structure - in ditch [410]
				Maintain existing perennial cover	Maintain CRP lands in beach ridge areas
					Maintain aspen parkland and oak savannah on top of beach ridge areas
					Protect native prairie lands identified under the National Tallgrass Prairie Project
					Protect riparian wetlands and perennial vegetation within the meander belt width of streams
				Open tile inlet and side inlet improvements	Side inlet improvement [410]
				Pasture management	Livestock access control [472]
				Streambanks, bluffs, and ravines protected/restored	Address excessive sediment from ditch blowouts or gullies occurring at the ditch/river confluences
					Protect nonchannelized reaches from alteration
					Ravine Stabilization
					Restore floodplain access for sediment and nutrient reductions
					Stream Channel Stabilization [584]
					Stream restoration using principles such as Natural Channel Design
					Streambanks/shoreline - stabilized or restored [580]
				Tillage/residue management	Conservation tillage - >30% residue cover [345, 346, 329B]
					No-till/ridge till [329, 329A]
				Urban Stormwater runoff control	Bioretention/Biofiltration (urban) [712M]
					Constructed Stormwater Pond (urban) [155M]
					Improved lawn/turf vegetation & soil practices
					Infiltration Basin (urban) [803M]

Pollutant/Stressor	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Phosphorus	n/a	10% reduction (Red River Basin goal from The Minnesota Nutrient Reduction Strategy [MPCA 2014b])	Achieve any additional needed reductions identified through international join efforts with Canada and in-state water quality standards (The Minnesota Nutrient Strategy [MPCA 2014b])	See Sediment Reduction Strategies	Reducing erosion and sediment loading will generally also result in reduced phosphorus loading
				Add cover crops for living cover in fall/spring	Cover Crops with Corn & Soybeans [340]
					Cover crops after early-harvest crops [340]
				Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
				Buffers and filters, field edge	Riparian Buffers, 50+ ft wide (replacing pasture) [390, 391, 327]
				Changing rotations to less erosive crops	Conservation Crop Rotation - adding small grains [328]
				Converting land to perennials	Conservation Cover Perennials [327, 327M, 342, 612]
					Perennial crops for regular harvest
				Designed erosion control and trapping	Water and Sediment Control Basin (cropland) [638]
				Maintain existing perennial cover	Maintain CRP lands in beach ridge areas
					Maintain aspen parkland and oak savannah on top of beach ridge areas
					Protect native prairie lands identified under the National Tallgrass Prairie Project
					Protect riparian wetlands and perennial vegetation within the meander belt width of streams
				Nutrient management (cropland)	Precision Nutrient Timing & Management (beyond 590 standard)
					Nutrient Management (fertilizer, soil, manure) [590]
					Green manure (cover crops incorporated into the fields instead of chemical
					Manure/fertilizer incorporation (within 24 hrs)
				Open tile inlet and side inlet improvements	Side inlet improvement [410]
				Pasture management	Livestock access control [472]
				Septic system improvements	Septic System Improvement [126M]
				Streambanks, bluffs, and ravines protected/restored	Stream Channel Stabilization [584]
					Restore floodplain access for sediment and nutrient reductions
				Tillage/residue management	Conservation tillage - >30% residue cover [345, 346, 329B]
				Urban Stormwater runoff control	Bioretention/Biofiltration (urban) [712M]
					Constructed Stormwater Pond (urban) [155M]
					Improved lawn/turf vegetation & soil practices
					Infiltration Basin (urban) [803M]
				Wastewater Point Source Management	Wastewater phosphorus reductions to meet TMDL & permit conditions
Nitrogen/nitrate	n/a	13% reduction (Red River Basin goal from The Minnesota Nutrient Reduction Strategy [MPCA 2014b])	Achieve any additional needed reductions identified through international join efforts with Canada and in-state water quality standards (The Minnesota Nutrient Reduction Strategy [MPCA 2014b])	Add cover crops for living cover in fall/spring	Cover crops after early-harvest crops [340]
				Agricultural tile drainage water treatment/storage	Controlled tile drainage water management [554]
					Wetland Restoration or Creation for treatment [657, 658]
				Buffers and filters, field edge	Riparian Buffers, 50+ ft (perennials replace tilled) [390, 391, 327]
				Changing rotations to less erosive crops	Conservation Crop Rotation - adding small grains [328]
				Converting land to perennials	Convert cultivated land to cover crops
					Perennial crops for regular harvest
				Maintain existing perennial cover	Maintain CRP lands in beach ridge areas
					Maintain aspen parkland and oak savannah on top of beach ridge areas
					Protect native prairie lands identified under the National Tallgrass Prairie Project
					Protect riparian wetlands and perennial vegetation within the meander belt width of streams

Pollutant/Stressor	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Nitrogen/nitrate strategies continued from previous page				Nutrient management (cropland)	Apply manure and incorporate into soil ASAP, vs. winter application or leaving on top of soil (runoff hazard)
					Green manure (cover crops incorporated into the fields instead of chemical
					Nutrient Management (fertilizer, soil, manure) [590]
				Streambanks, bluffs, and ravines protected/restored	Restore floodplain access for sediment and nutrient reductions
Dissolved Oxygen	n/a	n/a	n/a	See Nutrient Reduction Strategies	Achieving nutrient reduction strategies will help to address low DO throughout the watershed
				Buffers and filters, field edge	Riparian Buffers, 16+ ft (perennials replace tilled) [390, 391, 327]
					Riparian Buffers, 50+ ft (perennials replace tilled) [390, 391, 327]
				Habitat and stream connectivity management	Restore riffle substrate
				Mitigating flow extremes (high or low)	Increase Base Flows
Altered Hydrology	n/a	n/a	n/a	Agricultural tile drainage water treatment/storage	Controlled tile drainage water management [554]
					Wetland Restoration or Creation for treatment [657, 658]
				Changing rotations to less erosive crops	Conservation Crop Rotation - add more perennials [328]
				Drainage ditch modifications	Two stage ditch - open channel [582]
				Buffers and filters, field edge	Riparian Buffers, 16+ ft (perennials replace tilled) [390, 391, 327]
					Riparian Buffers, 50+ ft (perennials replace tilled) [390, 391, 327]
				Open tile inlet and side inlet improvements	Side inlet improvement [410]
				Maintain existing perennial cover	Maintain CRP lands in beach ridge areas
					Maintain aspen parkland and oak savannah on top of beach ridge areas
					Protect native prairie lands identified under the National Tallgrass Prairie Project
					Protect riparian wetlands and perennial vegetation within the meander belt width of streams
				Mitigating flow extremes (high or low)	Increase Base Flows
					Modify culvert sizing
					Reduce Flashiness of Flows
					Small to larger off-channel impoundment dikes
				Streambanks, bluffs and ravines protected/restored	Maintain or restore floodplain connectivity
					Protect nonchannelized reaches from alteration
					Re-meander channelized stream reaches [582]
					Stream restoration using principles such as Natural Channel Design
					Streambanks/shoreline - stabilized or restored [580]
				Tillage/residue management	Conservation tillage - >30% residue cover [345, 346, 329B]
				Urban Stormwater runoff control	Constructed Stormwater Pond (urban) [155M]
Habitat/connectivity	n/a	n/a	n/a	See Altered Hydrology Strategies	Addressing altered hydrology will generally yield aquatic habitat improvements
				Buffers and filters, field edge	Riparian Buffers, 16+ ft (perennials replace tilled) [390, 391, 327]
					Riparian Buffers, 50+ ft (perennials replace tilled) [390, 391, 327]
				Habitat and stream connectivity management	Actively manage vegetation on public and private conservation
					Culvert replacement
					Maintain existing CRP acreage
					Modify/replace dams, culverts & fish passage barriers
					Protect Shallow Lake and Native Plant Communities

Pollutant/Stressor	**Current WQ Conditions** (conc. & load as related to impairment)	**10-year Interim WQ Milestone (2030)** (% and load to reduce)	**Long-term WQ Goal** (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Habitat/connectivity strategies continued from previous page				Habitat and stream connectivity management (continued)	Riparian herbaceous cover [390]
					Riparian tree planting to improve shading [390, 612]
					Stream restoration (go to strategy "Streambanks, bluffs & ravines protected/restored")
				Maintain existing perennial cover	Maintain CRP lands in beach ridge areas
					Maintain aspen parkland and oak savannah on top of beach ridge areas
					Protect native prairie lands identified under the National Tallgrass Prairie Project
					Protect riparian wetlands and perennial vegetation within the meander belt width of streams
				Open tile inlet and side inlet improvements	Side inlet improvement [410]
				Streambanks, bluffs and ravines protected/restored	Buffers and perennial vegetation established in channel and along corridor
					Channel excavations are only allowed for sloughing banks, no more channel realignments allowed
					Culverts/Bridges are properly sizes per drainage area (not over wide, not undersized) and properly placed
					Incision and straightening naturally occurring should be restored
					Large debris jams and piled up trees causing stability issues (may not be a major issue but is part of the evolutional process)
					Lateral floodplain connectivity is maintained or restored
					Natural channel design is utilized on all restoration projects to ensure that natural river system processes are maintained or restored
					Protect native plant communities and key habitats
					Protect nonchannelized reaches from alteration
					Re-meandering of channelized river reaches (where channels have been ditched and old channels are still there)
					Reconnect channels with floodplain
					Remove dams and all illegal or undersized crossings (or redesign)
					Restore riffle substrate
					Riffles or grade control structures are in place to prevent channel bottom degradation and bank sloughing
					Riparian herbaceous cover [390]
					Sloughing banks are taken into consideration with ditch projects and are sloped back to stable side slopes (4:1 or 5:1).
					Stream restoration using principles such as Natural Channel Design
					Streambank restoration practices, may of the streams are incised and or entrenched
Bacteria/*E. coli*	n/a	n/a	n/a	Feedlot runoff controls	Apply manure and incorporate into soil ASAP, vs. winter application or leaving on top of soil (runoff hazard)
					Feedlot runoff reduction/treatment [635, 784]
					Feedlot manure/runoff storage addition [313, 784]
				Nutrient management (cropland)	Manure/fertilizer incorporation (within 24 hrs)
					Nutrient Management (fertilizer, soil, manure) [590]
					Precision Nutrient Timing & Management (beyond 590 standard)
					Green manure (cover crops incorporated into the fields instead of chemical)
					Nutrient Management (fertilizer, soil, manure) [590]
				Pasture management	Livestock access control [472]
				Septic system improvements	Septic System Improvement [126M]
				Urban stormwater runoff control	Animal waste control

Figure 16: Middle River HUC-10 Subwatershed land cover and priority streams.



The format of Table 21 has been modified to reflect the fact that all strategies presented in this table apply only to the Middle River HUC-10.

Table 21: Strategies and actions proposed for the Middle River HUC-10 Subwatershed (0902030902).

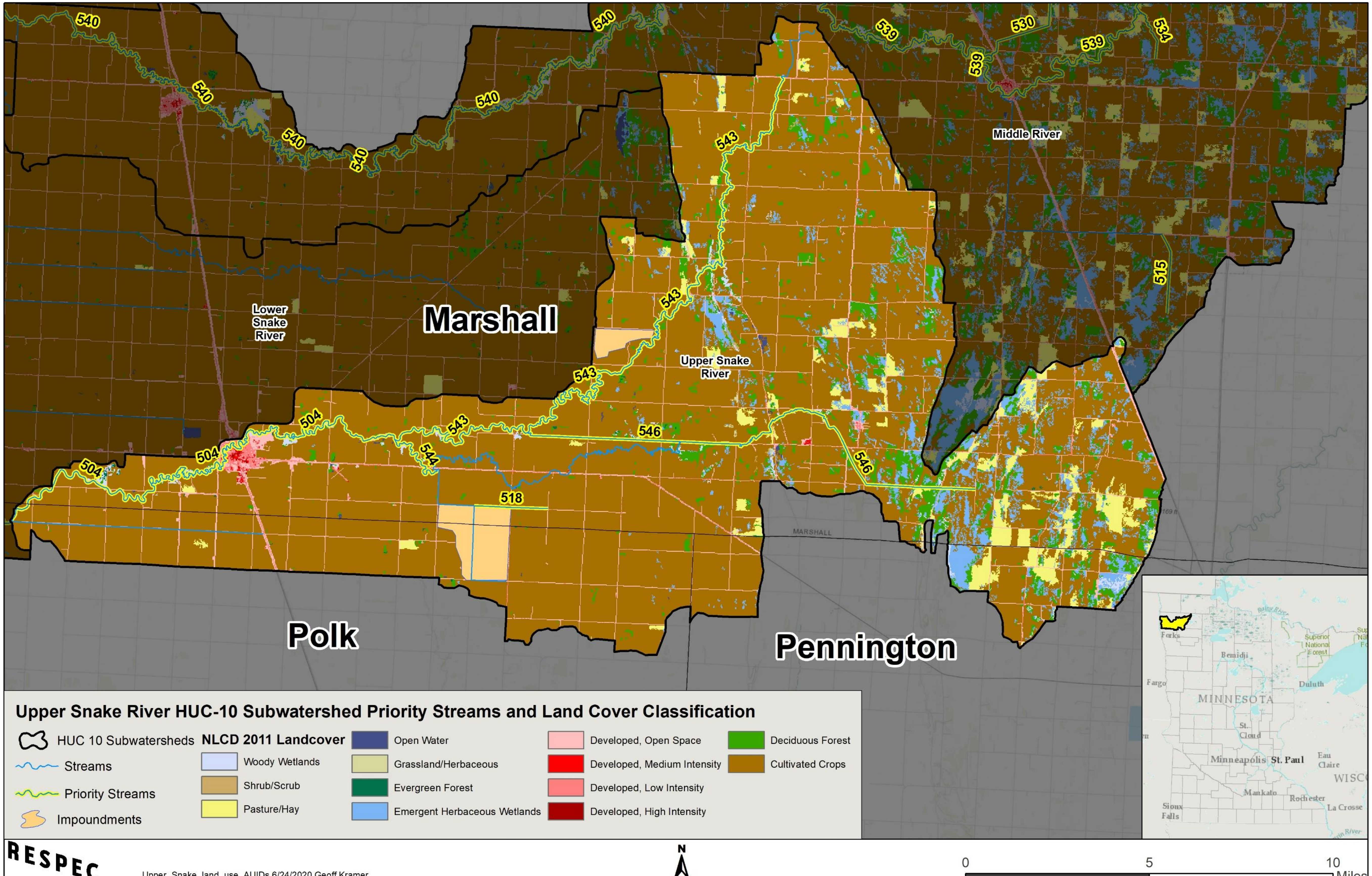
Waterbody (ID)	Description	Pollutant/Stressor (candidate causes)	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Unnamed creek (09020309-534)	Unnamed ditch to Middle R	Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD025: 66 Station ID: MIBI Score 13RD025: 43	Maintain or improve current scores (standard is 42 for FIBI and 37 for MIBI)	Maintain or improve current scores (standard is 42 for FIBI and 37 for MIBI)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
County Ditch 15 Branch [a] (09020309-515)	Headwaters to CD 15	Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 05RD020: 38 Station ID: MIBI Score 05RD020: 29	Maintain or improve current scores (standard is 23 for FIBI and 22 for MIBI)	Maintain or improve current scores (standard is 23 for FIBI and 22 for MIBI)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Judicial Ditch 21 (09020309-530)	380th Street to Middle R	Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD023: 60 Station ID: MIBI Score 13RD023: 36	Maintain or improve current FIBI score, improve current MIBI score (standard is 42 for FIBI and 37 for MIBI)	Maintain or improve current FIBI score, improve current MIBI score (standard is 42 for FIBI and 37 for MIBI)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Judicial Ditch 28 [a] (09020309-529)	Unnamed ditch to Middle R	Macroinvertebrate IBI (DO, TSS, altered hydrology, habitat)	Station ID: MIBI Score 13RD027: 13	Station ID: MIBI Score 13RD027: 14.3	Station ID: MIBI Score 13RD027: 24	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
		Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD027: 59	Maintain or improve current score (standard is 23)	Maintain or improve current score (standard is 23)	Address stressors causing macroinvertebrate IBI impairment	See macroinvertebrate IBI strategies for this reach
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
Middle River (09020309-538)	Headwaters to -96.171 48.4349	Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD026: 39 (While the score meets the standard of 15, the reach was still listed as impaired due to a low # of fish sampled, poor habitat, choking vegetation, and low DO)	Station ID: FIBI Score 13RD026: maintain or increase current score and improve stressor conditions	Station ID: FIBI Score 13RD026: standard is 15, maintain or increase current score and eliminate stressors	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

Waterbody (ID)	Description	**Pollutant/Stressor** (candidate causes)	**Current WQ Conditions** (conc. & load as related to impairment)	**10-year Interim WQ Milestone (2030)** (% and load to reduce)	**Long-term WQ Goal** (% and load to reduce)	**Strategy Type**	**EXAMPLE Best Management Practice (BMP)**
Middle River (090203090-539)	-96.171 48.4349 to Co Rd 114 Bridge	DO	1.23 mg/L (daily minimum)	1.35 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		TSS and associated TP loading from incised channel	n/a	n/a	n/a	Reduce TSS and associated loading and resulting effects on in-stream habitat	See TSS reduction strategies in HUC-8 table
							See TP reduction strategies in HUC-8 table
							See habitat/connectivity strategies in HUC-8 table
		Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	<u>Station ID: FIBI Score</u> 13RD103: 65 13RD002: 52 13RD100: 55, 47 <u>Station ID: MIBI Score</u> 05RD095: 46 13RD002: 41 13RD100: 47, 37	Maintain or improve current scores (standard for FIBI is 42 at 13RD103 and 47 at the other 2; standard for MIBI is 41 at 05RD095 and 37 at the other 2)	Maintain or improve current scores (standard for FIBI is 42 at 13RD103 and 47 at the other 2; standard for MIBI is 41 at 05RD095 and 37 at the other 2)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Middle River (09020309-540)	Co Rd 114 to T156 R49W S3, north line	Dissolved Oxygen	3.02 mg/L (daily minimum)	3.32 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		Macroinvertebrate IBI (DO, TSS, altered hydrology, habitat)	<u>Station ID: MIBI Score</u> 05RD014: 60 13RD022: 22, 30 13RD079: 26 13RD098: 36 93RD417: 54, 56	<u>Station ID(s): MIBI Score</u> 13RD022, 13RD079: 33 13RD098: 37 05RD014, 93RD417: maintain or increase current scores	<u>Station IDs: MIBI Score</u> 13RD022, 13RD079, 13RD098: 37 05RD014, 93RD417: standard is 41, maintain or increase current scores	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TSS and associated loading and resulting effects on in-stream habitat	See TSS reduction strategies in HUC-8 table
							See TP reduction strategies in HUC-8 table
							See habitat/connectivity strategies in HUC-8 table
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

Waterbody (ID)	Description	**Pollutant/Stressor** (candidate causes)	**Current WQ Conditions** (conc. & load as related to impairment)	**10-year Interim WQ Milestone (2030)** (% and load to reduce)	**Long-term WQ Goal** (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Middle River (09020309-540) (continued)	Co Rd 114 to T156 R49W S3, north line (continued)	Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 05RD014: 55 13RD022: 49, 54 13RD079: 56 13RD098: 62 93RD417: 50	Maintain or improve current scores (standard is 47 at 05RD014 and 13RD022, 50 at the other 3)	Maintain or improve current scores (standard is 47 at 05RD014 and 13RD022, 50 at the other 3)	Address stressors causing macroinvertebrate IBI impairment	See macroinvertebrate IBI strategies for this reach
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
Middle River (09020309-540 & 09020309-541)	Co Rd 114 to Snake R	Sediment/TSS	60.0 tons/day (HSPF)	54 tons/day	14.4 tons/day (76% reduction per TMDL)	Reduce TSS loading	See TSS reduction strategies in HUC-8 table
Middle River (09020309-541)	T157 R49W S34, south line to Snake R	DO	2.79 mg/L (daily minimum)	3.07 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD008: 54	Maintain or improve current score (standard is 35)	Maintain or improve current score (standard is 35)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Figure 17: Upper Snake River HUC-10 Subwatershed land cover and priority streams.



The format of Table 22 has been modified to reflect the fact that all strategies presented in this table apply only to the Upper Snake River HUC-10.

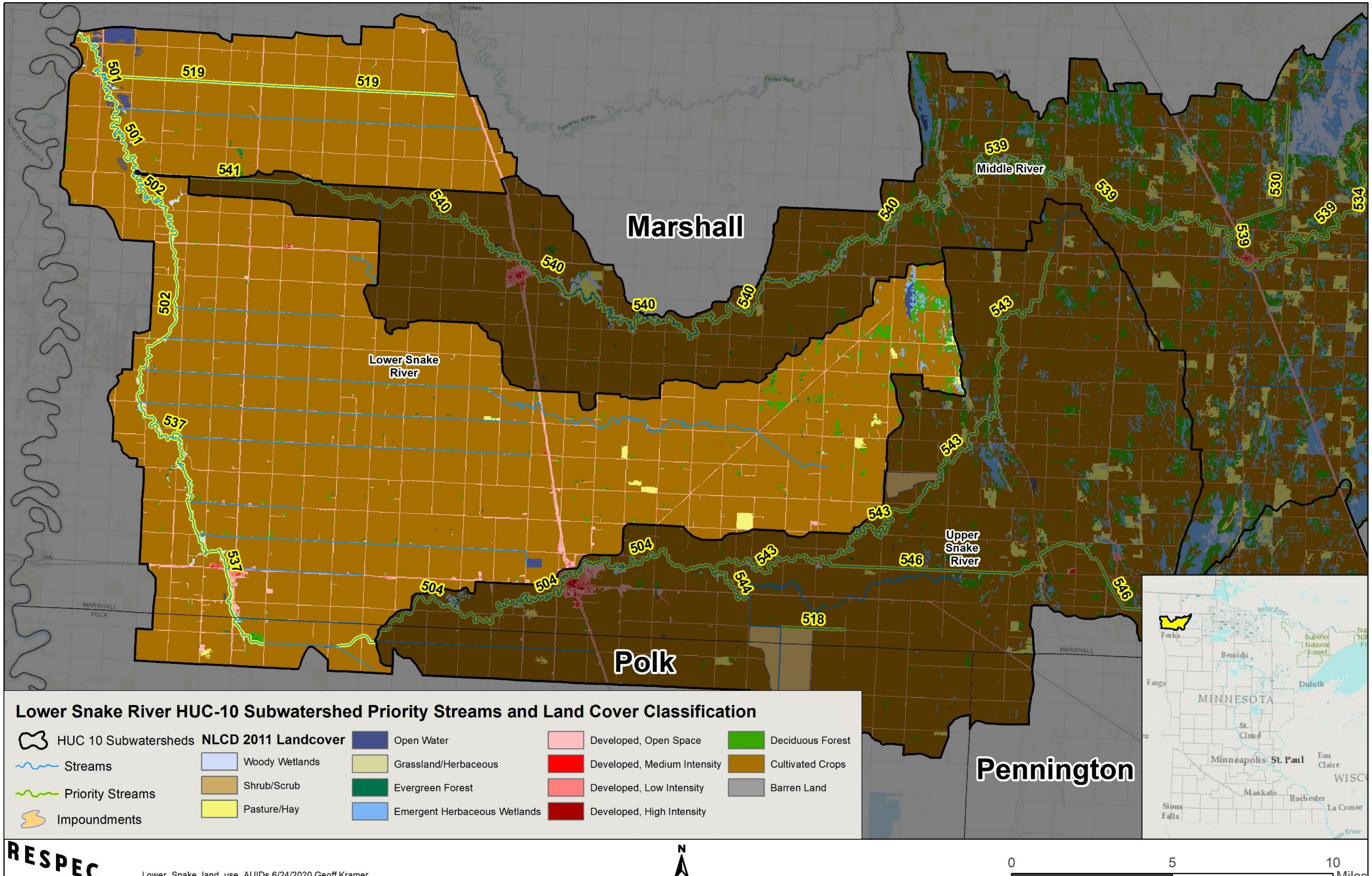
Table 22: Strategies and actions proposed for the Upper Snake River HUC-10 Subwatershed (0902030901).

Waterbody (ID)	**Description**	**Pollutant/Stressor** (candidate causes)	**Current WQ Conditions** (conc. & load as related to impairment)	**10-year Interim WQ Milestone (2030)** (% and load to reduce)	**Long-term WQ Goal** (% and load to reduce)	**Strategy Type**	**EXAMPLE Best Management Practice (BMP)**
Judicial Ditch 25-1 [a] (09020309-518)	Unnamed ditch to unnamed ditch	Macroinvertebrate IBI (DO, TSS, altered hydrology, habitat)	Station ID: MIBI Score 05RD011: 24	Maintain or improve current score (standard is 22)	Maintain or improve current score (standard is 22)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Snake River, South Branch (new channel) (09020309-546)	Headwaters to Snake R	Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score(s) 13RD034: 37 13RD099: 31, 37 13RD105: 23 13RD106: 43	Station ID(s): FIBI Score 13RD034, 13RD099: 38.5 13RD105: 33.6 13RD106: maintain or increase current score	Station ID(s): FIBI Score 13RD034, 13RD105: 42 13RD099: 47 13RD106: standard is 42, maintain or increase current score	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
		Macroinvertebrate IBI (DO, TSS, altered hydrology, habitat)	Station ID: MIBI Score 13RD034: 51 13RD106: 47 13RD099: 33	Maintain or improve current scores at first 2 stations, improve score at third station (standard is 37)	Maintain or improve current scores at first 2 stations, improve score at third station (standard is 37)	Address stressors causing fish IBI impairment	See fish IBI strategies for this reach
Snake River, South Branch (old channel) (09020309-544)	JD 25-1 [a] to Snake R	Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD035: 28 Station ID: MIBI Score 13RD035: 15	Station ID: FIBI Score 13RD035: 30.8 Station ID: MIBI Score 13RD035: 16.5	Station ID: FIBI Score 13RD035: 42 Station ID: MIBI Score 13RD035: 37	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Snake River (09020309-543)	Unnamed Cr to S Br Snake R	Bacteria/*E. coli*	Seasonal geomean 51.7 - 276.7 org/100mL	n/a	Seasonal geomean < 126 org/100mL	Reduce bacteria/*E. coli* load	See bacteria/*E. coli* strategies in HUC-8 table
						Monitoring	Increase monitoring to determine likely sources
		DO	2.81 mg/L (daily minimum)	3.09 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table

Waterbody (ID)	Description	Pollutant/Stressor (candidate causes)	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Snake River (09020309-543) (continued)	Unnamed Cr to S Br Snake R (continued)	Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Scores 13RD036: 26, 29 13RD104: 23, 25 Station ID: MIBI Score 13RD036: 42 13RD104: 13	Station IDs: FIBI Score 13RD036, 13RD104: 29.2 Station ID: MIBI Score 13RD036: maintain or increase current score 13RD104: 15.4	Station IDs: FIBI Score 13RD036, 13RD104: 47 Station ID: MIBI Score 13RD036: standard is 37, maintain or increase current score 13RD104: 37	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Snake River (09020309-504)	S Br Snake R to CD 7	Bacteria/*E. coli*	Seasonal geomean 69 - 134.1 org/100mL	n/a	Seasonal geomean < 126 org/100mL	Reduce bacteria/*E. coli* load	See bacteria/*E. coli* strategies in HUC-8 table
						Monitoring	Increase monitoring to determine likely sources
		Sediment/TSS	28.07 tons/day (HSPF)	25.26 tons/day	14.04 tons/day (50% reduction per TMDL)	Reduce TSS loading	See TSS reduction strategies in HUC-8 table
		Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 05RD175: 48 13RD004: 1 13RD108: 33 93RD416: 28 Station ID: MIBI Score 04RD002: 29 05RD175: 16 13RD004: 58 13RD108: 20 93RD416: 37	Station ID: FIBI Score 05RD175: 50 13RD004, 13RD108, 93RD416: 30.8 Station ID: MIBI Score 04RD002: 31.9 05RD175: 17.6 13RD004: maintain or increase current score 13RD108: 22 93RD416: 40.7	Station ID(s): FIBI Score 05RD175, 13RD004, 13RD108, 93RD416: 50 Station ID(S): MIBI Score 04RD002, 05RD175, 93RD416: 41 13RD004: standard is 41, maintain or increase current score 13RD108: 37	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

[a] Note that while MPCA's name for this waterbody is "Unnamed ditch", it was changed to represent the local name.

Figure 18: Lower Snake River HUC-10 Subwatershed land cover and priority streams.



The format of Table 23 has been modified to reflect the fact that all strategies presented in this table apply only to the Lower Snake River HUC-10.

Table 23: Strategies and actions proposed for the Lower Snake River HUC-10 Subwatershed (0902030903).

Waterbody (ID)	Description	Pollutant/Stressor (candidate causes)	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Judicial Ditch 29 (09020309-519)	Headwaters to Snake R	Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD010: 0	n/a	Station ID: FIBI Score 13RD010: 55	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Snake River (09020309-537)	T154 R49W S17, east line to CD 3	Bacteria/*E. coli*	Seasonal geomean 67.6 - 214.8 org/100mL	n/a	Seasonal geomean < 126 org/100mL	Reduce bacteria/*E. coli* load	See bacteria/*E. coli* strategies in HUC-8 table
						Monitoring	Increase monitoring to determine likely sources
		DO	1.24 mg/L (daily minimum)	1.36 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD006: 26 13RD080: 46 94RD511: 26 Station ID: MIBI Score 13RD006: 8 13RD080: 19 94RD511: 57	Station ID(s): FIBI Score 13RD006, 94RD511: 29.7 13RD080: 49 Station ID(s): MIBI Score 13RD006: 8.8 13RD080: 20.9 94RD511: maintain or increase current score	Station ID(s): FIBI Score 13RD006, 94RD511: 50 13RD080: 49 Station ID(s): MIBI Score 13RD006, 13RD080: 41 94RD511: standard is 41, maintain or increase current score	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

Waterbody (ID)	Description	Pollutant/Stressor (candidate causes)	Current WQ Conditions (conc. & load as related to impairment)	10-year Interim WQ Milestone (2030) (% and load to reduce)	Long-term WQ Goal (% and load to reduce)	Strategy Type	EXAMPLE Best Management Practice (BMP)
Snake River (09020309-502)	CD 3 to Middle R	Sediment/TSS	80.6 tons/day (HSPF)	72.54 tons/day	12.90 tons/day (84% reduction per TMDL)	Reduce TSS loading	See TSS reduction strategies in HUC-8 table
		DO	2.22 mg/L (daily minimum)	2.44 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		Fish IBI & Macroinvertebrate IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD007: 20 Station ID: MIBI Score 13RD007: 30	Station ID: FIBI Score 13RD007: 22 Station ID: MIBI Score 13RD007: 33	Station ID: FIBI Score 13RD007: 49 Station ID: MIBI Score 13RD007: 41	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table
Snake River (09020309-501)	Middle R to Red R	Sediment/TSS	197.17 tons/day (HSPF)	177.45 tons/day	13.80 tons/day (93% reduction per TMDL)	Reduce TSS loading	See TSS reduction strategies in HUC-8 table
		DO	0.85 mg/L (daily minimum)	0.94 mg/L (daily minimum)	> 5 mg/L (daily minimum)	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Reduce TP loading	See TP reduction strategies in HUC-8 table
						Reduce TN loading	See TN reduction strategies in HUC-8 table
						Increase baseflows	See altered hydrology strategies in HUC-8 table
						Decrease high flows	See altered hydrology strategies in HUC-8 table
						Improve channel function, geometry, and bed material	See habitat/connectivity strategies in HUC-8 table
						Stabilize streambanks and increase riparian vegetative cover	See habitat/connectivity strategies in HUC-8 table
		Fish IBI (DO, TSS, fish passage, altered hydrology, and habitat)	Station ID: FIBI Score 13RD009: 44	Station ID: FIBI Score 13RD009: 49	Station ID: FIBI Score 13RD009: 49	Increase DO levels	See DO strategies in HUC-8 table
						Reduce TSS loading	See TSS reduction strategies in HUC-8 table
						Fish passage	Evaluate fish passage as a possible stressor driving low FIBI score (SID report found that the available evidence neither supports or weakens the case for fish passage as a cause of fish IBI impairment)
						Reduce effects of altered hydrology	See altered hydrology strategies in HUC-8 table
						Habitat and stream connectivity	See habitat/connectivity strategies in HUC-8 table

4. Monitoring plan

IWM conducted in 2014-2015 helped establish the conditions of waterbodies in the SMRW, and future monitoring will help determine the effectiveness of implementation efforts and changes in waterbody conditions. Future monitoring efforts are subject to resources availability and priorities.

The intent of the implementing organizations (e.g., watershed district, SWCDs, counties, cities) in this watershed is to make steady progress in terms of pollutant reduction. As a very general guideline, progress benchmarks are accordingly established for this watershed that assume 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 stream reach with a long-term growing season TSS concentration of 90 milligrams per liter (mg/L), by year 10 the TSS concentration would be 90 – (10 * 0.9) = 81 mg/L. This guideline is general. Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., unstable bluffs and ravines, invasive species) and unfavorable climatic factors. Conversely, some impaired waters may have faster progress, especially where high-impact fixes occur.

Several monitoring recommendations were identified in the *Snake River Watershed Monitoring Plan* (RESPEC 2015):

1. Monitoring should be carried out with the long-term goal of reducing peak runoff and soil erosion in mind for evaluation;
2. Continuing four continuous-flow gaging stations should be a high priority for tracking long-term performance of flood reduction measures and conservation practices to reduce sediment and phosphorus losses. Other recommendations included:
    a. Restart continuous flow monitoring on the Snake River near Radium;
    b. Install a continuous flow gage below the confluence of the Snake and Middle Rivers; and
    c. Pursue year-round monitoring at key sites.
3. Closely tracking annual and seasonal weather patterns is recommended with increasing emphasis on defining snowmelt, wet and dry periods, and aspects that will help the agricultural community's competitiveness and better address water quality issues.
4. Increase monitoring to guide improvements of stream habitat and biology. Reducing peak runoff and increasing base flows will be beneficial for river biology.
5. Continue to advance remedial actions as possible within the watershed. As feasible, smaller scale project performance can be tracked with paired watershed or time series monitoring.

Data from three state monitoring programs overseen by the MPCA will continue to be collected and analyzed for the SMRW based on the current strategy in *Minnesota's Water Quality Monitoring Strategy 2011 to 2021* (MPCA 2011). These monitoring programs are summarized below:

1. Through the IWM approach, chemistry and biological data are collected throughout each major watershed for 2 years once every 10 years. (See *Watershed Approach to Restoring and Protecting Water Quality* [MPCA 2019c]). This work is scheduled for its second iteration in the SMRW in 2024. These data provide a periodic but intensive snapshot of water quality throughout the watershed. In

addition to the monitoring conducted in association with this process, other watershed partner organizations (e.g., local, state, federal) within the watershed may have their own monitoring activities. All of the data collected locally should be submitted regularly to the MPCA for entry into the EQuIS database system for ultimate use in water quality assessments.

2. The *Watershed Pollutant Load Monitoring Network* (MPCA 2019d) intensively collects pollutant samples and flow data to calculate sediment and nutrient loads on either an annual or seasonal (no-ice) basis. In the SMRW, two subwatersheds and one major watershed (i.e., HUC-8) pollutant load monitoring sites exist. The two subwatershed sites are the Middle River at Argyle, Minnesota (S000-700 [DNR 2020]), and the Snake River upstream of Warren, Minnesota (USGS 05085450 [USGS 2020]). The HUC-8 Site H68011001 is located three river miles before the Snake River's confluence with the Red River of the North at the bridge where MN 220 crosses the Snake River.

3. The *Citizen Surface Water Monitoring Program* (MPCA 2020a) is a network of volunteers who make monthly lake and river transparency readings. One data collection location exists within the SMRW (station S001-598: Swift Coulee, 4.5 miles southwest of Argyle). These data provide a record of intra- and inter-year transparency trends.

4. In addition to the monitoring conducted in association with the processes noted above, other monitoring programs exist where data have been and will continue to be collected periodically on surface-water resources within or associated with this watershed. The programs include the following:

    a. Minnesota's Fish Contaminant Monitoring Program (MPCA 2008) helps support human health and environmental protection programs within Minnesota by providing information on fish consumption, mercury cycling/trends, and analyzing potential newly identified bioaccumulative pollutants.

    b. *Wetland Monitoring And Assessment* (MPCA 2019b) – Wetlands are an integral part of Minnesota's water resources, and wetland monitoring information will be an essential component in implementing efforts to protect and restore lakes and streams.

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Appendix A: TMDL Load Allocation Tables

E.coli TMDLs

Table 24. Snake River Reach 543 *E. coli* TMDL Summary

09020309-543		Flow Zone				
***E. coli* TMDL Component (organisms/day)**		**Very High**	**High**	**Mid**	**Low**	**Very Low**
Total Daily Loading Capacity		9.75E+11	2.29E+11	5.94E+10	1.11E+10	1.13E+09
Margin of Safety		9.75E+10	2.29E+10	5.94E+09	1.11E+09	1.13E+08
Wasteload Allocations	Permitted Wastewater Dischargers	–	–	–	–	–
	Industrial and Construction Stormwater	–	–	–	–	–
Load Allocation		8.77E+11	2.06E+11	5.35E+10	9.99E+09	1.02E+09
Total Current Load		6.65E+11	1.57E+11	2.48E+10	1.01E+10	(a)
Reduction Required		0%	0%	0%	0%	(a)

(a) No data available to calculate current load.

Table 25. Snake River Reach 537 *E. coli* TMDL Summary

09020309-537		Flow Zone				
***E. coli* TMDL Component (organisms/day)**		**Very High**	**High**	**Mid**	**Low**	**Very Low**
Allowable Loading at Pourpoint		2.28E+12	5.73E+11	1.96E+11	4.89E+10	6.92E+09
Boundary Condition (BC) Allowable Loading (Reach 504)		1.44E+12	3.96E+11	1.39E+11	3.57E+10	5.17E+09
Total Daily Loading Capacity (Adjusted for BC)		8.43E+11	1.78E+11	5.76E+10	1.32E+10	1.74E+09
Margin of Safety		8.43E+10	1.78E+10	5.76E+09	1.32E+09	1.74E+08
Wasteload Allocations	Permitted Wastewater Dischargers	2.59E+10	2.59E+10	2.59E+10	*	*
	Industrial and Construction Stormwater	–	–	–	–	–
Load Allocation		7.33E+11	1.34E+11	2.59E+10	1.19E+10	1.57E+09
Current Load at Pourpoint		4.16E+12	2.59E+11	1.22E+11	6.01E+10	1.18E+10
Current BC Load (Reach 504)		9.56E+11	4.27E+11	6.56E+10	3.47E+10	1.26E+09
Current Load (Adjusted for BC)		3.21E+12	0.00E+00	5.63E+10	2.54E+10	1.05E+10
Reduction Required		74%	0%	0%	48%	83%

Note: The wasteload allocations (WLAs) for the permitted wastewater dischargers are based on facility design flow. The WLA exceeded the low-flow regime total daily loading capacity and is denoted in the table by a “*”. For this flow regime, the WLA and nonpoint-source load allocation is determined by the following formula:

Allocation = (flow contribution from a given source) × (*E. coli* concentration limit or standard) × conversion factor.

Table 26. Snake River Reach 504 *E. coli* TMDL Summary

09020309-504		Flow Zone				
E. coli TMDL Component (organisms/day)		Very High	High	Mid	Low	Very Low
Allowable Loading at Pourpoint		1.44E+12	3.96E+11	1.39E+11	3.57E+10	5.17E+09
BC Allowable Loading (Reach 543)		9.75E+11	2.29E+11	5.94E+10	1.11E+10	1.13E+09
Total Daily Loading Capacity (Adjusted for BC)		4.61E+11	1.67E+11	7.93E+10	2.46E+10	4.04E+09
Margin of Safety		4.61E+10	1.67E+10	7.93E+09	2.46E+09	4.04E+08
Wasteload Allocations	Viking WWTF	1.17E+09	1.17E+09	1.17E+09	1.17E+09	1.17E+09
	Industrial and Construction Stormwater	–	–	–	–	–
Load Allocation		4.14E+11	1.49E+11	7.02E+10	2.10E+10	2.47E+09
Current Load at Pourpoint		9.56E+11	4.27E+11	6.56E+10	3.47E+10	1.26E+09
Current BC Load (Reach 543)		6.65E+11	1.57E+11	2.48E+10	1.01E+10	(a)
Current Load (Adjusted for BC)		2.91E+11	2.71E+11	4.08E+10	2.46E+10	(a)
Reduction Required		0%	38%	0%	0%	(a)

(a) No data available to calculate adjusted current load.

WWTF = wastewater treatment facility.

TSS TMDLs

Table 27. Middle River Reaches 540 and 541 Combined TSS TMDL Summary

09020309-540 and 541 Combined		Flow Zone				
TSS TMDL Component (U.S. tons/day)		Very High	High	Mid	Low	Very Low
Total Daily Loading Capacity		138.4	35.24	10.42	2.103	0.3054
Margin of Safety		13.84	3.524	1.042	0.2103	0.0305
Wasteload Allocations	Permitted Wastewater Dischargers	2.083	2.083	2.083	*	*
	Industrial/Construction	0.0872	0.0222	0.0066	0.0013	0.0002
Load Allocation		122.4	29.61	7.29	1.891	0.2747
Total Current Load		737.0	73.35	21.13	4.435	0.1511
Reduction Required		81%	52%	51%	53%	0%
Overall Reduction Required		76%				

Table 28. Snake River Reach 504 TSS TMDL Summary

09020309-504		Flow Zone				
TSS TMDL Component (U.S. tons/day)		Very High	High	Mid	Low	Very Low
Total Daily Loading Capacity		86.49	25.00	8.935	2.217	0.2613
Margin of Safety		8.649	2.500	0.8935	0.2217	0.0261
Wasteload Allocations	Viking WWTF	0.0459	0.0459	0.0459	0.0459	0.0459
	Industrial/Construction	0.0545	0.0158	0.0056	0.0014	0.0002
Load Allocation		77.74	22.44	7.990	1.948	0.1891
Total Current Load		349.9	32.39	14.74	1.969	0.0204
Reduction Required		75%	23%	39%	0%	0%
Overall Reduction Required		50%				

Table 29. Snake River Reach 502 TSS TMDL Summary

09020309-502		Flow Zone				
TSS TMDL Component (U.S. tons/day)		Very High	High	Mid	Low	Very Low
Allowable Loading at Pourpoint		176.3	45.60	16.14	3.560	0.4216
Boundary Condition (BC) Allowable Loading (Reach 504)		86.49	25.00	8.935	2.217	0.2613
Total Daily Loading Capacity (Adjusted for BC)		89.81	20.60	7.205	1.343	0.1603
Margin of Safety		8.981	2.060	0.7205	0.1343	0.0160
Wasteload Allocations	Permitted Wastewater Dischargers	1.021	1.021	1.021	1.021	*
	Industrial/Construction	0.0566	0.013	0.0045	0.0008	0.0001
Load Allocation		79.75	17.51	5.459	0.1869	0.1442
Current Load at Pourpoint		981.9	156.0	67.21	11.07	0.0843
Current BC Load (Reach 504)		349.9	32.39	14.74	1.969	0.0204
Current Load (Adjusted for BC)		632.0	123.6	52.47	9.101	0.0639
Reduction Required		86%	83%	86%	85%	0%
Overall Reduction Required		84%				

Note: The WLA for the permitted wastewater dischargers are based on facility design flow. The WLA exceeded the low-flow regime total daily loading capacity and is denoted in the table by a "*". For this flow regime, the WLA and nonpoint-source LA is determined by the following formula:

Allocation = (flow contribution from a given source) × (TSS concentration limit or standard) × conversion factor.

Table 30. Snake River Reach 501 TSS TMDL Summary

09020309-501		Flow Zone				
TSS TMDL Component (U.S. tons/day)		Very High	High	Mid	Low	Very Low
Allowable Loading at Pourpoint		328.7	86.86	29.64	6.400	0.9300
Boundary Condition (BC) Allowable Loading (Reach 502)		176.3	45.60	16.14	3.560	0.4216
BC Allowable Loading (Reach 541)		138.4	35.24	10.42	2.103	0.3054
Total Daily Loading Capacity (Adjusted for BC)		14.03	6.017	3.080	0.7369	0.2013
Margin of Safety		1.403	0.6017	0.3080	0.0737	0.0201
Wasteload Allocations	Permitted Wastewater Dischargers	–	–	–	–	–
	Industrial/Construction	0.0088	0.0038	0.0019	0.0005	0.0001
Load Allocation		12.62	5.411	2.770	0.6627	0.1811
Current Load at Pourpoint		2285	306.5	115.7	18.79	0.2364
Current BC Load (Reach 502)		981.9	156.0	67.21	11.07	0.0843
Current BC Load (Reach 541)		737.0	73.35	21.13	4.435	0.1511
Current Load (Adjusted for BC)		566.3	77.15	27.36	3.281	0.0010
Reduction Required		98%	92%	89%	78%	0%
Overall Reduction Required		93%				

Appendix B: Key for Strategies

Table 31 provides a more exhaustive list of available strategies and BMPs than the more focused lists of strategies and BMPs presented in the body of the report. This list may be helpful for developing plans to address specific challenges related to water quality and aquatic habitat. Examples include methods for reducing TSS loading, increasing DO concentrations, addressing altered hydrology or in-stream macro-invertebrate habitat, and developing plans for monitoring, education, and outreach.

Table 31: Key for strategies column

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
Total Suspended Solids (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
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of streambank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Riparian forest/herbaceous buffer
		Livestock access control/exclusion - controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field runoff and increasing vegetative cover near ravines. Also may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management - conservation tillage
	Stream Channel Restoration	Addressing road crossings (direct erosion) and floodplain cut-offs
		Clear water discharge: urban areas, ag tiling, etc. – direct energy
		Two-stage ditches
		Large-scale restoration – channel dimensions match current
		Re-meander channel and connect to floodplain

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
		Ditch Abandonment
		Stream channel restoration using vertical energy dissipation: step
Total Suspended Solids (TSS), continued	Improve forestry management	Proper Water Crossings and road construction
		Forest Roads - Cross-Drainage
		Maintaining and aligning active Forest Roads
		Closure of Inactive Roads & Post-Harvest
		Location & Sizing of Landings
		Invasive species control
		Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
		Riparian Management Zone Widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
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 (U of MN recommendations)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure stockpiles meeting 7020 rules
		Manure application based on nutrient testing, calibrated equipment, recommended rates, and so on.
	Store and treat tile drainage waters: Managing tile drainage waters so that nitrate can be denitrified or so that water volumes and loads from tile drains are reduced	Saturated buffers
		Restored or constructed wetlands
		Controlled drainage
		Woodchip bioreactors
		Two-stage ditch
	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
	Reduce bank/bluff/ravine erosion.	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	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
		Manure storage in ways that prevent runoff
Phosphorus (TP), continued	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 phosphorus testing and applying nutrients on fields needing phosphorus
		Fertilizer rates matching University of MN recommendations
		Precision nutrient timing and management
		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
		Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	In-lake TP treatment	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
		Alum Treatments
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.
	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: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli	Reducing livestock bacteria in surface runoff: Preventing manure from entering streams	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Improve feedlot runoff control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Manure stockpiles meeting 7020 rules
		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: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli, continued	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
	Reduce Industrial/Municipal wastewater bacteria.	Reduce straight pipe (untreated) residential discharges
		Reduce WWTP untreated (emergency) releases
DO	Reduce phosphorus.	See strategies above for reducing phosphorus
	Increase river flow during low-flow years.	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	Goal of channel stability: transporting the water and sediment of a watershed without aggrading or degrading
		Restore riffle substrate
Chloride	Road salt management.	[Strategies currently under development within Twin Cities Metro Area Chloride Management Plan]
Altered hydrology; peak flow and/or low base flow (FIBI/MIBI)	Increase living cover: Planting crops and vegetation that maximize vegetative cover and evapotranspiration especially during the high-flow spring months.	Grassed waterways
		Cover crops
		Conservation cover (easements & buffers of native grass & trees, pollinator habitat)
		Rotations including perennials
	Improve drainage management: Managing drainage waters to store tile drainage waters in fields or at constructed collection points and releasing stored waters after peak flow periods.	Treatment wetlands
		Restored wetlands
	Reduce rural runoff by increasing infiltration: Decrease surface runoff contributions to	Conservation tillage (no-till or strip till with high residue)
		Water and sediment basins, terraces

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	peak flow through soil and water conservation practices.	
	Improve urban stormwater management.	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve irrigation water management: Increase groundwater contributions to surface waters by withdrawing less water for irrigation or other purposes.	Groundwater pumping reductions and irrigation management
Poor Habitat (Fish/Macroinvertebrate IBI)	Improve riparian vegetation: Planting and improving perennial vegetation in riparian areas to stabilize soil, filter pollutants, and increase biodiversity.	50-foot vegetated buffer on waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near waterbodies, to create corridors
		Improve/increase natural habitat in riparian, control invasive species
Poor Habitat (Fish/Macroinvertebrate IBI), continued		Tree planting to increase shading
		Streambank and shoreline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
	Restore/enhance channel: Various restoration efforts largely aimed at providing substrate and natural stream morphology.	Retrofit dams with multi-level intakes
		Restore riffle substrate
		Two-stage ditch
		Dam operation to mimic natural conditions
		Restore natural meander and complexity
Water Temperature	Urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve riparian vegetation: Actions primarily to increase shading, but also some infiltration of surface runoff.	Riparian vegetative buffers
		Tree planting to increase shading
Connectivity (FIBI)	Remove fish passage barriers: Identify and address barriers.	Remove impoundments
		Properly size and place culverts for flow and fish passage
		Culvert Inventory
		Conduct desktop recon of stream crossings
		Manage beaver dams
		Construct by-pass
Monitoring	Increase/Targeted monitoring	Conduct source assessment for identified pollutant
		Conduct continuous DO analysis
		Conduct water quality monitoring on identified waterbody

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
		Monitor drained wetlands along corridor to determine if cause for low DO
Education	Public Outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
		Implement DNR "Score Your Shore"
		Provide information to local landowners on impacts of pet waste on local waterbodies
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: http://stormwater.pca.state.mn.us/index.php