Hawk Creek Watershed

and Surrounding Direct Minnesota River Tributaries

Restoration and Protection Strategies

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Contents

Glossary

Altered hydrology (USGS 2013): Changes in the amount of and way that water moves through the landscape. Examples of altered hydrology include changes in: river flow, precipitation, subsurface drainage, impervious surfaces, wetlands, river paths, vegetation, and soil conditions. These changes can be climate- or human-caused.

Animal Units: A term typically used in feedlot regulatory language. One animal unit is roughly equivalent to 1,000 pounds of animal, but varies depending on the specific animal.

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

Aquatic consumption impairment: Streams are impaired for impacts to aquatic consumption when the tissue of fishes from the water body contains unsafe levels of a human-impacting pollutant. The Minnesota Department of Health provides safe consumption limits.

Aquatic life impairment: Streams are 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. The presence and vitality of aquatic life is indicative of the overall water quality of a stream.

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

Civic Engagement (CE): CE is a subset of public participation (IAP2 2007) where decision makers involve, collaborate, or empower citizens in the decision making process. The University of Minnesota Extension (2013) provides information on CE and defines CE as "Making resourceful decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration."

Designated (or Beneficial) Use: Water bodies are assigned a designated use based on how the water body is used. Typical beneficial uses include: drinking, swimming, fishing, fish consumption, agricultural uses, and limited uses. Water quality standards for pollutants or other parameters are developed to determine if water bodies are meeting their designated use.

Flow-weighted Mean Concentration (FWMC): The total mass of a pollutant delivered (by water) over a set period of time by the total volume of water over that same period of time. Typical units are: lbs/ac-ft or grams/m^3

Geographic Information Systems (GIS): A geographic information system or geographical information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. https://en.wikipedia.org/wiki/Geographic_information_system

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

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

Index of Biotic integrity (IBI): A numerical value between 0 (lowest quality) to 100 (highest quality) that describes water quality using characteristics of aquatic communities.

Knick Zone: An area carved much deeper than the surrounding area by a river that drops elevation drastically in attempt to meet the lower elevation of the outlet. Knick zones are common in the Minnesota River basin due to glacial River Warren carving the deep Minnesota River valley.

Nonpoint source pollutants: Pollutants that are from diffuse sources; most of these sources are not regulated. Nonpoint sources include: agricultural field run-off, agricultural drain tile discharge, storm water from smaller cities and roads, bank, bluff, and ravine failures, atmospheric deposition, failing septic systems, animals, and other sources.

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

Point Source Pollutant: Pollutants that can be directly attributed to one location; generally, these sources are regulated by permit. Point sources include: wastewater treatment plants, industrial dischargers, and storm water discharge from larger cities (MS4 Permit (MPCA 2013f)), and storm water runoff from construction activity (Construction Storm Water Permit (MPCA 2013g)).

Polychlorinated Biphenyls (PCBs): A group of toxic, man-made organic chemicals sometimes found as a pollutant in water bodies, formerly used in the US in industrial and commercial applications. See EPA site for more information on PCBs.

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

Source (or Pollutant Source): Actions, locations, or entities that deliver/discharge pollutants.

Stream Class: a classification system for streams to specify the stream's beneficial or designated uses.

> **Stream Class 2B**: The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.
>
> **Stream Class 2C**: The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.
>
> **Stream Class 7 waters**: The quality of Class 7 waters of the state shall be such as to protect aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

Stream reach: "Reaches in the network are segments of surface water with similar hydrologic characteristics. Reaches are commonly defined by a length of stream between two confluences, or a lake or pond. Each reach is assigned a unique reach number and a flow direction. The length of the reach, the type of reach, and other important information are assigned as attributes to each reach." USGS 2014

Stressor (or Biological Stressor): A broad term that includes both pollutants and non-pollutants or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant (or load capacity) a water body can receive without exceeding the water quality standard. In addition to calculating the load capacity, TMDL studies identify pollutant sources by allocating the load capacity between point sources (or wasteload) and nonpoint sources (or load). Finally, TMDLs calculate the necessary pollutant reductions necessary for a water body to meet its standards.

Yield (water, pollutant, crop, etc.): the amount of mass, volume, or depth per unit land area (e.g. lbs/ac, in/ac)

WRAPS Legislative Requirements

There are specific legislative definitions and requirements associated with Clean Water Legacy legislation on Watershed Restoration and Protection Strategy (WRAPS), (ROS 2016). This table is provided to help reviewers ensure those requirements are adequately addressed.

114D.26 Section	Description	Location in WRAPS report
(1)	impaired and supporting waters	Status subsections in 2.2
(2)	biological stressors	
(3)	watershed modeling summary	Subsection in 3.1, App. 5.11 and 5.20
(3)	priority areas	Prioritizing and Targeting in 3.3
(4)	NPDES-permitted point sources	Appendix 5.27
(5)	nonpoint sources	Sources: overview 2.1, subsections 2.2
(6)	current pollutants and load reductions	Goals subsections in 2.2, Table 14A
(7)	monitoring plan	Monitoring Plan in 1.3
(8)	strategies table with components:	Table 14A and Table 14B
(i)	water quality parameter of concern	Table 14A and Table 14B
(ii)	current conditions	Table 14A
(iii)	water quality goals and targets	Table 14A
(iv)	strategies by parameter	Table 14A and Table 14B
(iv)	strategy adoption rates	Table 14A and Table 14B
(v)	timeline to achieve water quality targets	Table 14A
(vii)	responsibility	Table 14B

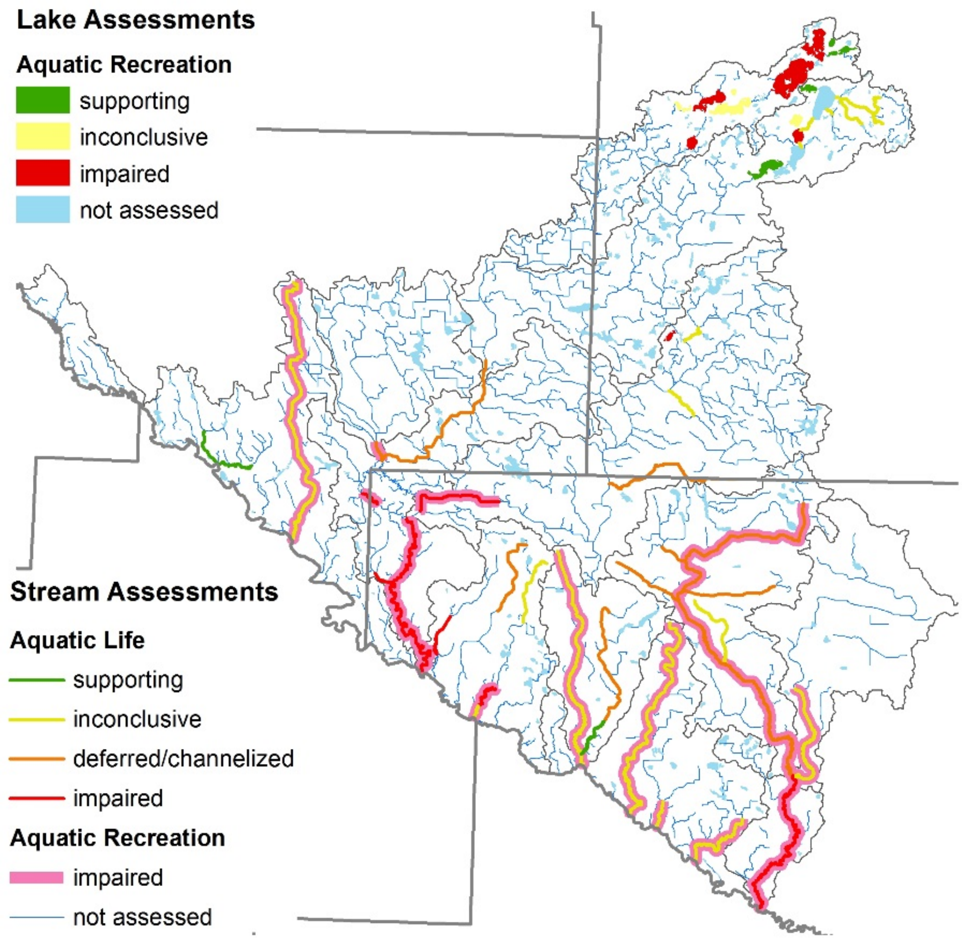
Legislation also requires that the WRAPS and Total Maximum Daily Load (TMDL) Reports have a public comment period. An opportunity for public comment on the draft WRAPS report was provided via a public notice from May 22, 2017 to June 21, 2017.

Summary

Minnesota has adopted a “watershed approach” to address water quality within the state’s 80 major watersheds. The watershed approach follows a 10-year cycle where water bodies are 1) monitored for chemistry and biology and assessed to determine if they are fishable and swimmable, 2) pollutants and stressors and their sources are identified, and then local partners and citizens are engaged to help 3) develop strategies to restore and protect water bodies, and 4) plan and implement restoration and protection projects. This WRAPS report summarizes work done in Steps 1 - 3 above in this first cycle of the Watershed Approach in the Hawk Watershed.

The Hawk Watershed area drains approximately 626,000 acres to the Minnesota River. Fifteen towns and cities are in or partially in, the watershed including: Bird Island, Clara City, Granite Falls, Montevideo, Olivia, and Willmar, as are portions of three counties: Renville, Kandiyohi, and Chippewa. Land use in the watershed is dominated by cultivated crops. Roughly, 35,000 people and 156,000 feedlot animal units reside in the watershed.

The map to the right shows streams and lake monitoring and assessment results. Poor conditions were common throughout the watershed. Only one stream reach and six lakes of those monitored were found healthy enough to safely support aquatic recreation, and one stream reach was healthy enough to support an appropriate fish and macroinvertebrate community (green). Several lakes and stream reaches need more data to make a conclusive finding (yellow). Impairments (red and pink) were common.



The types and sources of pollutants and stressors causing impairments were identified. Strategies and practices to address these pollutants and stressors were then developed using data, models, and local input. A summary of the identified pollutants and stressors, goals, strategies, and recommended practices follows. Refer to the Strategies Table (Table 14) for more details.

Altered hydrology: Altered hydrology harms aquatic life by affecting the amount of water in the stream, as both too little and too much stream flow have negative impacts. Because altered hydrology also increases the amount and movement of other pollutants and stressors (nutrients, sediment, etc.) to water bodies, addressing altered hydrology should be a top priority for the watershed. Three of the four assessed stream reaches were found to be stressed by altered hydrology. Unmitigated artificial drainage, climate change, crop/vegetation changes, soil changes, ditching, and impervious surfaces are sources of altered hydrology. These sources of altered hydrology are common across the watershed. Therefore, altered hydrology is likely negatively impacting water quality watershed-wide. The goal for altered hydrology is a 25% total and peak flow reduction and an increase in dry season base flow. Key strategies to address altered hydrology include improving soil health and water-holding capacity, increasing the amount and length of time living vegetation is on the land, creating water storage areas, and mitigating artificial farm and city drainage. These strategies should be targeted in the "farmed zone" of the Hawk Watershed. Recommended practices include cover crops, reduced tillage, diverse crop rotations, conservation cover, wetland restorations, detention/infiltration ponds, and controlled drainage.

Sediment/Turbidity: Sediment and other particles impact aquatic life by reducing habitat, suppressing photosynthesis, damaging gills, decreasing visibility and increasing sediment oxygen demand. More than two-thirds of the 20 analyzed stream reaches were found to be impacted by excess sediment/turbidity. Stream and ditch bank erosion account for an estimated half of the sediment load in the watershed; however, much of this is due to unnaturally accelerated erosion of stream banks caused by the altered hydrology. Data show that the lower half of the watershed (the area closer to the Minnesota River) tends to have higher concentrations of sediment, with small portions of the watershed currently meeting sediment standards. Recent short-term trends show an improvement in sediment, but continued efforts are needed to achieve the watershed-wide 50% reduction goal. While stream and ditch banks are a large source of sediment, stabilizing stream banks in most cases is not financially feasible or biologically beneficial. The key strategy to controlling sediment is to address the cumulative, upstream altered hydrology impacts across the watershed; additional strategies include preventing and capturing surface runoff and stabilizing stream banks and ravines where necessary to protect high-value property. Recommended practices include cover crops, reduced tillage, buffers and field borders, detention/settling ponds, with limited stream and ravine stabilization where justified.

Bacteria: Fecal bacteria indicate sewage or manure in water, which makes water unsafe for swimming. All 15 analyzed stream reaches were found to be impaired by fecal bacteria. With a robust animal agriculture sector throughout the watershed, manure is the largest source of the fecal bacteria. The most common pathway for fecal bacteria to reach water bodies is runoff from farm fields where manure has been surface-applied. The watershed-wide goal is to reduce fecal bacteria by 80%. Key strategies to reduce fecal bacteria include preventing and capturing surface runoff from manured fields and improving manure application, with adherence to state rules and guidelines. Improvements to failing septic systems and pastures that allow direct animal access to water bodies are important to improve fecal bacteria problems at low flow conditions. Recommended practices include improved manure application and management, cover crops, buffers and field borders, livestock exclusion and watering facilities, and septic system upgrades.

Nitrogen: Excess nitrogen is toxic to aquatic life and contributes to the Gulf of Mexico's hypoxic zone. Two of the four analyzed streams were found to be stressed by excess nitrogen, and no conclusion could be made for the other two. Agricultural tile drainage and agricultural groundwater contribute most of the nitrogen to these water bodies. Most of the agricultural zone within the watershed is tile drained, indicating nitrogen problems are likely widespread in and downstream from this zone. Short-term trend data indicates increasing nitrogen in large portions of the watershed, including Chetomba and West Fork Beaver Creeks. The watershed-wide goal is to reduce nitrogen by 45%. Key strategies to reduce nitrogen include improving nutrient management, retaining and treating drainage water, increasing the amount and length of time living vegetation is on the land, and addressing altered hydrology. Recommended practices include improving manure and fertilizer application practices, cover crops, reduced tillage, bio-reactors, and treatment wetlands.

Phosphorus: Excess phosphorus fuels algae growth that degrades habitat and recreation and contributes to oxygen depletion problems. Excess phosphorus was found to be a pollutant in 6 of the 17 lakes monitored and found to stress 3 of the 4 analyzed stream reaches. Crop runoff and drainage account for the majority of phosphorus contributions to water bodies. However, runoff from cities and point sources each contribute roughly 10% to 15% of the load, and are more significant at lower stream flows. Recent improvements in phosphorus loading are attributed to wastewater treatment plant (WWTP) upgrades in the watershed. The watershed-wide goal is to reduce phosphorus by 60%. Key strategies to reduce phosphorus include improving nutrient management, increasing the amount and length of time living vegetation is on the land, and improving soil health. Recommended practices include improving manure and fertilizer application practices, with strict adherence to current manure application rules, field borders and buffers, replacing open tile intakes, cover crops, and reduced tillage. Swan Lake and West Solomon Lake are the two impaired lakes in the Hawk Creek Watershed that are closest to meeting their water quality standards. Resources should be focused on all of the impaired lakes in the watershed, but these two lakes might have the greatest potential for achieving standards in a relatively short period and could therefore be considered priority lakes for restoration.

Habitat: In-stream and riparian habitat are necessary for aquatic life to survive. Poor habitat was identified as a stressor in the four analyzed stream reaches. The identified habitat problems include degraded riparian zone, lack of natural buffers, and excess sediment in the stream bed primarily due to altered hydrology. The watershed-wide goal for habitat is to increase the average habitat score by 45%. Key strategies to improve habitat include addressing altered hydrology and improving the riparian zone land use. Recommended practices include stream buffers, conservation cover, livestock exclusion and watering facilities, and wetland restorations.

Dissolved Oxygen: Aquatic life requires sufficient oxygen for respiration. Low dissolved oxygen (DO) was an identified problem in 7 of the 19 analyzed stream reaches, inconclusive in 9, and supporting in 3. Low DO is often due to oxygen depletion caused by decaying organic matter (algae) whose overgrowth was spurred by excess phosphorus. These problems can also be due to a lack of re-oxygenation caused by excessively low flows or over-warmed water – both symptoms of altered hydrology and degraded riparian zone. Key strategies to address low DO are to address the phosphorus, altered hydrology, and habitat problems. Recommended practices include stream buffers, cover crops, fertilizer and manure management, and conservation cover.

In summary: Everyone within the watershed has a responsibility to transition to more sustainable practices to achieve clean water. Cultivated crop production accounts for approximately 80% of the land use in the watershed with conventional farming practices leading to substantial contributions of all pollutants and stressors. Therefore, the greatest opportunity for water quality improvement is from land management changes to farm fields in the Hawk Watershed. The highest priority agricultural strategies include improving soil health, improving manure and fertilizer application, eliminating open tile intakes, and replacing marginally-productive crop lands with perennials and water storage. Likewise, cities, residents, animal operations, and other land uses must transition to more sustainable practices.

While the biophysical means to restore and protect the watershed are fairly well understood, the transition to sustainable practices is limited by social-based challenges. Most of the transitions that must occur are not under regulatory control; hence, citizens need to voluntarily adopt these changes to make substantial improvements happen. Additional social-based challenges include inadequacies in current programs, lack of markets, pressure to maintain the status quo, lack of trust between producers and agency staff, lack of successful demonstrations, threats to profitability, and unwillingness to make changes. Some solutions to these social-based challenges include re-structuring or expanding financial incentive programs, increasing enforcement of regulatory programs, and developing alternative markets. However, these large-scale, top-down solutions can be difficult to actualize and often, can be distasteful to citizens.

A growing body of evidence detailed in *Pathways for Getting to Better Water Quality: The Citizen Effect* (Morton and Brown 2011) suggests that to achieve clean water in the voluntary-adoption system in place, a citizen-based approach is likely the most feasible means to success. Specifically, the transition to more sustainable practices must be developed, demonstrated, and spread by trusted leaders within the community. When leaders embrace a transition, communities are more likely to accept and adopt the transition. When leaders and communities develop solutions, they are likely to intertwine financial security and environmental stewardship - instead of viewing them as conflicting goals. In this way, the community is more likely to improve water quality while securing sustainable farms and cities for future generations. If this pathway to water body improvement is to be embraced, then one of the most important uses for limited resources is to further develop and support local leaders to take on this challenging work.

1. Background Information

1.1 Watershed Approach and WRAPS

The state of Minnesota uses a "*Watershed Approach*" (MPCA 2015a) to assess and address the water quality of each of the state's 80 major watersheds on a 10 year cycle (Figure 1). In each cycle of the Watershed Approach, rivers, lakes and wetlands across the watershed are monitored, pollution sources are identified, needed pollutant reductions are calculated, WRAPS are developed, and conservation practices are continually implemented. The Watershed Approach provides information to local partners, landowners, and other stakeholders to prioritize and target conservation practice implementation in local water plans– the ***goal*** of which is to protect and restore water quality.

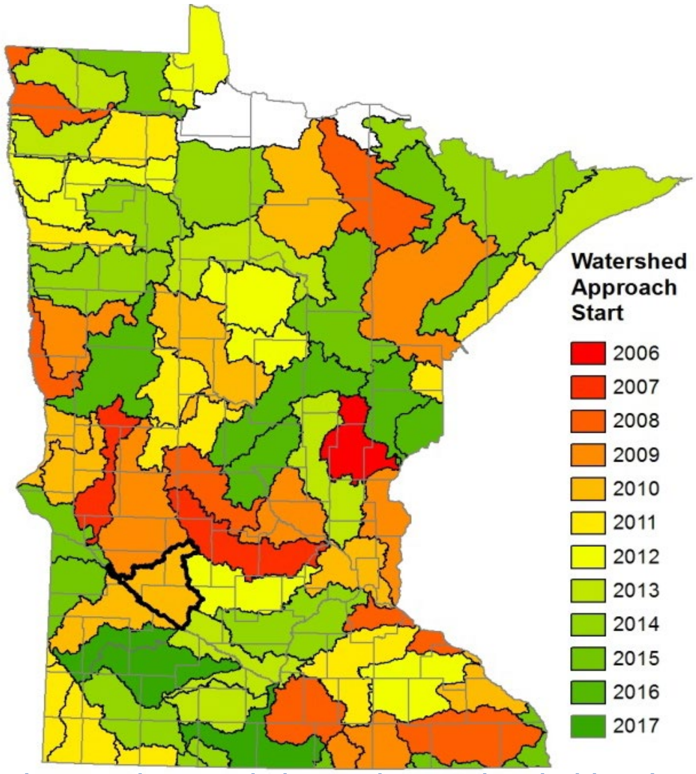


Figure 1: In the "Watershed Approach", approximately eight major watersheds start evaluation every year. After 10 years, a watershed is re-visited to see how water quality has changed and to improve and expand work done in previous years. Work in the Hawk Watershed (in bold) started in 2010.

The ***purpose*** of this WRAPS report is to summarize work done in this first application of the Watershed Approach in the Hawk Watershed, and to present strategies to restore and protect waters within the watershed. The ***scope*** of the report is surface water bodies and their aquatic life and aquatic recreation beneficial uses, as currently assessed by the Minnesota Pollution Control Agency (MPCA). The primary ***audience*** for the WRAPS report is local planners, decision makers, and conservation practice implementers; watershed residents, government agencies, and other stakeholders are the secondary audience. The WRAPS report in conjunction with the *TMDL* (TMDL; MPCA 2013f) and project work plans satisfies the EPA (2008) Nine Minimum Elements for Section 319 project funding. Information provided in the WRAPS report will assist in selecting goals and methods to prioritize and target within the One Watershed, One Plan (1W1P; BWSR 2014b). As the WRAPS report summarizes an extensive amount of information, the reader should review the supplementary information provided (links and references in document) for more detailed information.

1.2 Watershed Description

The Hawk Watershed is the portion of the Hawk Creek-Yellow Medicine River major (HUC-8, [USGS 2014a]) watershed northeast of the Minnesota River (Figure 2). The watershed area drains approximately 626,000 acres to the Minnesota River including Hawk Creek and several direct Minnesota River tributaries. In this report, "Hawk Creek Watershed" refers to areas that drain to Hawk Creek; "Hawk Watershed" refers to both the Hawk Creek Watershed and the watersheds of the direct Minnesota River tributaries as shown in Figure 2. Fifteen towns and cities are in or partially in the watershed: Bird Island, Blomkest, Clara City, Danube, Granite Falls, Maynard, Montevideo, Olivia, Pennock, Prinsburg, Raymond, Renville, Sacred Heart, Watson, Willmar, across Renville, Kandiyohi, and Chippewa counties.

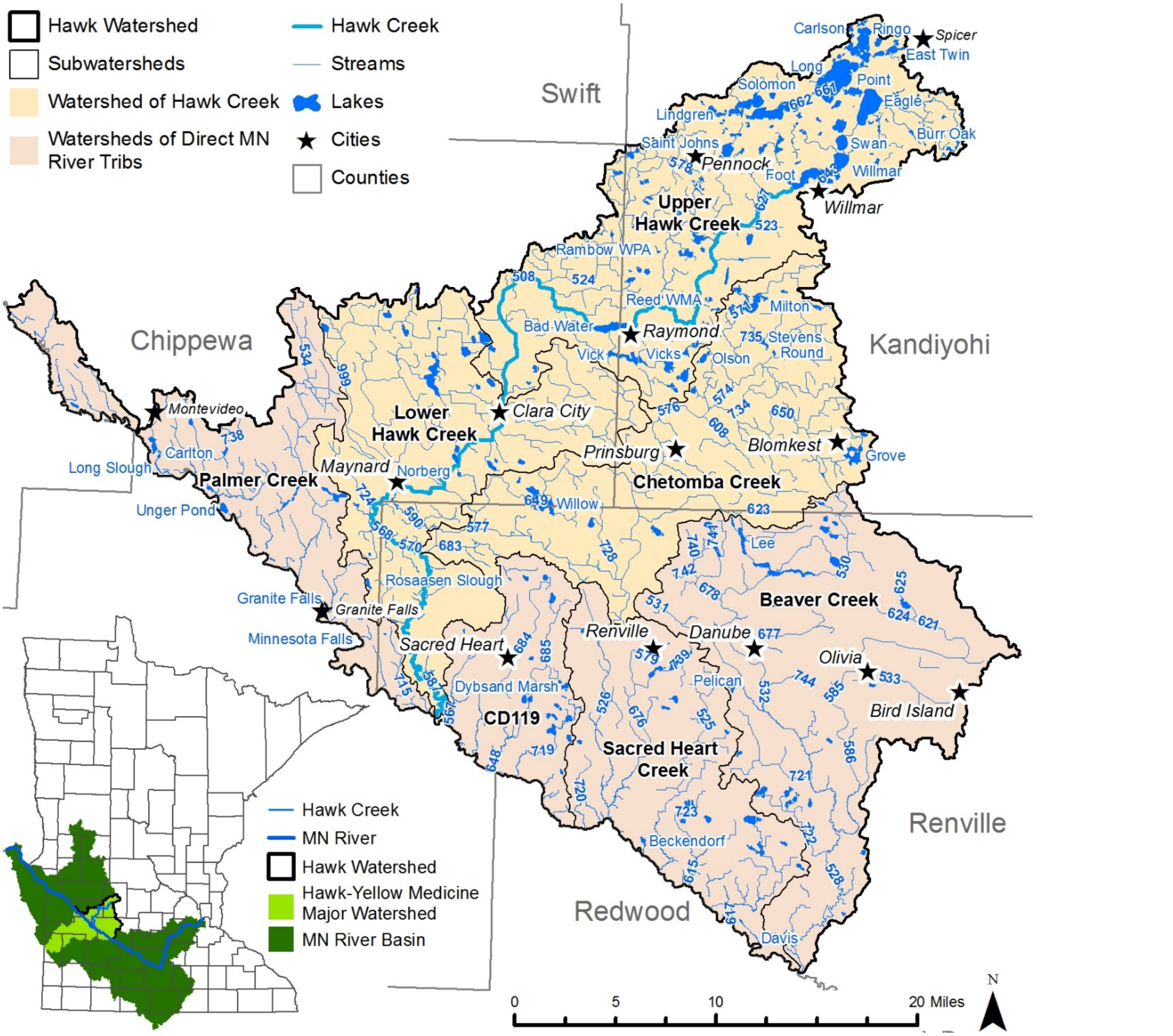


Figure 2: The Hawk Watershed drains rivers in Southwest Minnesota into the Minnesota River, which then flows into the Mississippi River. The watershed contains or overlaps three counties and 15 cities. Stream reaches are labeled by the last three digits of the assessment unit identification number (AUID-3).

The Hawk Creek Watershed Project (HCWP) was formed in 1997 with a purpose of "improving the water quality/quantity issues in the watershed while also promoting a healthy agricultural, industrial, and recreational-based economy for the region." In 2013, a joint powers agreement between the three counties of the watershed (Chippewa, Kandiyohi, and Renville) became the organizing structure of the HCWP. The HCWP addresses water quality issues in a number of Minnesota River tributaries and directly along 78 river miles of the Minnesota River itself. The HCWP works closely with the SWCD/NRCS offices in the three counties to spread out resources to complete BMP projects to improve and protect water quality in the watershed. To see successful BMP practices implemented through HCWP or to learn about HCWP please refer to their website https://www.hawkcreekwatershed.org/.

The Hawk Watershed landscape is dominated by cultivated, warm-season, annual crops with small portions of grassed and developed areas (Figure 3). The watershed contains roughly 156,000 feedlot AUs and 35,000 humans. Permitted point source dischargers in the watershed include 14 WWTP and 13 industrial wastewater dischargers.

The watershed can be broken into three management zones based on land use and topography (Figure 4): 1) the "Lakes Zone" in the northeast of the watershed, which is rich in lakes, 2) the "Farmed Zone", which is the intensively farmed central and largest portion of the watershed, and 3) the "Minnesota River Zone" in the southwest part of the watershed, which contains riparian areas and steep transitions to the Minnesota River. The watershed is relatively flat through the farmed zone with steep elevation changes and knick zones (Gran et al. 2011b) as the watershed transitions from the Farmed Zone to the Minnesota River Zone. More information on the Hawk Watershed can be found at the *Rapid Watershed Assessment* (NRCS 2010), the *Watershed Health Assessment Framework* (DNR 2013), and the *Minnesota Nutrient Planning Portal* (MSU 2014).

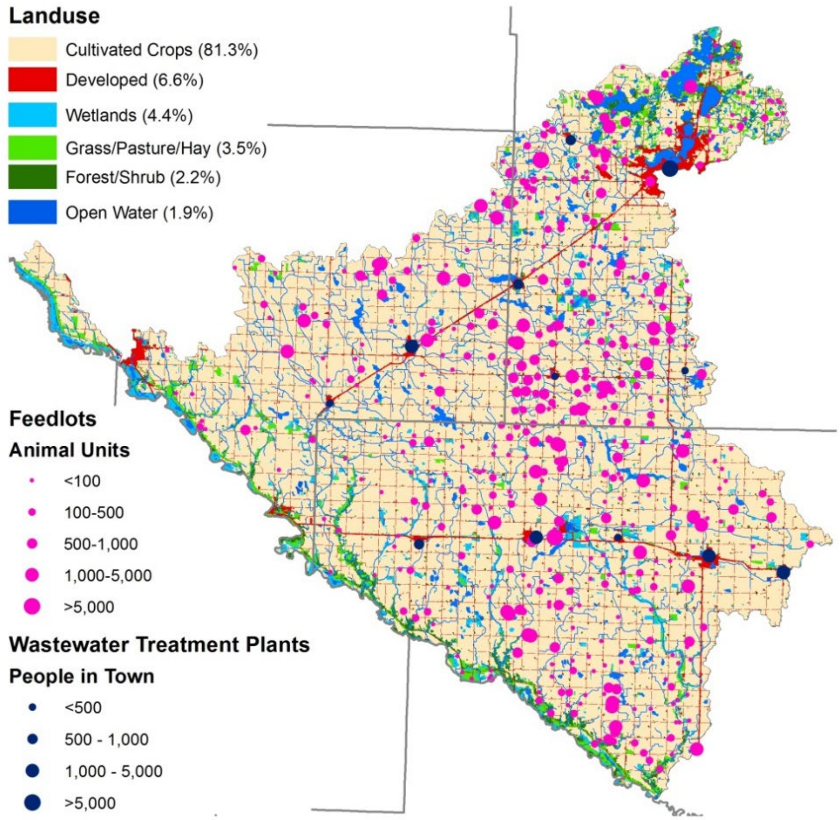


Figure 3: The current land use in the Hawk Watershed is dominated by cultivated crops. Hundreds of feedlots and over a dozen small cities are also located in the watershed.

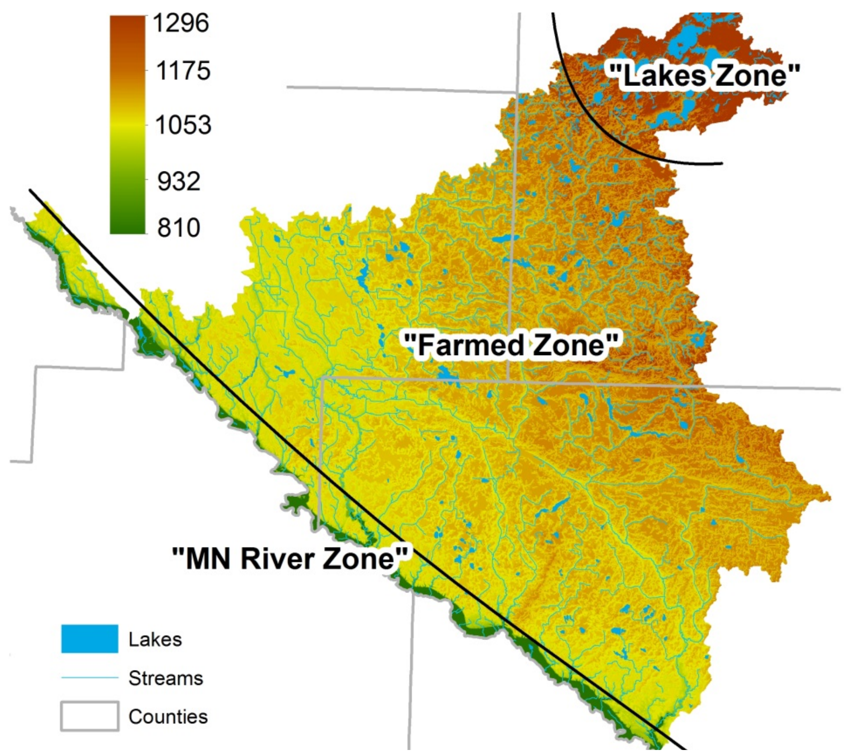


Figure 4: The highest elevations in the watershed are in the "Lakes Zone" while the lowest elevations are in the "Minnesota River Zone".

1.3 Assessing Water Quality

Assessing water quality is a complex process with many steps including: developing water quality standards, monitoring the water, ensuring the monitoring data set is comprehensive and accurately represents the water, and local professional review. A summary of some process steps is included below.

1.3.1 Water Quality Standards

Water quality in an altered landscape is not expected to be as healthy as it would under undisturbed, "natural background" conditions. However, water bodies are expected to support designated beneficial uses including fishing (aquatic life), swimming (aquatic recreation), and eating fish (aquatic consumption). Water quality standards (MPCA

2015b; also referred to as "standards") are set after extensive review of information and data about the safe level of pollutants for different beneficial uses and are intended to allow for natural background conditions.

1.3.2 Water Quality Assessment

To determine if water quality is supporting its designated use, data on the water body is compared to relevant standards. When pollutants/parameters in a water body exceed the water quality standard, the water body is considered impaired (MPCA 2011a). When pollutants/parameters in a water body meet the standard (usually when the monitored water quality is cleaner than the water quality standard), the water body is considered supporting (of beneficial uses of the water). If the monitoring data sample size is not robust enough to ensure that the data adequately/statistically represents the water body, or if monitoring results seem unclear regarding the condition of the water body, an assessment is delayed until further data are collected; this is referred to as an inconclusive or insufficient finding.

1.3.3 Monitoring Plan

Data from three water quality monitoring programs enable water quality assessment and create a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the Hawk Watershed as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA 2011b). Combined, these programs collect data at dozens of locations around the watershed (Figure 5). Additional data are collected by local partners to supplement the MPCA programs. Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. These monitoring programs are summarized below:

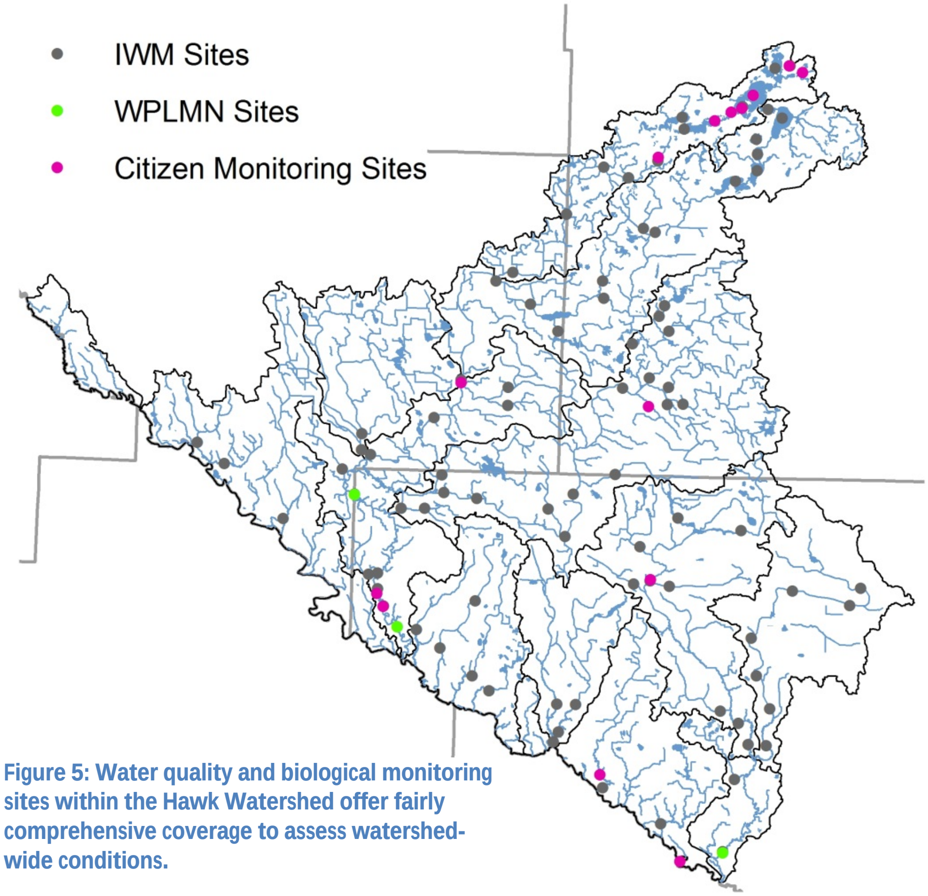


Figure 5: Water quality and biological monitoring sites within the Hawk Watershed offer fairly comprehensive coverage to assess watershed-wide conditions.

Intensive Watershed Monitoring (IWM; MPCA 2012a) data provide a periodic but intensive "snapshot" of water quality throughout the watershed. This program collected water quality and biological data at roughly 73 stream and 13 lake monitoring stations across the watershed in 2010 and 2011. Monitoring sites are generally selected to provide comprehensive coverage of the watershed. This work is scheduled to start its second iteration in the Hawk Watershed in 2020.

Watershed Pollutant Load Monitoring Network (WPLMN; MPCA 2015c) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, and sediment and nutrient loads. In the Hawk Creek Watershed, there is an annual site, which is sampled at least once a month throughout the year near the outlet of Hawk Creek, and two seasonal (spring through fall) subwatershed sites in the Hawk Watershed.

Citizen Stream and Lake Monitoring Program (MPCA 2015d) data provide a continuous record of water body transparency throughout much of the watershed. This program relies on a network of volunteers who make monthly lake and river measurements. Roughly 10 volunteer-monitored locations exist in the Hawk Watershed.

1.3.4 Computer Modeling

With the Watershed Approach, monitoring for pollutants and stressors is generally extensive, but not every stream or lake can be monitored due to financial and logistical constraints. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as Hydrological Simulation Program – FORTRAN (HSPF [USGS 2014c]), represent complex natural phenomena with numeric estimates and equations of natural features and processes. HSPF incorporates data, including stream pollutant monitoring, land use, weather, soil type, etc., to estimate flow, sediment, and nutrient conditions within the watershed. *Building a Picture of a Watershed* (MPCA 2014c) explains the model's uses and development. Information on the HSPF development, calibration, and validation in the Hawk Watershed are available*: HSPF Model Development and Hydrologic Calibration Report* (Tetra Tech 2011a) and the *HSPF Water Quality Calibration and Validation Report* (Tetra Tech 2011b), Model Resegmentation and Extension for Minnesota River Watershed Model Applications (RESPEC 2014a), and Hydrology and Water Quality Calibration and Validation of Minnesota River Watershed Model Applications (RESPEC 2014b).

These model data can provide a reasonable estimate of pollutant concentrations across watersheds. The model output, along with additional lines of evidence, can be used to estimate pollutant loads per subwatershed areas and the pollutant concentrations in streams and lakes. However, these data are not used for impairment assessments since monitoring data are required for those assessments. Modeled pollutant and stressor yields are presented in Appendix 5.11, and modeled landscape and practice changes (referred to as scenarios) are discussed in Section 3.1 and summarized in Appendix 5.20.

2 Water Quality Conditions

"Condition" refers to the water bodies' ability to support fishable and swimmable water quality standards. This section summarizes condition information including water quality data and associated impairments. For water bodies found not able to support fishable, swimmable standards, the reason for these poor conditions – the pollutants and/or stressors – are identified. Information presented in this section is a compilation of many scientific analyses and reports. Information on the pollutants and stressors is summarized from the *Monitoring and Assessment Report* (MPCA 2013e) and the *Stressor Identification (SID) Report* (MPCA 2013a); the reader should reference those reports for additional details. Data for individual streams and lakes can be reviewed on the *Environmental Data Application* (MPCA 2015e).

This report covers only impairments to aquatic recreation and aquatic life. Several lakes and stream reaches are impaired for aquatic consumption (due to mercury and PCBs). The *Statewide Mercury TMDL* (MPCA 2015f) has been published and *Fish Consumption Advice* (MDH 2013) is available from the Minnesota Department of Health (MDH).

2.1 Conditions Overview

This section provides an overview of watershed conditions and information to orient the reader to Section 2.2. The status, sources, and goals are presented for each of the identified pollutants and stressors in Section 2.2.

2.1.1 Status Overview

Many of the monitored stream reaches and lakes have impaired aquatic recreation (swimming) and/or aquatic life (fish and macroinvertebrates; Figure 6, red and pink). Only a few stream reaches and lakes are meeting standards (Figure 6, green). Several reaches and lakes need more data to make a scientifically conclusive finding (Figure 6, yellow). Assessments on channelized streams were deferred (Figure 6, orange) but will be completed during the next iteration of the watershed approach now that the tiered aquatic life use framework (TALU; MPCA 2015g) has been developed.

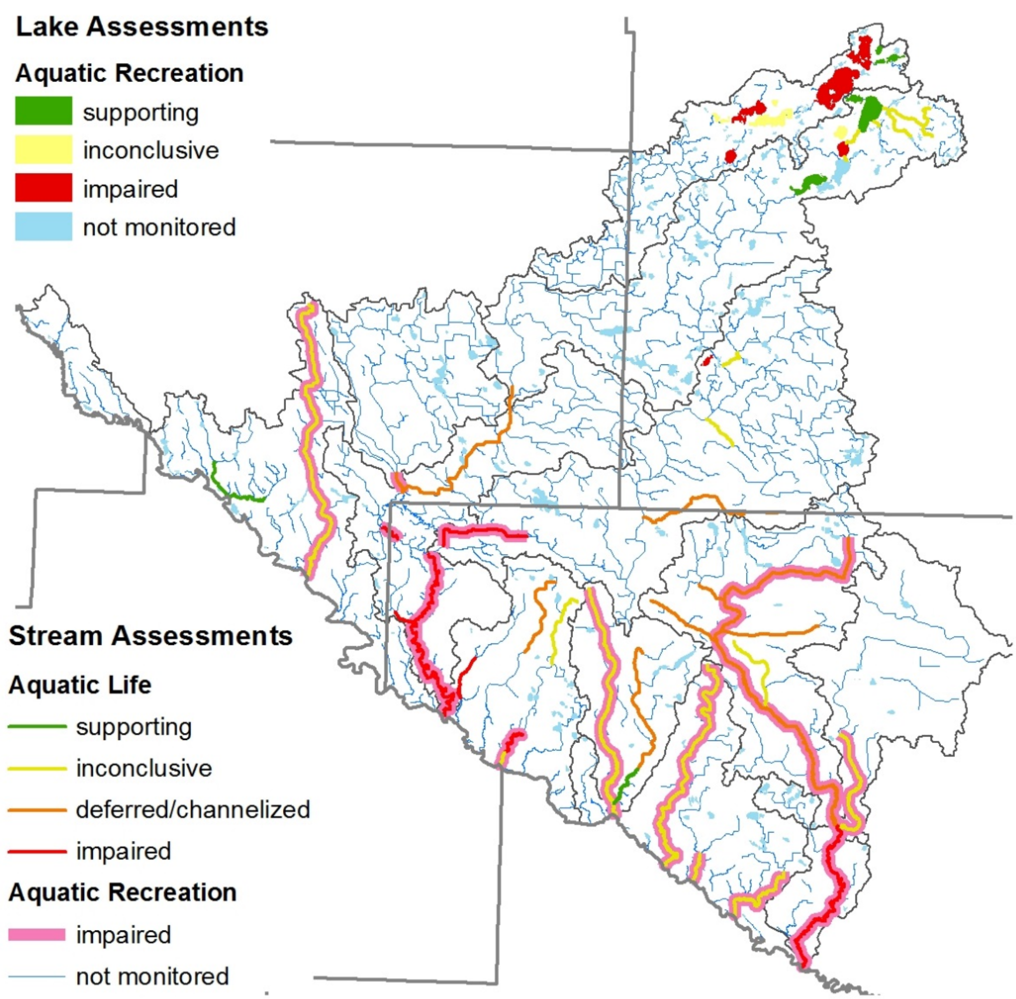


Figure 6: Six lakes and zero of the stream reaches that were monitored were found healthy enough to safely support aquatic recreation, and three stream reaches were healthy enough to support an appropriate fish and macroinvertebrate community (green). Impairments (red and pink) and channelized streams (orange) are common. Several lakes and streams need more data to make a conclusive finding (yellow). A large number of streams and lakes have not been assessed (blue).

Pollutants and stressors were identified by either direct measurements of the parameter in the water body (pollutants) or through the SID process of "bio-impaired" stream reaches (stressors).

Bio-impaired stream reaches are stream reaches with an aquatic life impairment due to low or imbalanced aquatic life populations, as discovered during fish and macroinvertebrates sampling. Stressors of these bio-impairments were: altered hydrology, high phosphorus, lack of habitat, low DO, high sediment, and high nitrates. Identified pollutants were: sediment, phosphorus, fecal bacteria, and low DO.

A breakdown of the total number of water bodies (monitored and not monitored) and the assessment results (impaired, supporting, inconclusive, or deferred) are presented in Figure 7. Refer to Appendix 5.1 for a table of all impairments, stressors, and pollutants by stream reach. Results for lakes are presented in the phosphorus section below. Each pollutant and stressor is analyzed in more detail in Section 2.2.

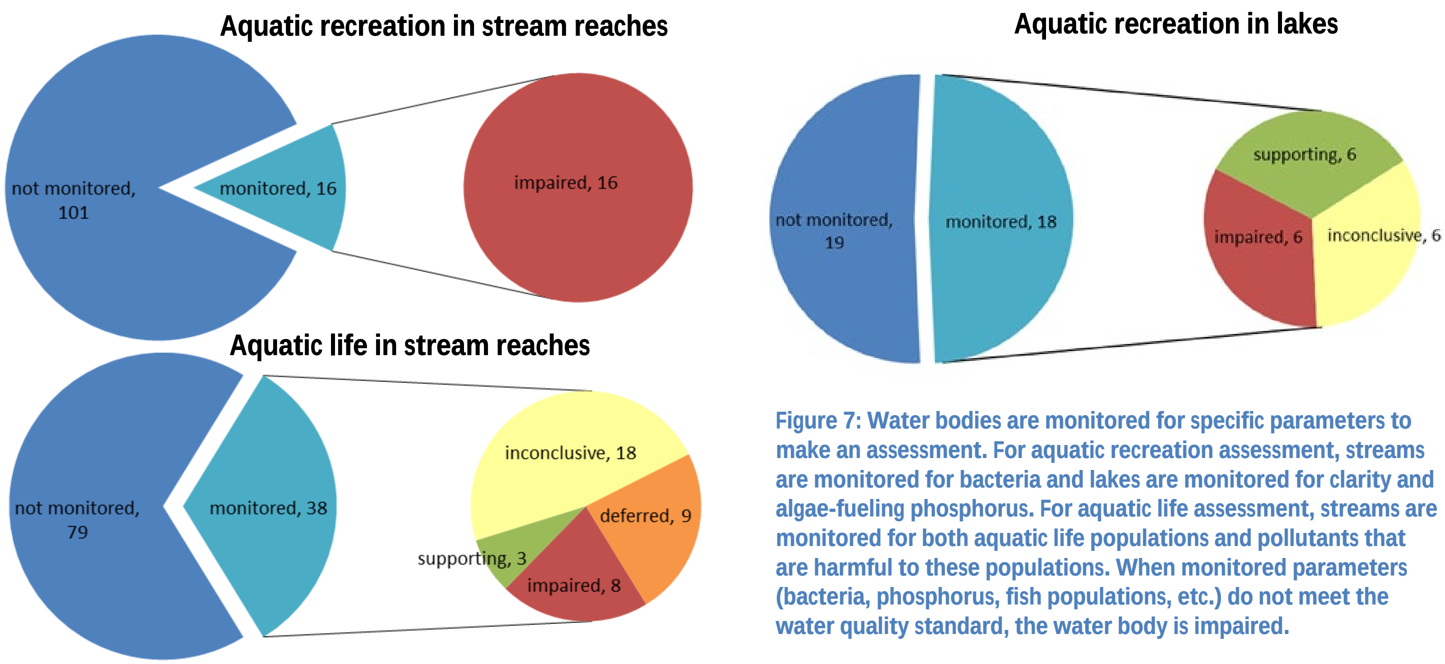


Figure 7: Water bodies are monitored for specific parameters to make an assessment. For aquatic recreation assessment, streams are monitored for bacteria and lakes are monitored for clarity and algae-fueling phosphorus. For aquatic life assessment, streams are monitored for both aquatic life populations and pollutants that are harmful to these populations. When monitored parameters (bacteria, phosphorus, fish populations, etc.) do not meet the water quality standard, the water body is impaired.

2.1.2 Trends Overview

A substantial amount of change has occurred across the landscape over the past two centuries in terms of land use, farming practices, human populations, etc. Trends observed in the Minnesota River Basin are discussed in the *Minnesota River Basin Trends Report* (MSU 2009a).

Statistical trends in water quality parameters cannot be observed without a substantial data set. Furthermore, trends in environmental data can be difficult to identify due to the "noisy" nature of environmental data. In other words, weather can cause large variability in environmental data and make trends difficult to identify. Statistical water quality trends were found in the *Minnesota River Basin Statistical Trend Analysis* (MSU 2009b) in the Hawk Creek Watershed for total suspended solids (TSS), nitrate (NO_3), and total phosphorus (TP) for the years 1999 through 2008, a relatively short period of time for water quality trend analysis (Table 1). As more data are collected through the WPLMN and Citizen Monitoring programs, more trends may emerge and the statistical significance of trends may increase.

Table 1: Some trends were found in data that were collected in the Hawk Creek Watershed between 1999-2008. Values in green indicate improving trends; values in pink indicate degrading trends; values in grey were not statistically significant. Trends analysis used Seasonal Kendall with 95% confidence.

	Period	Hawk Creek Outlet	Hawk Creek, Priam	Beaver Creek Outlet	Chetomba Creek	West Fork Beaver Creek
TSS	1999-2008	-70%	-72%	-47%	-30%	-48%
NO_3	1999-2008	16%	7%	21%	65%	69%
TP	2001-2008	19%	2%	11%	36%	-17%

2.1.3 Sources Overview

Sources of pollutants and stressors can be grouped into either point sources (NOAA 2008) like wastewater plants and industries, or nonpoint sources (MPCA 2013d) like farm and city runoff. In the Hawk Watershed, pollutant and stressors are mostly from nonpoint sources. In years 2009 to 2013, point sources contributed approximately: less than 1% of sediment, 21% of phosphorus, and 6% of nitrogen to the watershed's total load delivered to the Minnesota River (see Appendices 4.12 and 4.13). While continuously discharging point sources have a relatively small contribution to the multiyear total watershed pollutant load, these sources can contribute a relatively substantial portion of pollutant loads during times of low flow. Point source dischargers in the watershed include 14 WWTPs and 13 Industrial Wastewater Permits (Table 2).

Table 2: Municipal and Industrial wastewater dischargers within the Hawk Watershed

Municipal Wastewater Facilities	County	Industrial Wastewater Facilities	County
Clara City WWTP	Chippewa	Chippewa Co Highway Dept - Miller Pit	Chippewa
Granite Falls WWTP	Chippewa	Granite Falls Energy LLC	Chippewa
Maynard WWTP	Chippewa	Granite Falls Redi-Mix	Chippewa
Bird Island WWTP	Kandiyohi	Xcel - Minnesota Valley Plant	Chippewa
Community of Roseland WWTP	Kandiyohi	BNSF Railway Co - Willmar	Kandiyohi
Pennock WWTP	Kandiyohi	Duininck Bros Inc - Aggregate	Kandiyohi
Prinsburg WWTP	Kandiyohi	Jennie-O Turkey Store Inc	Kandiyohi
Raymond WWTP	Kandiyohi	Willmar Municipal Utilities Power Plant	Kandiyohi
Willmar WWTP	Kandiyohi	Alliance Pipeline LP	Renville
Blomkest Svea Sewer Board WWTP	Renville	Gordy Serbus & Sons Gravel LLC	Renville
Danube WWTP	Renville	MinAqua Fisheries	Renville
Olivia WWTP	Renville	Rembrandt Enterprises Inc	Renville
Renville WWTP	Renville	Southern Minnesota Beet Sugar - Renville	Renville
Sacred Heart WWTP	Renville		

Most nonpoint sources in the Hawk Watershed are non-regulated or minimally regulated including: runoff from cultivated crops and subsurface drainage tile system discharge; runoff from yards, smaller cities, and storm sewer networks; runoff from manure-applied crops; and runoff from pastures. Regulated nonpoint sources include: stormwater runoff from several construction projects, industries, and larger feedlots (Appendix 5.27), which require a National Pollutant Discharge Elimination System (NPDES) Permits (Permit) (EPA 2014a) and must follow rules associated with each of the programs to eliminate or limit stormwater runoff.

Septic systems (subsurface treatment systems; SSTS) are tracked but not necessarily regulated, depending on County ordinance. Information on septics is reported by county and indicates a relatively small to medium number of failing septic SSTS in the region (Figure 8). The impacts of failing SSTS will be most pronounced in areas with high concentrations of failing systems or at times of low precipitation and/or flow.

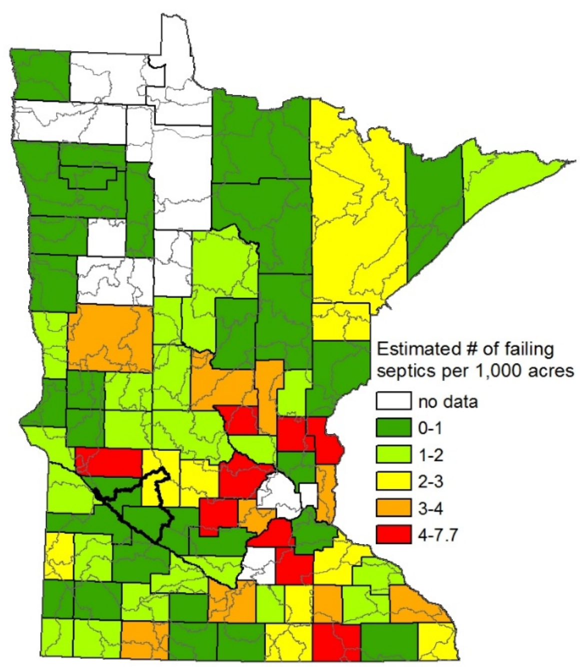


Figure 8: Counties within the Hawk Watershed have an estimated average of one to three failing septic systems per 1,000 acres.

Feedlot statistics are summarized in Table 3 and illustrated in Figure 9. Like other types of nutrient application, the location, method, rate, and timing of manure application are important considerations to estimate the impact and likelihood of manure runoff. While this information is recorded by each facility and could be very helpful for source assessment, this information is rarely compiled and analyzed due to staff time limitations. However, some inferences can be made based on the animal statistics. See Appendix 5.19 for an interpretation of feedlots statistics that is helpful for source assessment and prioritizing and targeting work.

Table 3: Over 155,000 animal units are registered with the county and/or MPCA feedlot program. Compared to other parts of the state, there is a high percentage of poultry. See Animal Unit Calculator (MPCA 2016c) for conversions of animal numbers to units.

	Pigs	Birds	Bovines	Goats/ Sheep	Horses	Other
Animal Units	85893	28238	38530	2253	346	240
% of total	55%	18%	25%	1%	0.2%	0.2%

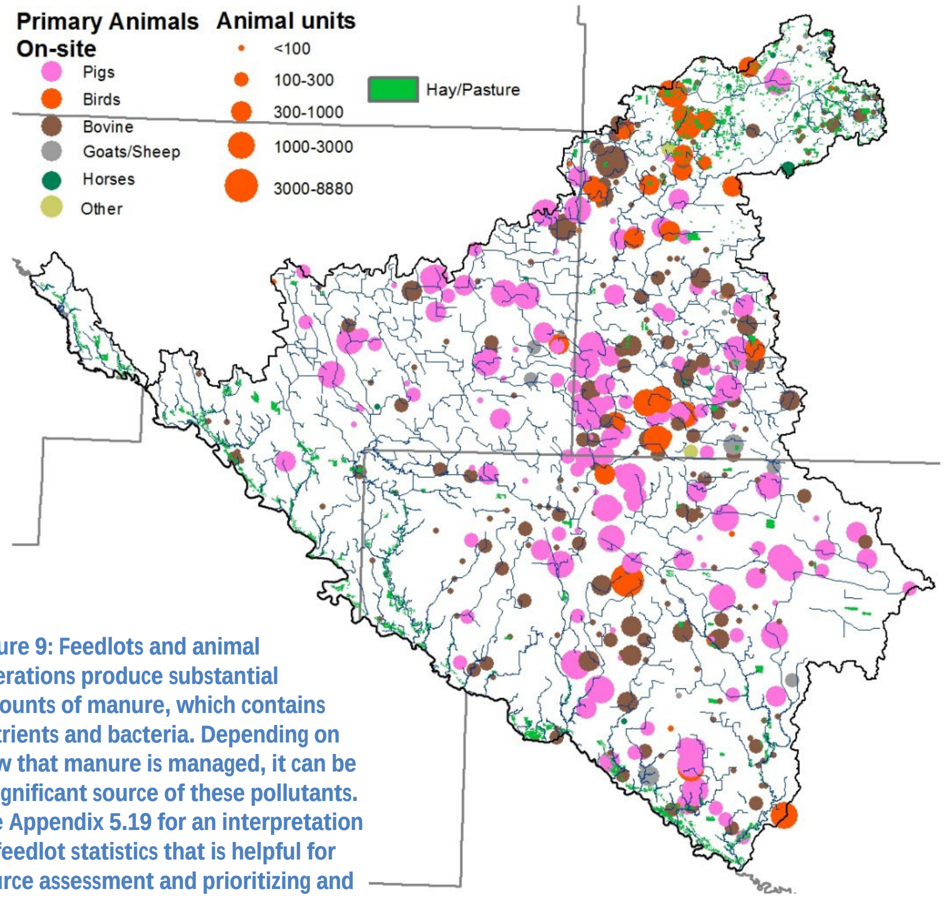


Figure 9: Feedlots and animal operations produce substantial amounts of manure, which contains nutrients and bacteria. Depending on how that manure is managed, it can be a significant source of these pollutants. See Appendix 5.19 for an interpretation of feedlot statistics that is helpful for source assessment and prioritizing and targeting.

To determine the nonpoint pollutant and stressor contributions, multiple lines of evidence were compiled and reviewed. In addition to information presented above, the compiled information (see Appendix 5.13) includes state and basin-level reports, model studies, and field and watershed data. Because this information did not always apply directly to the Hawk Watershed (for instance, basin level data applies to the larger Minnesota River Basin as a whole), the WRAPS workshop attendees were asked to review and use this information, applying their professional judgment and local knowledge, to develop source assessments specifically for the Hawk Watershed. In this process, WRAPS workshop attendees were able to apply their knowledge of the watershed including: land uses, common farming and urban practices, and programs and policies.

The source assessments created by the WRAPS workshop attendees were the basis for the final presented source assessments. However, small adjustments were made in some cases to ensure all likely sources were included and to provide consistency. Refer to Appendix 5.14 for the workshop and final source assessment results. These source assessments represent the watershed area as a whole and estimate the portions of the total load delivered over the past 10 years. Source assessments for individual stream reaches and lakes will vary according to the land use, land management practices, and landscape features in that particular area. However, the watershed-scale source assessment provides a good understanding of sources in the watershed and a good starting point for more specific source assessment work.

The Watershed Approach starts a new iteration every 10 years, each time striving for more refined and widespread analysis. Therefore, source assessments will be revisited and revised with each iteration to ensure that new data and science are incorporated and landscape changes are reflected.

2.1.4 Goals & Targets Overview

The water quality goals presented for the Hawk Watershed synthesize multiple layers of water quality goals into one watershed-wide goal, with individual stream reach or lake goals illustrated where possible. These individual goals were developed using the *Hawk Creek Watershed TMDL* (MPCA 2016b) and the *Long and Ringo Lake TMDL* (MPCA 2011c). The goals considered to set the watershed-wide goal include: restoration of water quality to meet TMDLs within the watershed, protection of water quality to prevent degradation, and restoration and protection of downstream waters including the Minnesota River Sediment Reduction Strategy (MPCA 2015h), the Lake Pepin Phosphorus Reduction Project (MPCA 2016a), and state-level and national-level goals such as the Minnesota State Nutrient Reduction Strategy (MPCA 2015j).

The goals for each pollutant and stressor are illustrated in maps, where the individual water body's contributing area/watershed is delineated and shaded according to its goal. Darker colors of grey correspond to higher pollutant/stressor reductions and lighter colors correspond to lower reductions, with white illustrating areas in need of protection. Likewise, water bodies in red are in need of restoration and those in green are in need of protection. Specific stream reach and lake goals were calculated in the TMDLs (see Appendix 6 for a TMDL summary) and illustrated in the goals maps. Goals for areas without ample data to specify an individual stream reach or lake goal reflect the watershed-wide goal.

The 10-year targets for this iteration of the WRAPS report were developed in collaboration with the WRAPS workshop attendees and local technical conservation staff. At one WRAPS workshop, information on each pollutant/stressor was reviewed (goal and sources) and groups were asked to discuss their knowledge of the pollutant/stressor along with local and downstream expectations. From this, each small group made a recommendation for a 10-year target for an assigned pollutant/stressor. Then, technical staff were asked to review this goal and provide their best professional judgment in recommending a 10-year target. Finally, the medians of the technical staffs' recommended 10-year targets were selected as the 10-year targets that are presented in this report.

The years to achieve the total goal as presented in this iteration of the WRAPS report was also developed in collaboration with local technical conservation staff. Like the 10-year target, each technical staff was asked to submit an estimated number of years to meet the water quality goal for each pollutant/stressor. The median value of the submitted goals was selected as the "years to goal" as presented in the strategies table in Section 3.3.

The goals may be reassessed in future iterations of the Watershed Approach due to changes in water body conditions reflected by new data, or due to changes in standards or state-level goals. Interim water quality "10-year targets" are set and allow opportunities to adaptively manage implementation efforts. With each iteration of the Watershed Approach, progress will be measured, goals will be reassessed, and new 10-year targets will be set.

2.2 Identified Pollutants and Stressors

This section looks at each of the identified pollutants and stressors in detail, describing: the extent of the pollutant/stressor, the sources or causes of the pollutant/stressor, what areas may be contributing higher amounts of the pollutant/stressor, and the amount of pollutant/stressor reduction that is necessary to meet water quality goals. Often times, pollutants and stressors, along with their causes or sources, can be complex and interconnected. Furthermore, an identified stressor can be more of an effect than a cause, and will therefore have additional stressors and/or sources driving the problem. An example: a commonly identified stressor is degraded habitat; one common cause of degraded habitat is excess sediment; one common cause of excess sediment is stream bank erosion; one common cause of the stream bank erosion is altered hydrology, which is another commonly identified stressor.

2.2.1 Altered Hydrology

Altered hydrology can directly harm aquatic life by affecting the amount of water in the stream; both too little and too much stream flow impact aquatic life. Furthermore, altered hydrology accelerates the movement and amount of other pollutants and stressors (nutrients, sediment, etc.) to water bodies.

Hydrology (USGS 2014b) is the study of the amount of and way that water moves through the landscape. Altered hydrology refers to changes in hydrologic parameters including: stream flow, precipitation, drainage, impervious surfaces, wetlands, stream paths, vegetation, soil conditions, etc. Hydrology is interconnected in a landscape; when changes are made to one hydrologic parameter, there are responses in other hydrologic parameters. For instance, tile drainage quickly removes ground water from the soil profile, increasing the total volume and accelerating the timing of water inputs to rivers. Changes in stream flow are symptoms of this and other changes in hydrologic parameters.

The landscape in the Hawk Watershed has an especially high rate of ditching: 84% of the stream miles with definable channels are ditches in the Hawk Watershed, compared to a 67% average ditching rate for the basin (see Appenix 4.7). Ditches typically lack many natural stream features: they tend to be simple, straight, and uniform in depth. In contrast, natural streams tend to be complex, meandering, and variable in depth. Ditch features result in unnatural flow dynamics such as excessive flow speed and have poor geomorphic and biologically-important features (lack of riffle and pool formation and excessive bank failures).

2.2.1.1 Status

Of the four bio-impaired stream reaches, altered hydrology was identified as a stressor in three and ruled out in one (Table 4, Figure 10). Specifically, excessive/peak stream flow, low/absent stream flow, and channelization were found to be directly impacting the bio-impaired streams. Altered hydrology is only investigated when a bio-impairment is identified, but the sources of altered hydrology (discussed later in this section) are common across the watershed. Therefore, altered hydrology is likely negatively impacting water quality watershed-wide, despite being identified as a stressor in only select locations. More information will be available once TALU is applied.

Table 4: Stream reaches assessed for altered hydrology

Stream	Reach (AIUD-3)	Assessment
Unnamed creek	566	x
Smith Creek (CD 125A)	617	√
County Ditch 119	687	x
County Ditch 36	716	x

√ = not a stressor
x = stressor

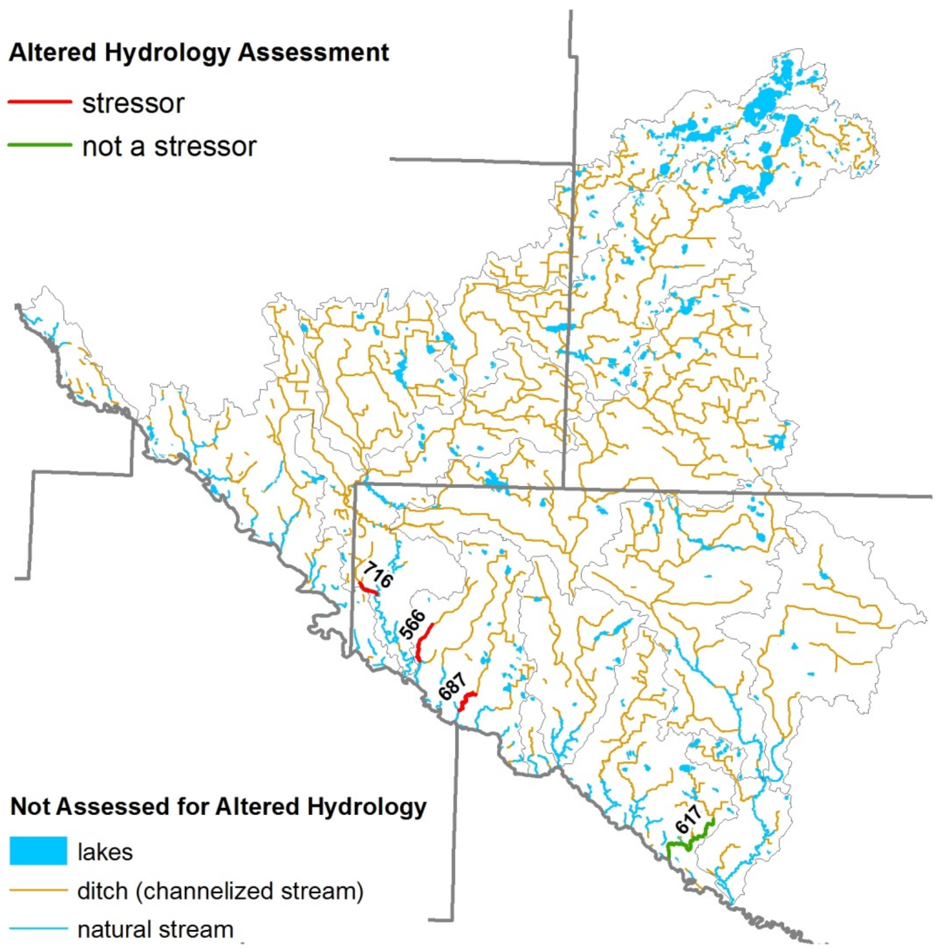


Figure 10: Stream reaches assessed for altered hydrology and the assessment results

From a statewide perspective (Figure 11), the Hawk Watershed has moderate to moderately high amount of precipitation, runoff, and runoff ratio. These hydrologic parameters are useful data for tracking hydrologic status and changes through time.

2.2.1.2 Sources

There are several causes of altered hydrology in the Hawk Watershed. These causes range from landscape and climate changes, to crop and vegetative changes, to soil and drainage changes. This subsection discusses the various causes of altered hydrology and the pathways in which water travels from the land to water bodies. This information is necessary to determine how to mitigate the negative impacts of altered hydrology.

Figure 12 compares the streams, lakes, and wetlands of pre-European settlement to those of today. In 1855, the natural landscape was speckled with prairie potholes (EPA 2015), which provided water storage across the landscape. This water storage kept most precipitation on the landscape to be used by plants or to recharge groundwater, which resulted in relatively few streams. Today, most of the prairie potholes have been drained or highly altered. Vast drainage networks have replaced the prairie potholes to move water off the landscape, into ditches, and down to the Minnesota River.

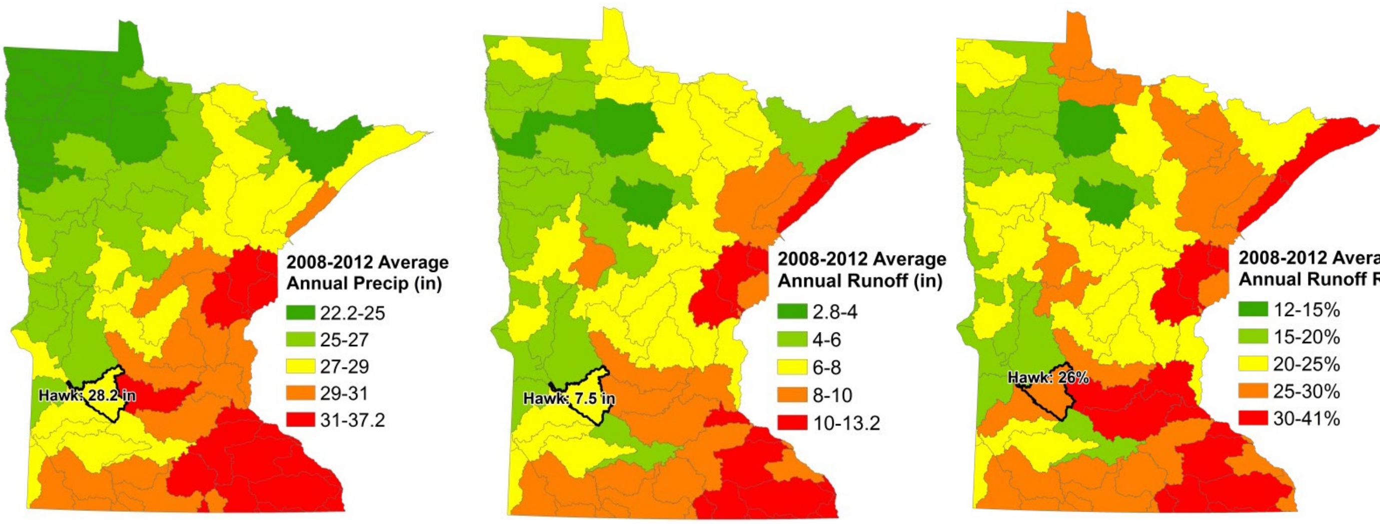


Figure 11: Precipitation, runoff, and the runoff ratio (or the ratio of precipitation that leaves the watershed as river flow) are hydrologic parameters. Precipitation is a result of climate and weather. Runoff, however, is influenced by precipitation but also by several hydrologic parameters: slope, soil types, long-term storage, etc. These data are from the WPLMN and State of Minnesota Climatology (DNR 2015c).

The extensive drainage networks that replaced wetlands across the landscape create a "short-circuit" in hydrologic conditions. Water draining from farms and developed areas is transferred via subsurface tile drainage networks in fields and subsurface storm sewer networks in cities. Subsurface drainage networks then drain to an extensive network of human-made ditches before reaching natural streams.

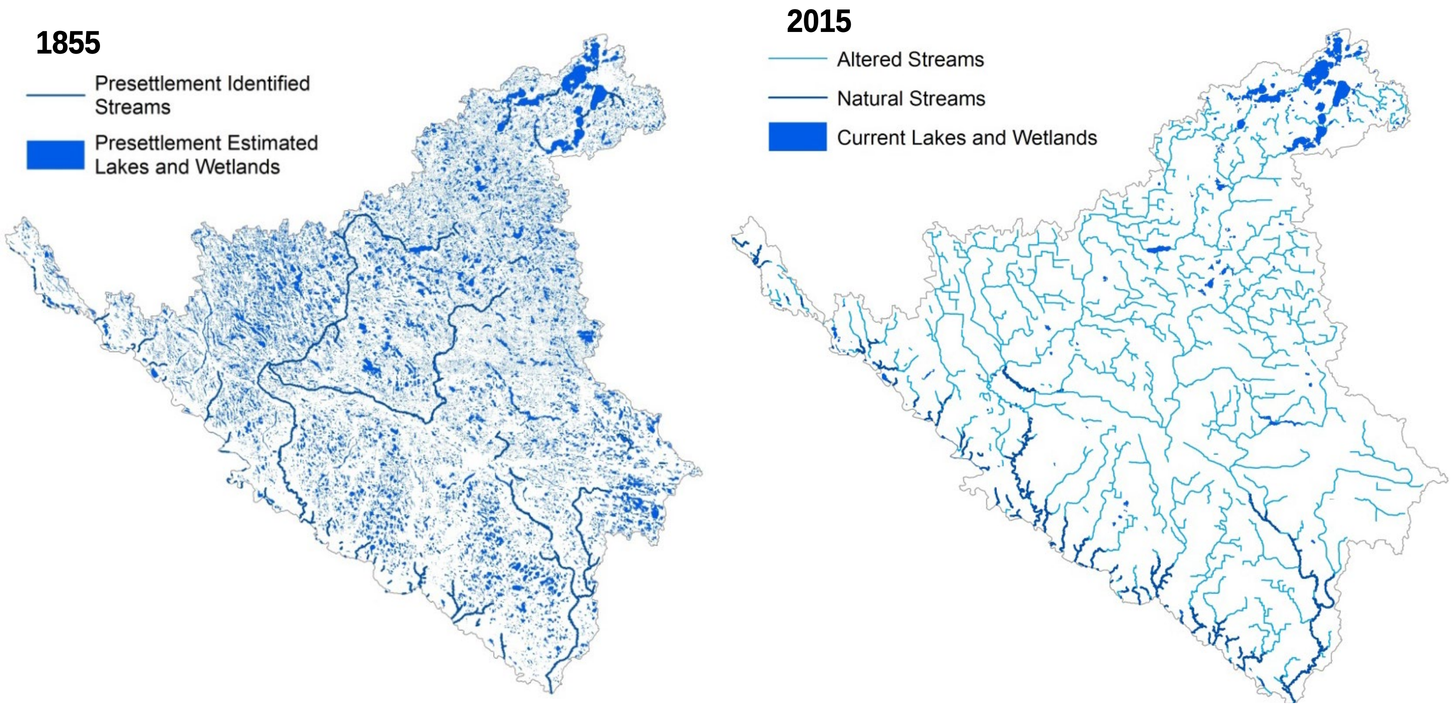


Figure 13: Before European settlement (1855), there were roughly 120,000 acres of lakes and wetlands and 190 stream miles. Today, there are roughly 12,000 acres of lakes and wetlands, 150 natural stream miles, and 770 altered/ditched stream miles. 1855 data are from the historic plat map (MnGeo 2011), the National Wetland Inventory, (USFW 2016) and the Restorable Wetland Inventory (USFW 2009).

Changes in the amount and timing of evapotranspiration (ET) affect hydrology. Figure 13 illustrates the monthly average ET of crops, grass, and wetlands and the monthly average precipitation. The monthly average precipitation corresponds more closely to the ET of perennial crops such as hay and alfalfa. In contrast, corn and soybeans use much less water than precipitation supplies in the spring and much more than is supplied later in the summer. Therefore, a landscape that is almost exclusively corn and soybeans is less synced with historic precipitation patterns and more prone to exacerbate high flows in the spring and low flows in the later summer.

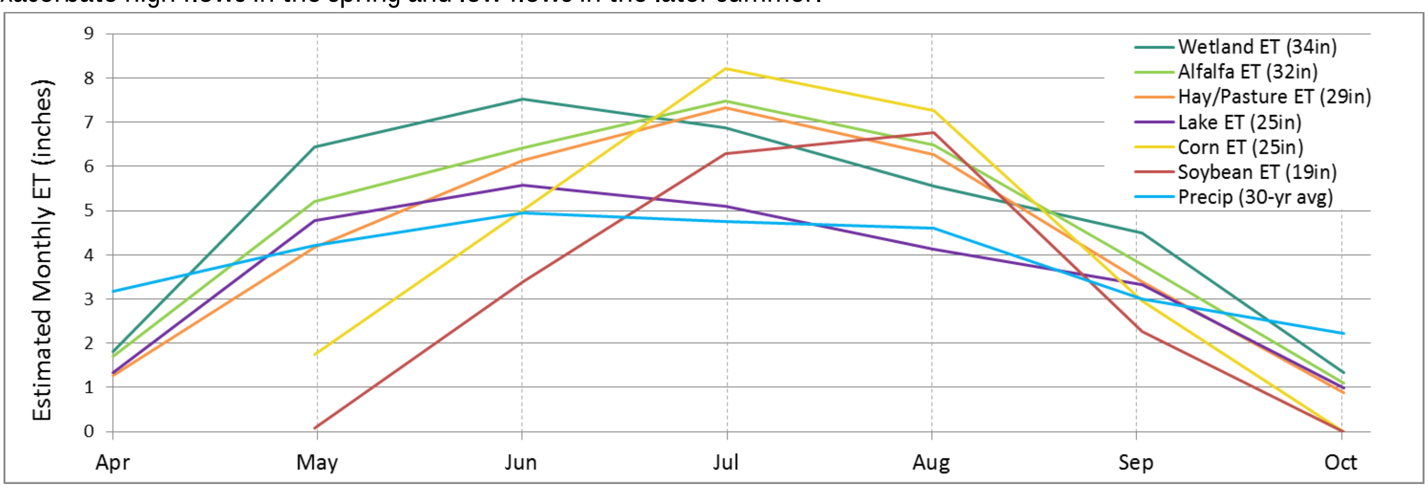


Figure 12: Since European settlement, prairies and wetlands were replaced first by diverse crops and then by corn and soybeans. The total annual ET rates (indicated in the figure legend) of these replacement crops are smaller and the timing of ET through the year has shifted. These changes affect the hydrology of the watershed. See Appendix 5.10 for data sources and calculations. Roughly 10% of the lake/wetland area remains and ditch/stream miles have increased by 500%.

Subsurface agricultural tile drainage is widespread in the Hawk Watershed. Based on a Geographic Information System (GIS) analysis, 32% of the watershed is likely tile drained, 28% may be tile drained, and 40% is not likely tile drained

(Figure 14). The WRAPS Workshops attendees estimated that closer to 60% of the watershed was likely tile drained based on their knowledge and observation of the watershed.

Agricultural drainage negatively impacts watershed hydrology unless mitigated. Tile drainage systems are typically designed to drain water from fields within a couple days of a precipitation event. With recent crop and yield changes, the application and density of subsurface drainage tile has increased substantially. This has further decreased the ability of the landscape to hold (within wetlands and soils) and use water (by ET of a diverse plant community).

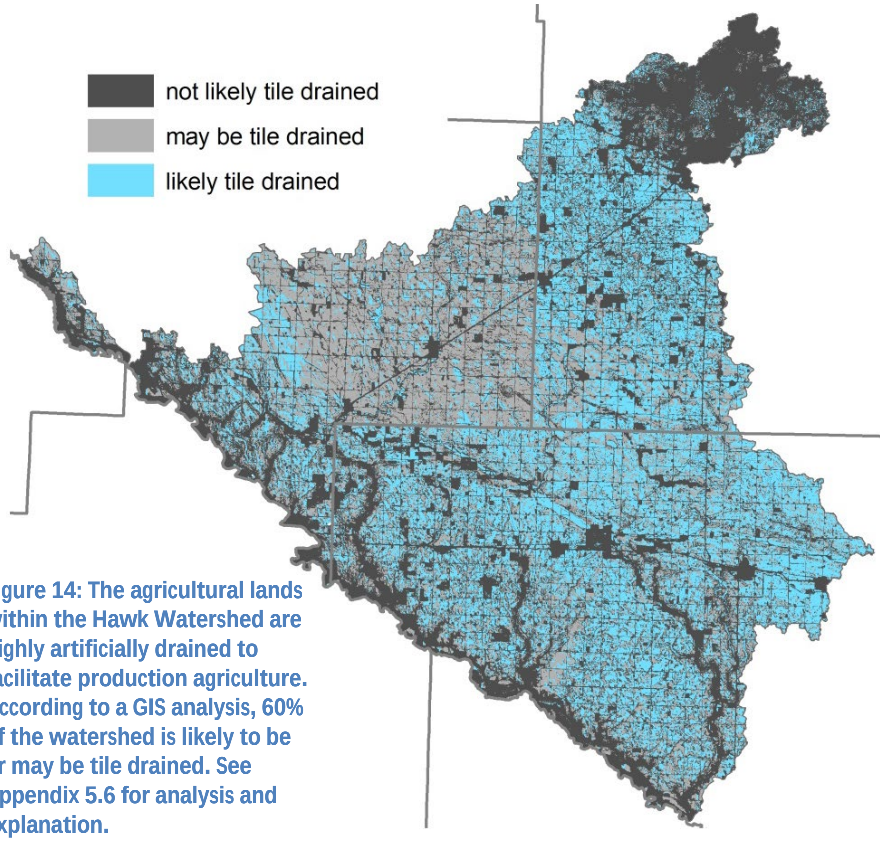


Figure 14: The agricultural lands within the Hawk Watershed are highly artificially drained to facilitate production agriculture. According to a GIS analysis, 60% of the watershed is likely to be or may be tile drained. See Appendix 5.6 for analysis and explanation.

Artificial drainage coupled with crop and other landscape changes has created flashy stream systems: very high flows immediately following precipitation events. Foufoula-Georgiou et al. (2015) present differences in flow in 1971 and 2002 in the neighboring Redwood River (Figure 15). Both years had similar precipitation totals. However, between 1971 and 2002, when substantial crop and tile changes occurred, the annual peak flow quadrupled and the total annual flow nearly tripled. Figure 15 illustrates that dry season base flow has increased, which is notable since low flow was identified as a stressor.

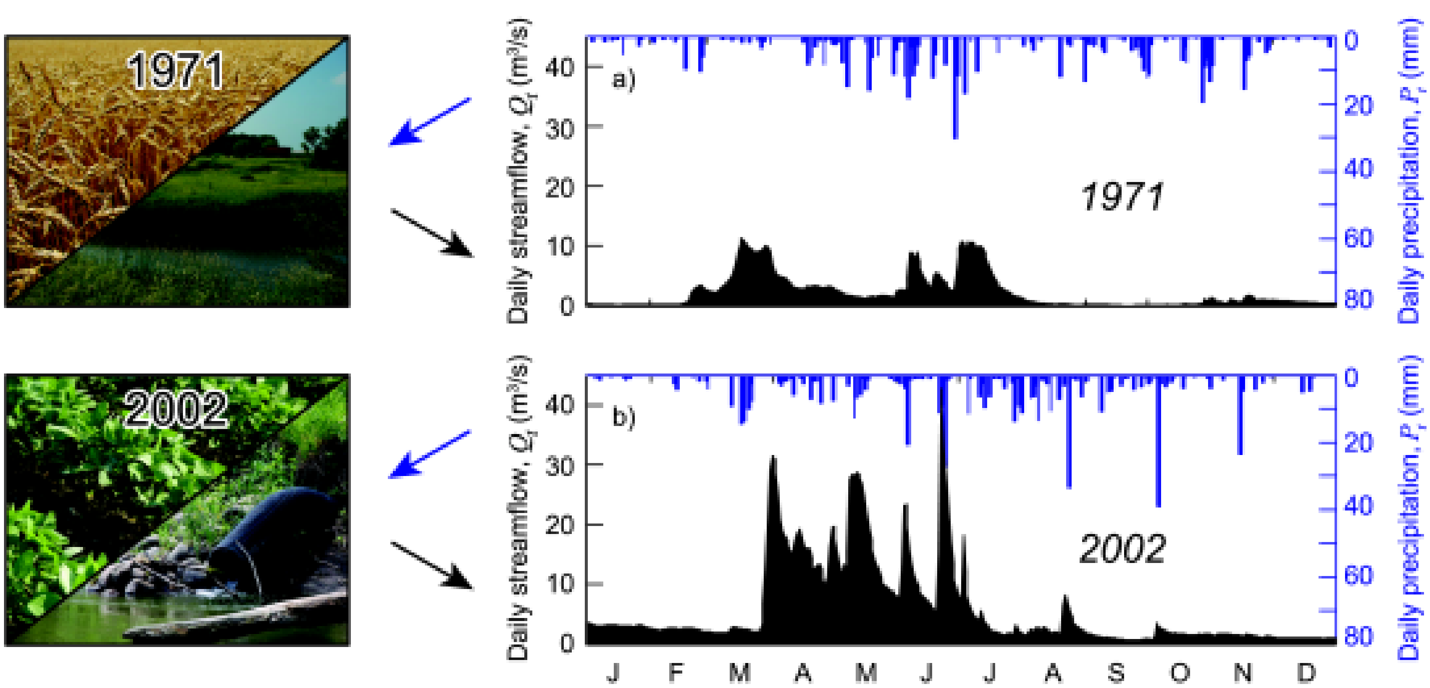


Figure 15: Crop and drainage changes have increased the peak flow and total flow volume of streams as illustrated by this data from the Redwood River, a close watershed with a more extensive flow data set than available in the Hawk Watershed. The total precipitation in 1971 in the watershed was 24" and in 2002 was 25", a 4% increase. The average stream flow rate for the same years was 2.3 and 6.0m^3/sec (36,000 and 95,000 gallons per minute), respectively, a 160% increase. Image from Foufoula-Georgiou et al. 2015.

There are two reasons that explain this seeming discrepancy: 1) larger streams are less likely than smaller streams to run dry since they accumulate waters from much larger areas, and 2) even when historic increases in baseflow have been observed, the streams have gone through such huge geomorphic changes due to higher and more frequent flow events, that the channel geometries are vastly different. Namely, streams are typically much wider than they were historically, and it now takes much more flow during low flow conditions to provide enough water for the stream to remain healthy.

Tile drainage, in particular, has been identified as a primary cause of stream flow changes over the last few decades, which is after many crops changed from small grains and hay to soybeans. Several research papers find that roughly 60% or more of increases in stream flow between mid- and late-20th century in agriculturally dominated areas of the Midwest and Southern Minnesota is due to agricultural drainage changes: *Twentieth Century Agricultural Drainage Creates More Erosive Rivers* (Schottler et al. 2013), Temporal Changes in Stream Flow and Attribution of Changes… (Gyawali, Greb, and Block 2015), and Quantifying the Relative Contribution of the Climate and Direct Human Impacts… (Wang and Hejazi 2011).

While human-altered hydrology negatively impacts water resources, the historical perspective and agricultural and infrastructural benefits of drainage are important to recognize. European settlers drained wetlands to settle and farm lands. For decades, the government further encouraged drainage to reduce pests, increase farmable lands, and clear lands for roads and infrastructure. Today, drainage is still encouraged by some agricultural interests to increase crop production. All in all, drainage is sometimes necessary for crop production and development; however, drainage impacts can be better managed to mitigate the impacts to water bodies.

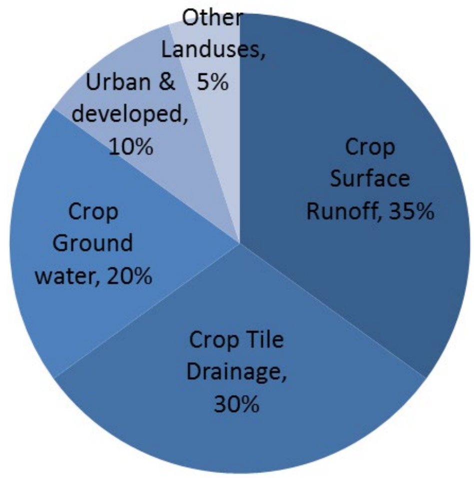


Figure 16: Water bodies are fed by precipitation. Precipitation falls across the landscape and travels to water bodies via different pathways including: surface runoff, groundwater flow, or artificial subsurface drainage. An estimated 85% of the water in water bodies is from croplands, which have three pathways to deliver water. The pathways for urban and developed and other land uses are not broken out since these land uses have relatively smaller total contributions.

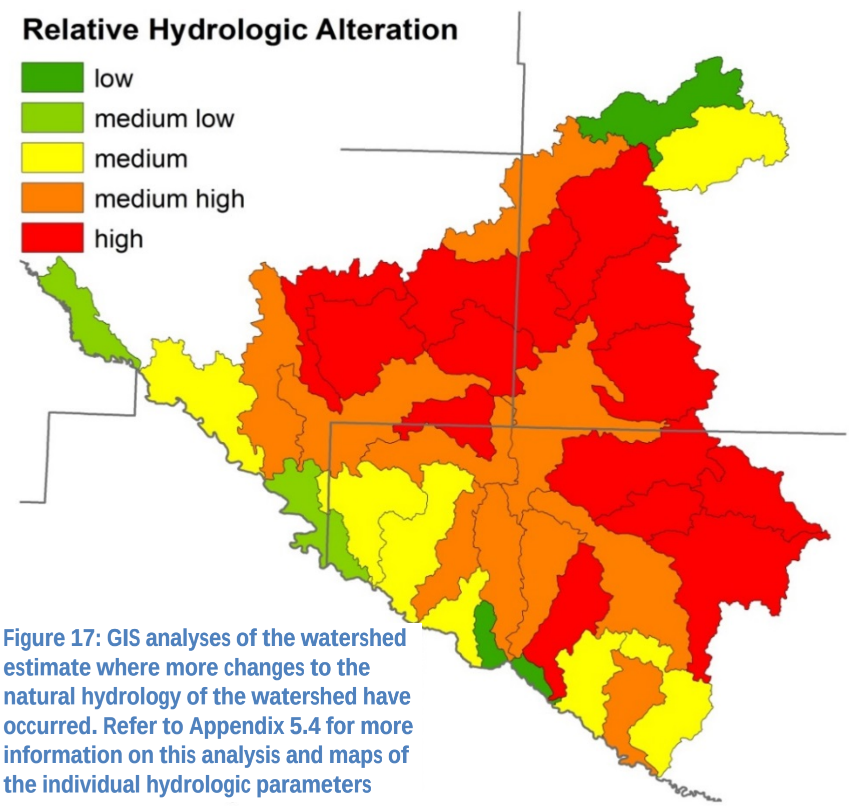


Figure 17: GIS analyses of the watershed estimate where more changes to the natural hydrology of the watershed have occurred. Refer to Appendix 5.4 for more information on this analysis and maps of the individual hydrologic parameters

Water in water bodies originates as precipitation on the landscape. Most precipitation is returned to the atmosphere by evapotranspiration; the remaining water travels to water bodies via different pathways. Pathways for water to travel to water bodies include: surface runoff, groundwater flow, or artificial subsurface drainage such as drainage tile or storm sewer networks. Numeric estimates of the Hawk Watershed's land uses' contributions of water to water bodies are presented in Figure 16; refer to the Sources Overview in Section 2.1 and Appendices 5.13 and 5.14 for more details.

The relative amount of hydrologic alteration per subwatershed areas was estimated using GIS. Hydrologic factors considered in the analysis presented in Figure 17 include: 1) the estimated percentage of land area that is tile drained, 2) the percentage of stream length that is channelized/artificially straightened, 3) the percentage of watershed area where wetlands were drained, 4) the percentage of land in non-perennial vegetation, 5) the percentage of land covered in impervious surfaces, and 6) the number of road crossings per stream length. See Appendix 5.4 for maps of the individual hydrologic factors per subwatershed.

2.2.1.3 Goal & 10-year Target

For watershed conditions to improve, many of the hydrologic alterations that have been made and most of the alterations that continue to be made must be mitigated. Furthermore, the *Sediment Reduction Strategy for the Minnesota River Basin* (MPCA 2015h) identifies flow reduction across the Minnesota River Basin as a key strategy to reducing sediment.

Based on the identified stressors, a comparison of the altered hydrology conditions in the Hawk Watershed and the Yellow Medicine Watershed (see Appendix 5.5), and the basin level sediment reduction strategy, the selected hydrology goal is: a 25% reduction in annual flow volume (or yield), with a 25% decrease in 2-year peak flow and duration, and an increase in dry season base flow. The goal and known impairments are illustrated in Figure 18. Compared to the 2004 to 2013 baseline period, this goal represents a drop in the average annual water yield from 5.9 to 4.4 inches (see Appendix 5.9 for baseline calculation). The reach not stressed by altered hydrology has a protection goal. This goal is revisable and will be revisited in the next iteration of the Watershed Approach. The selected 10-year target is a 5% reduction in the peak and annual flow and an increase in base flow.

Decreases in the total annual flow volume should focus on decreasing peak flows, shifting flow timing to the dry season, and maintaining the biologically and geomorphologically-important dynamic properties of the natural hydrograph. Strategies to accomplish these tasks must increase ET to reduce the total flow volume, and store and infiltrate water on the landscape to increase ground water contributions (base flow) to streams during dry periods. Strategies and methods to prioritize regions to address altered hydrology are summarized in Section 3.

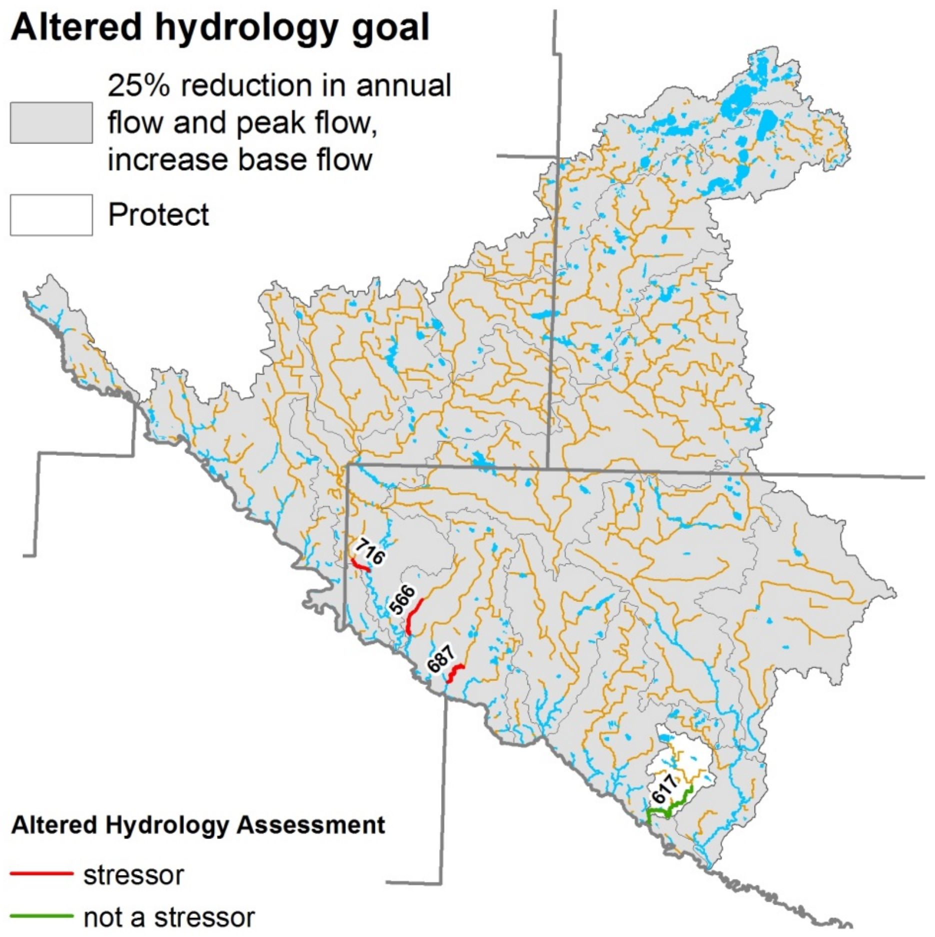


Figure 18: Watershed-wide flow goals were selected for the watershed. These altered hydrology goals address total annual flow, peak flow, and dry season base flow. Altered hydrology was found to stress aquatic life in investigated reaches and is accelerating other pollutant contributions across the watershed. Addressing this stressor watershed-wide is important to stabilizing and improving watershed conditions.

2.2.2 Sediment

Sediment and other suspended material in water impacts aquatic life by: reducing visibility, which reduces feeding, clogging gills, which reduces respiration, and smothering substrate, which limits reproduction. Sediment also impacts downstream waters used for navigation (larger rivers) and recreation (lakes). While technically the water quality standard looks at the TSS, most TSS is composed of sediment, and these words are used to refer to the same issue.

2.2.2.1 Status

Of the stream reaches monitored to assess if sediment is a pollutant: 14 were impaired, 6 were supporting, and 13 were inconclusive. Of the bio-impaired stream reaches, sediment as a stressor was identified in one, ruled out in one, and could not be determined in two. Table 5 and Figure 19 illustrate the stream reaches that were assessed for sediment.

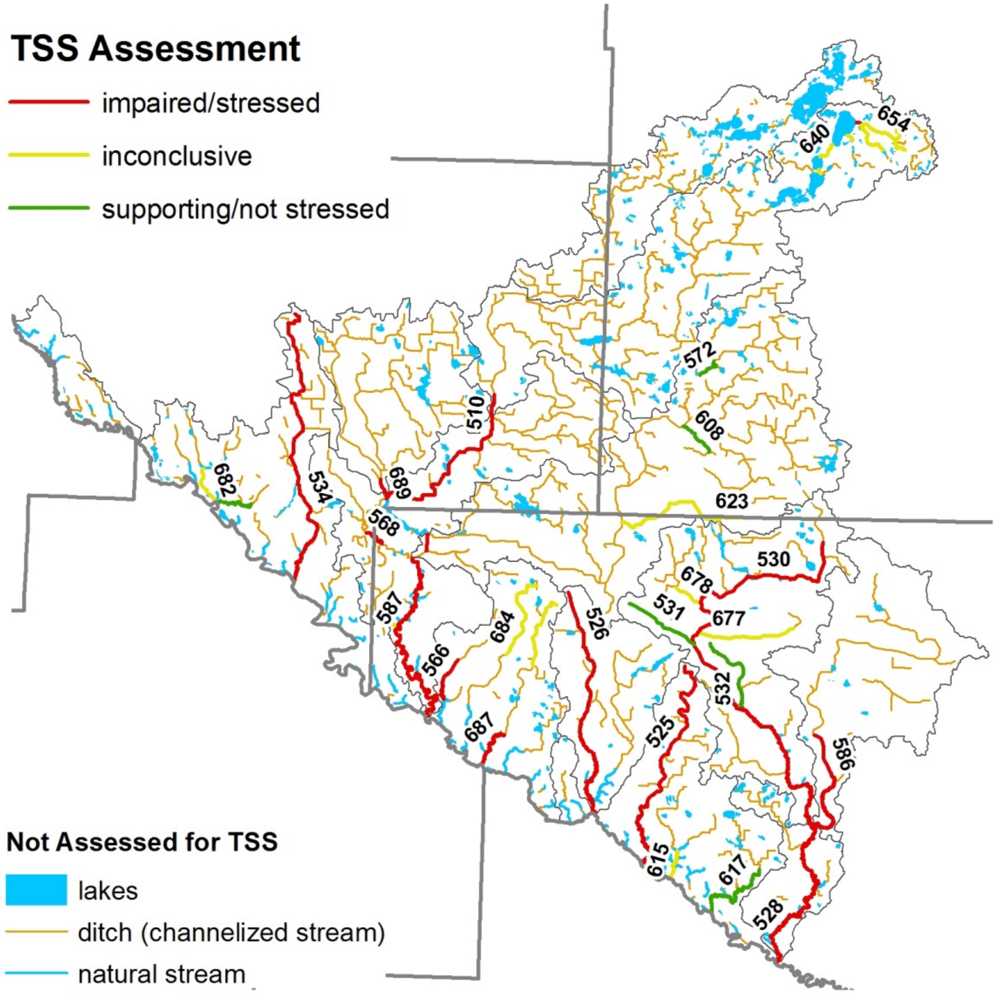


Figure 19: Stream reaches assessed for TSS and the assessment results

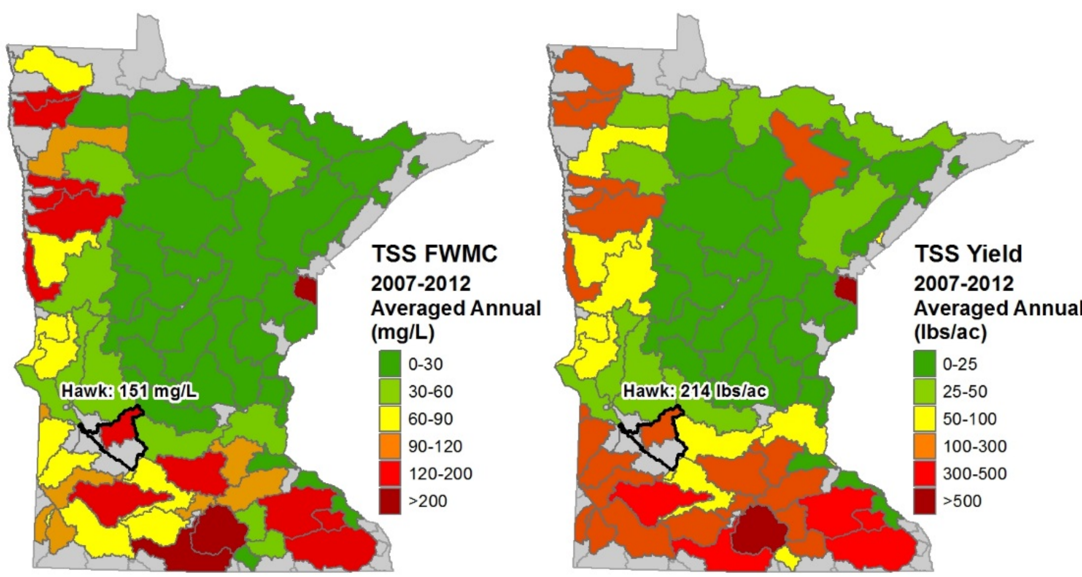


Figure 20: Hawk Creek has a high annual sediment yield (the total amount leaving the watershed), losing over 200 pounds per acre on average. The averaged concentration over the same period was more than double the water quality standard for TSS. Data are from the WPLMN.

From a statewide perspective, the Hawk Watershed has a high yield and flow-weighted mean concentration (FWMC) of TSS (Figure 20). Data from the outlet of Hawk Creek consistently show that the river concentration often spikes above the 65mg/L standard.

Table 5: Stream reaches assessed for sediment

Stream	Reach (AUID-3)	Assessment
Hawk Creek	510	x
Timms Creek	525	x
Sacred Heart Creek	526	x
Beaver Creek	528	x
Beaver Creek, West Fork	530	x
County Ditch 37 (1)	531	√
County Ditch 37 (2)	532	√
Palmer Creek (CD 68)	534	x
Unnamed creek	566	x
Hawk Creek	568	x
Unnamed creek	572	√
Hawk Creek	587	x
Unnamed ditch	589	x
Unnamed (Eagle Lake Inlet)	602	x
Unnamed ditch	608	√
Brafees Creek	610	√
Middle Creek	615	?
Smith Creek (CD 125A)	617	√
Judicial Ditch 16	623	?
Unnamed (Hawk Creek)	640	?
Unnamed (Hawk Creek)	642	?
Unnamed creek (CD 119)	648	x
Unnamed creek	653	?
Unnamed creek	654	?
Unnamed creek	656	?
Unnamed creek	657	?
County Ditch 59	677	?
County Ditch 17A	678	?
County Ditch 36A	682	?
County Ditch 116	684	?
County Ditch 119	685	?
County Ditch 119	687	x
County Ditch 11	689	x
County Ditch 36	716	?

√ = supporting/not a stressor
? = inconclusive (need more data)
x = impaired/stressor

2.2.2.2 Sources

The primary sources of sediment as discussed in *Identifying Sediment Sources in the Minnesota River Basin* (MPCA 2009a) can be summarized into three groups: upland, channel, and ravine. Point source contributions for the years of 2009 through 2013 totaled less than 0.25% of the Hawk Creek Watershed's sediment load.

Upland sediment contributions typically happen when bare soils erode after rains or during snowmelt. Upland erosion includes farm field surface and gully erosion, sediment that is washed away from roads and developed areas, and surface erosion from other areas.

Ravines occur in locations where a flow path drops elevation drastically. Because of the knick-zone created in the Minnesota River Valley (refer to Background section), ravines are common through this area. While some ravine erosion is natural, oftentimes the natural erosion rate is greatly accelerated when drainage waters from farms and cities are routed down the ravine. In this way, altered hydrology can cause excessive ravine erosion.

Channel sediment contributions are dominated by stream bank and bluff erosion, but also include channel bed and other material in or directly adjacent to the water body. While some amount of channel migration and associated bank/bluff erosion is natural, altered hydrology has substantially increased stream flow, causing excessive bank/bluff erosion. The Minnesota Department of Natural Resources (DNR) (2010) discusses the multiple causes of Streambank Erosion, including how altered hydrology influences stream bank erosion.

Not only does altered hydrology directly increase stream bank erosion, the maintenance of drainage ditches also increases erosion from these channelized streams. Ditch maintenance (Figure 21) entails cleaning sediment and vegetation out of the ditch to maintain the designed ditch cross-section. The loss of vegetation and material from the ditch destabilizes the ditch, causing bank erosion from formerly protected areas of the ditch. Ditch clean-outs also remove the meanders, floodplains, and other natural stream conditions beginning to form within the channel. These clean-outs degrade multiple aspects of water body quality and can contribute excessive sediment for years.

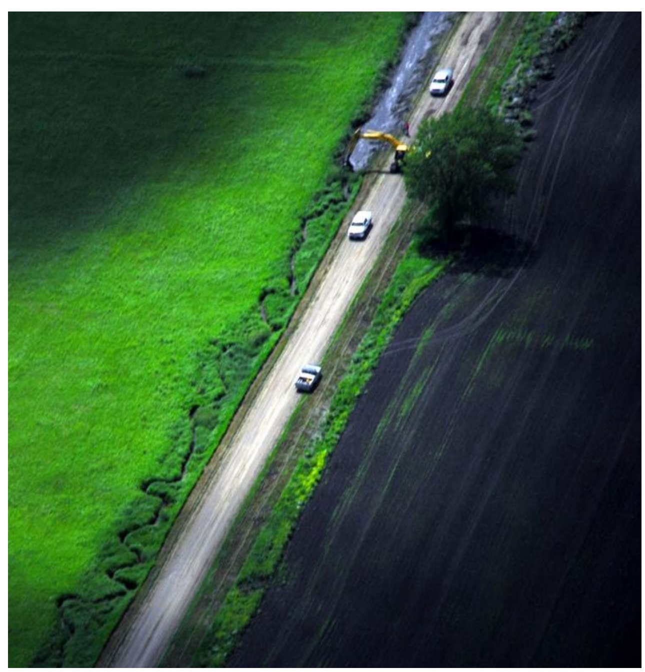


Figure 21: An excavator works down the ditch (top to bottom of picture), performing a ditch clean-out. The more natural conditions (vegetation, meanders, etc. visible in bottom of photo) are destroyed in the process. Photo from DNR 2015d.

A numeric estimate of the Hawk Watershed's sediment sources is presented in Figure 22; refer to the Sources Overview in Section 2.1 for more details. The single largest sediment source was estimated to be channel erosion, which includes erosion from natural stream migration in addition to the unnaturally accelerated erosion due to altered hydrology, ditch clean-outs, and other human activities. Accelerated channel erosion should be mitigated to improve watershed conditions.

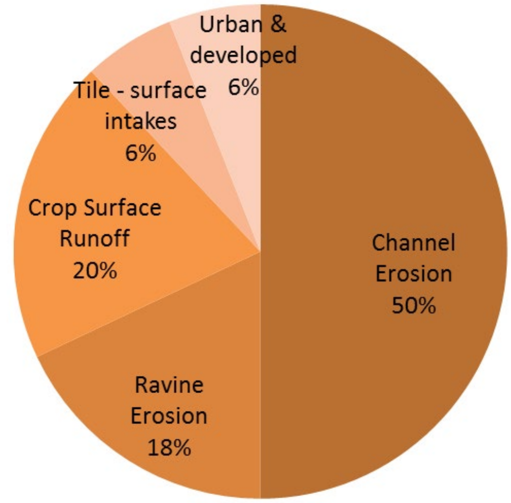


Figure 22: Channel erosion (stream and ditch bank erosion) is estimated as the largest source of sediment in the Hawk Watershed. Altered hydrology and ditch clean-outs are two human activities that accelerate this erosion.

2.2.2.3 Goal & 10-year Target

To calculate a watershed-wide TSS reduction goal, the 2009 to 2013 baseline period TSS FWMC at the watershed outlet was compared against the water quality standard. The TSS reduction goal presented in the *Sediment Reduction Strategy for the Minnesota River Basin* (MPCA 2015h) was also considered, in conjunction with the relative yield of Minnesota River Basin major watersheds. The selected watershed-wide goal is 50% reduction in sediment concentration and load. This goal is also the adopted goal for any region that does not have data to calculate an individual goal. This goal represents a drop in the TSS FWMC from 130 to 65 mg/L at the Hawk Creek outlet. Stream reaches that were analyzed in the TMDL have varied goals based on the data available for that reach. Individual subwatershed goals were calculated from TMDL data. The watershed goals and impairments are illustrated in Figure 23. These goals are revisable and will be revisited in the next iteration of the Watershed Approach. The reaches not stressed or impaired by sediment have a protection goal. WRAPS Workshop attendees selected a 10-year target of a 10% reduction in TSS FWMC. Strategies and methods to prioritize regions for sediment reductions are summarized in Section 3.

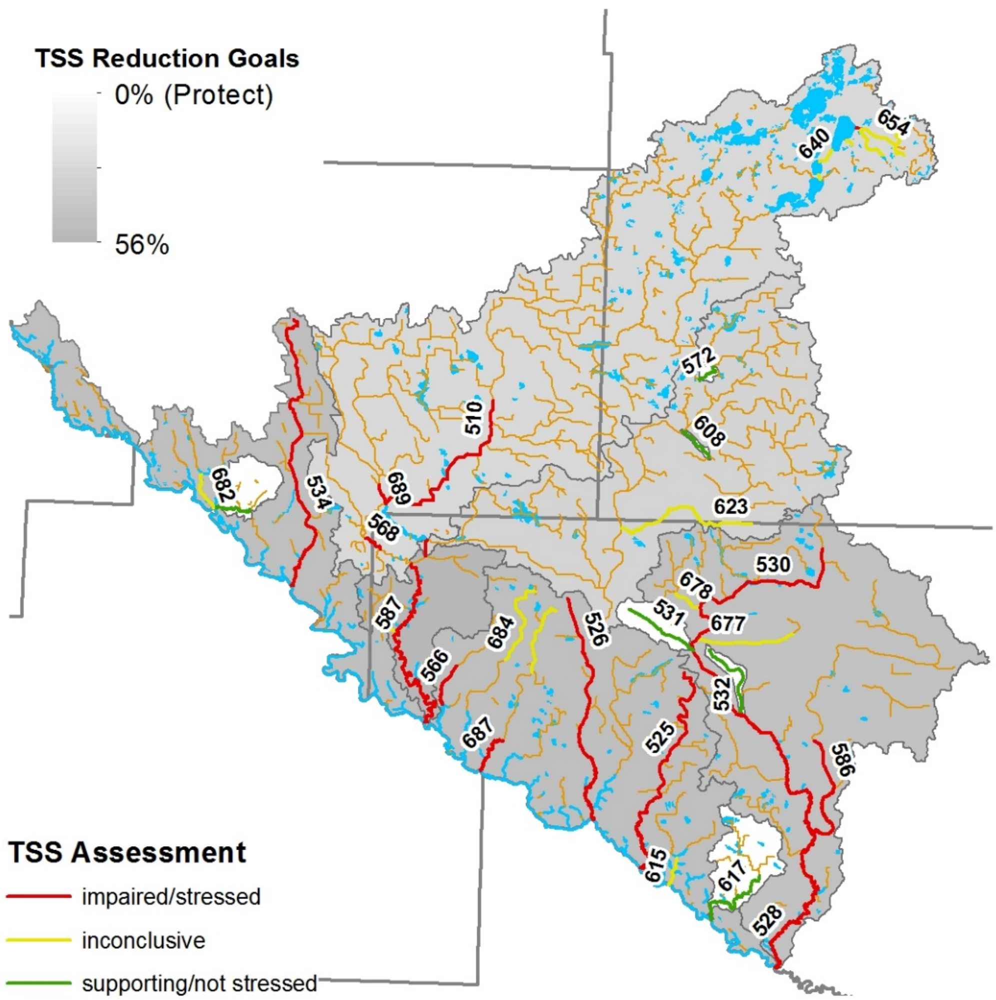


Figure 23: Sediment reduction goals were developed for the watershed as a whole (50% reduction) and by individual stream reach contributing areas where ample data were available (up to a 56% reduction). Contributing watersheds for areas found to meet sediment standards or found to not be stressing aquatic life have a protection goal.

2.2.3 Phosphorus

Phosphorus impacts aquatic life by changing food chain dynamics, impacting fish growth and development, increasing algae growth, and decreasing DO. Phosphorus impacts aquatic recreation in lakes by fueling algae growth, making waters undesirable, or even dangerous to swim in due to the potential presence of toxic blue-green algae.

2.2.3.1 Status

Of the lakes that were monitored to determine if phosphorus is a pollutant, six were impaired, six were supporting recreation, and six were inconclusive. Of the bio-impaired stream reaches, phosphorus as a stressor was identified in three and ruled out in one. Several lakes are starting to compile data for trends analysis, but at this time, trends have not been detected. (Table 6 and Figure 24).

Table 6: Lakes and stream reaches assessed for phosphorus

Lake	Assessment	Trend
Eagle	√	-
Foot	√	-
Henderson	√	?
Lindgren	?	?
Lindgren, West	?	?
Long	x	-
Olson	x	?
Point	√	?
Ringo	x	?
Saint Johns	x	-
Skataas	?	?
Solomon, East	?	?
Solomon, West	x	?
Swan	x	?
Twin, East	√	?
Twin, West	√	?
Unnamed (Hogan)	?	?
Willmar	?	?

Stream	Reach (AUID-3)	Assessment
Unnamed creek	566	x
Smith Creek (CD 125A)	617	√
County Ditch 119	687	x
County Ditch 36	716	x

√ = supporting/not a stressor
? = inconclusive (need more data)
x = impaired/stressor
\- = no trend detected

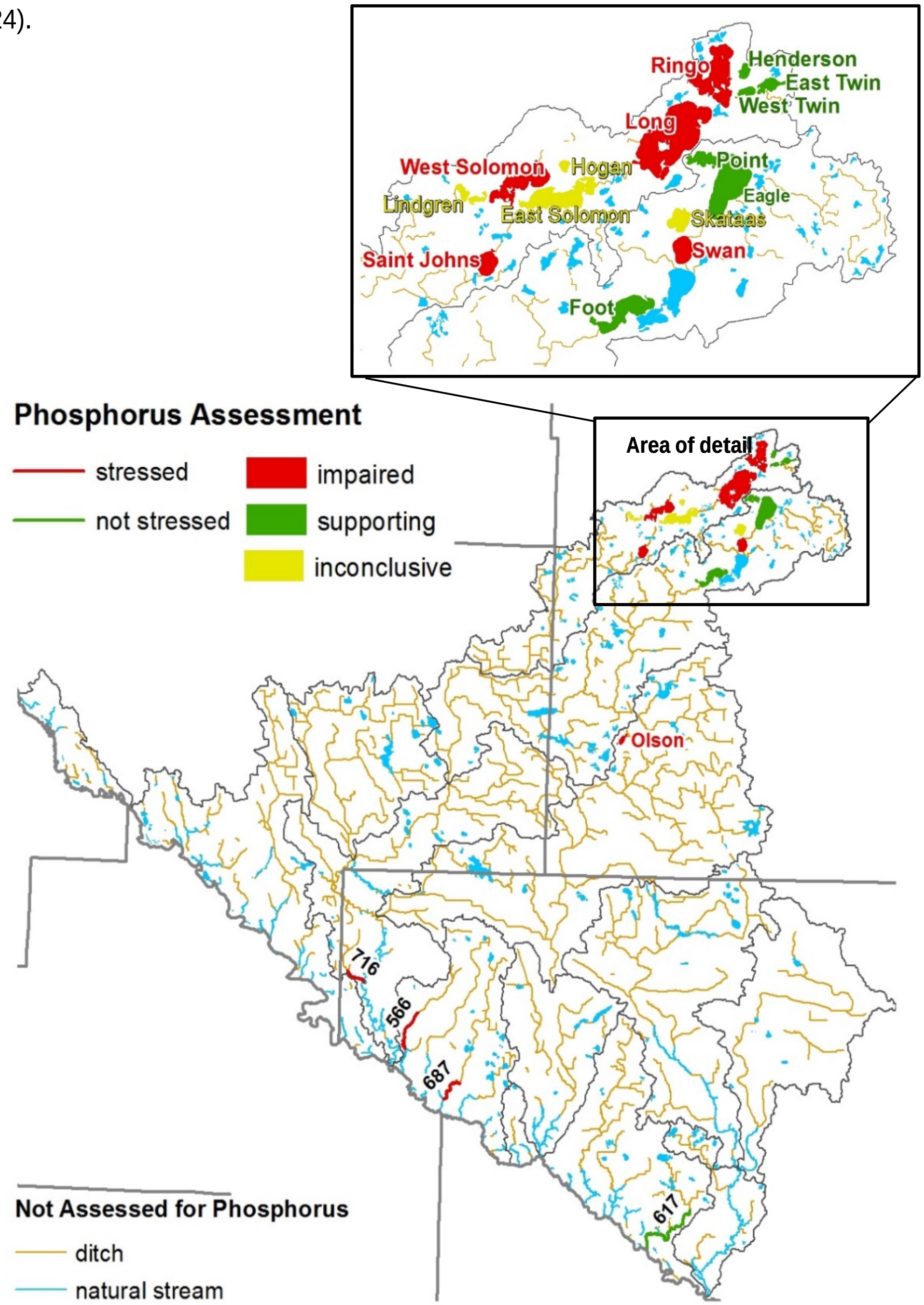


Figure 24: Streams and lakes assessed for phosphorus and the assessment results

From a statewide perspective (Figure 25), Hawk Creek's phosphorus concentration and yield are high. Data from the outlet of Hawk Creek consistently show that the river concentration often exceeds the new stream eutrophication standard of 0.15 mg/L. The newly adopted River Eutrophication Standards (RES) will be used for assessment in the second cycle of the Hawk Creek Watershed Approach.

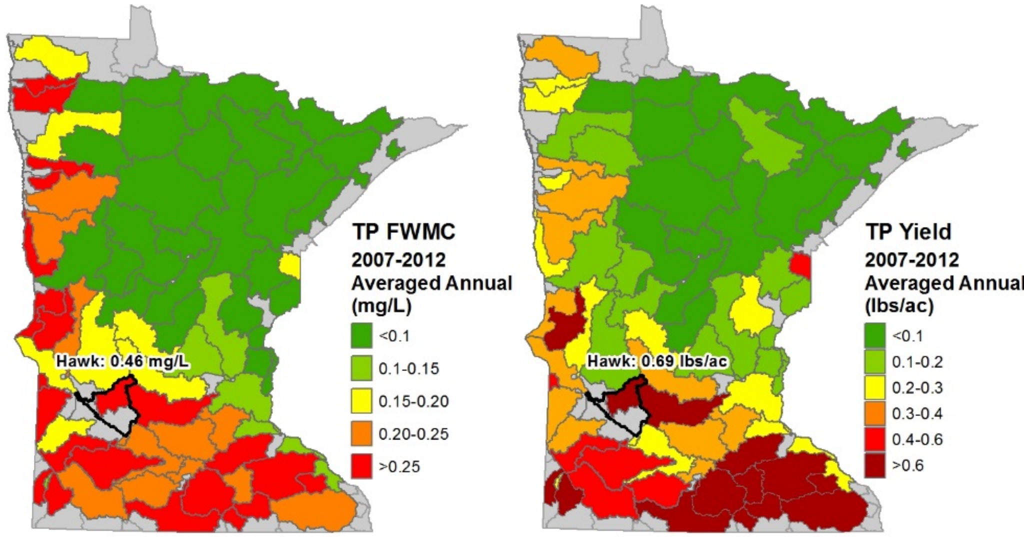


Figure 25: The Hawk Creek Watershed has a high FWMC and yield of TP compared to the rest of the state. Data from the WPLMN.

2.2.3.2 Sources

In the Hawk Watershed, phosphorus sources are dominated by nonpoint sources. Prior to 2011 in the Hawk Watershed, WWTP contributed roughly 25% of the phosphorus load. However, recent upgrades to Willmar's WWTP have greatly reduced point source phosphorus contributions. Since the recent upgrade, through years 2011 through 2013, roughly 10% to 15% of the watershed-wide phosphorus is from point sources (see Appendix 5.12).

A numeric estimate of the Hawk Watershed's phosphorus sources is presented in Figure 26; the identification of sources and amount of each source was determined through best professional judgment and local knowledge by WRAPS workshop attendees in the process described in section 2.1.3. Based upon this source assessment, agricultural land uses and drainage were estimated to be the largest source of phosphorus and most of the phosphorus leaving agricultural fields is from applied fertilizer and manure.

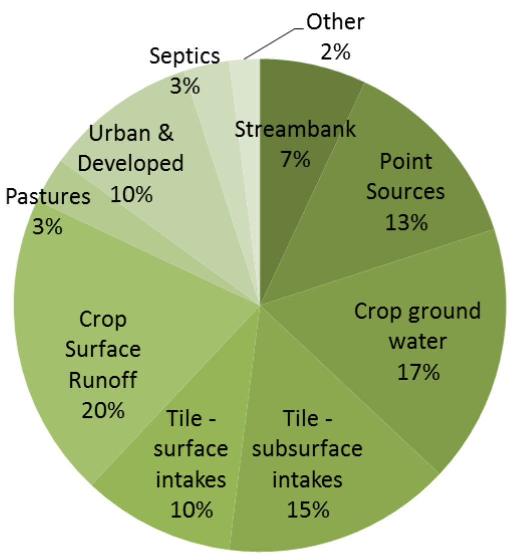


Figure 26: Crop surface runoff, open tile intakes, and tile drainage are the largest phosphorus sources. Point source contributions have been improved by recent upgrades to waste water treatment plants.

2.2.3.3 Goal & 10-year Target

To set a watershed-wide pollutant reduction goal, several lines of evidence were considered. Data from the Hawk Creek Watershed outlet was compared to the new *River Eutrophication Standard* (MPCA 2015i) for southern Minnesota streams of 0.15 mg/L. Phosphorus reductions for impaired lakes ranged from 30% to 74%, with an average 50% reduction. The Minnesota Nutrient Reduction Strategy (MPCA 2015j) calls for a 45% total reduction in phosphorus from the Mississippi River Basin (from 1980 to 1996 conditions, of which a 33% reduction has already occurred). Effectively, this equates to an 18% reduction (see calculation Appendix 5.8) from the WRAPS baseline 2009 to 2016 data years from the Mississippi River Basin. However, the Hawk Watershed contributes substantially more phosphorus than many other Mississippi River Basin major watersheds. Therefore, the Hawk Watershed needs a larger phosphorus reduction than the state nutrient reduction strategy recommends.

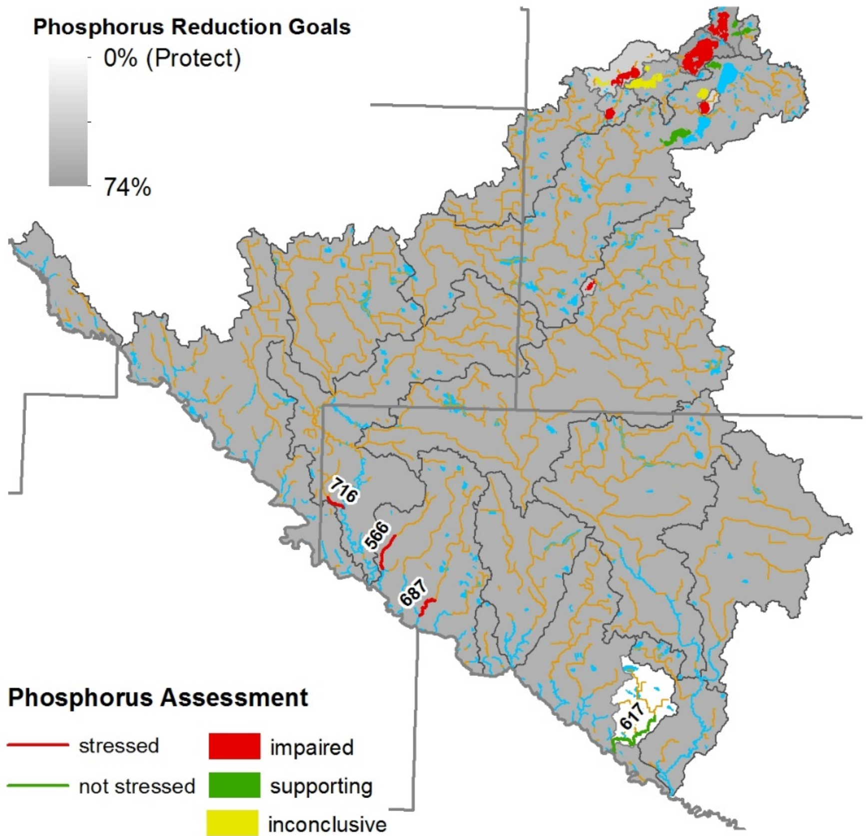


Figure 27: Phosphorus reduction goals were developed for the watershed as a whole (60% reduction) and for individual lake watersheds where ample data were available (up to a 74% reduction). Contributing watersheds for areas found to meet phosphorus standards or found to not stress aquatic life have a protection goal.

Based on the standard, the state-wide strategy, and the relative yield of the Hawk Watershed to other Mississippi River Basin major watersheds, a 60% reduction in the baseline 2009 to 2013 FWMC and load is the selected watershed-wide goal. This represents a drop in the FWMC from 0.39 mg/L to 0.15 mg/L. This goal is revisable and will be revisited in the next iteration of the Watershed Approach. The reach and lakes supporting beneficial water uses based on phosphorus have a protection goal. Individual subwatershed goals were calculated from TMDL data. Phosphorus goals and impairments are illustrated in Figure 27. The selected 10-year target for phosphorus reduction was a 10% reduction for streams and a 20% reduction for lakes. Strategies and methods to prioritize regions to address phosphorus are summarized in Section 3.

2.2.4 Nitrogen

Excessive nitrogen can be toxic to fish and macroinvertebrates, and even at low concentrations can limit sensitive species. The eutrophication causing the Gulf Hypoxic Zone (NOAA 2015) is due to excessive nitrogen contributions from the Mississippi River Basin. Nitrogen is also a major human health concern, as excessive nitrogen consumption via drinking water causes blue baby syndrome (Encyclopedia, 2003). Due to this health risk, excessive nitrogen in drinking water can necessitate expensive treatments.

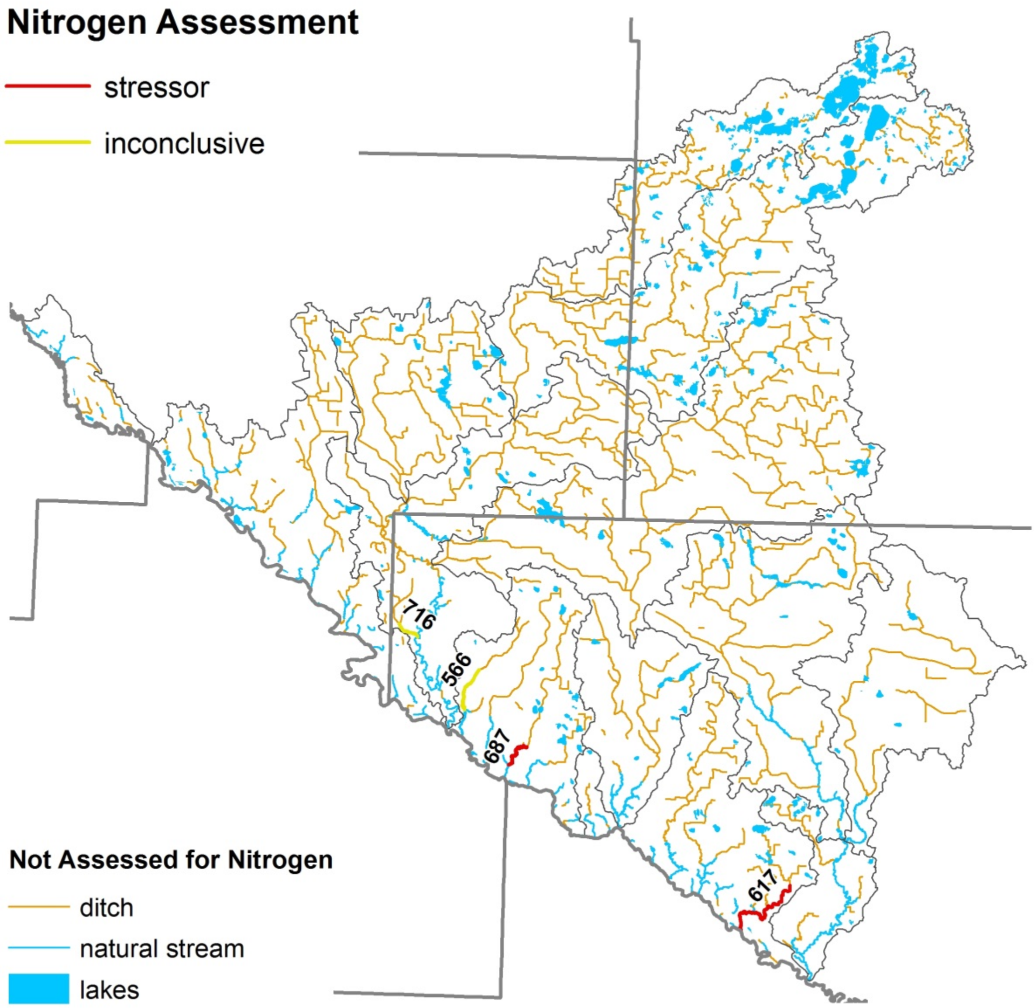


Figure 28: Stream reaches assessed for nitrogen and the assessment results

2.2.4.1 Status

Of the bio-impaired stream reaches, nitrogen as a stressor was identified in two and could not be ruled out in two (Table 7 and Figure 28). From a statewide perspective, the Hawk Watershed has a high yield and FWMC of Total Nitrogen (TN) (Figure 29).

Table 7: Stream reaches assessed for nitrogen

Stream	Reach (AUID-3)	Assessment
Unnamed creek	566	?
Smith Creek (CD 125A)	617	x
County Ditch 119	687	x
County Ditch 36	716	?

x = stressor
? = inconclusive (need more data)
√ = not a stressor

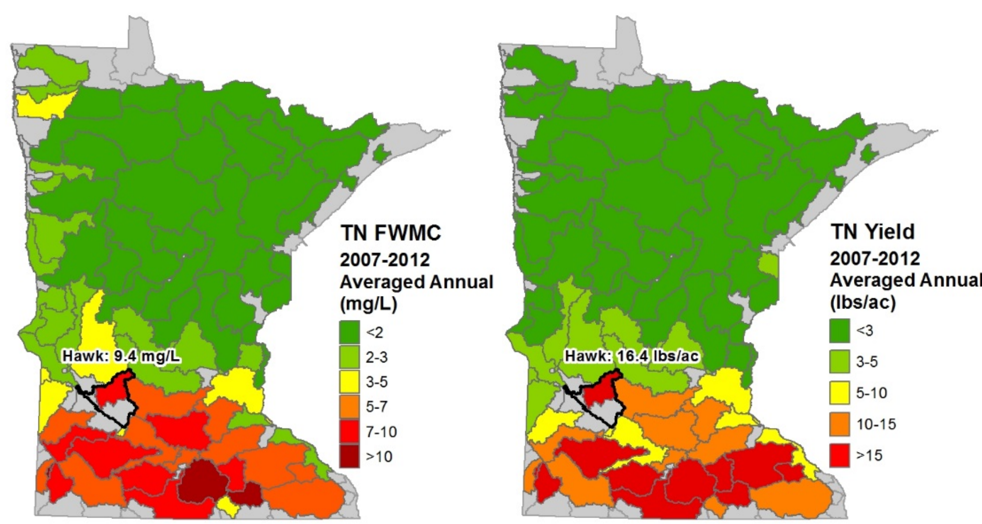


Figure 29: The Hawk Creek Watershed has a high FWMC and yield of TN compared to the rest of the state. Data are from the WPLMN.

2.2.4.2 Sources

In the Hawk Watershed, most nitrogen that reaches water bodies is from nonpoint sources. In years 2008 through 2012, 6% of nitrogen was from point sources. A numeric estimate of the Hawk Watershed's nitrogen sources is presented in Figure 30; the identification of sources and amount of each source was determined through best professional judgement and local knowledge by WRAPS workshop attendees in the process described in section 2.1.3. Based upon this source assessment, the single largest nitrogen source was estimated to be crop tile drainage.

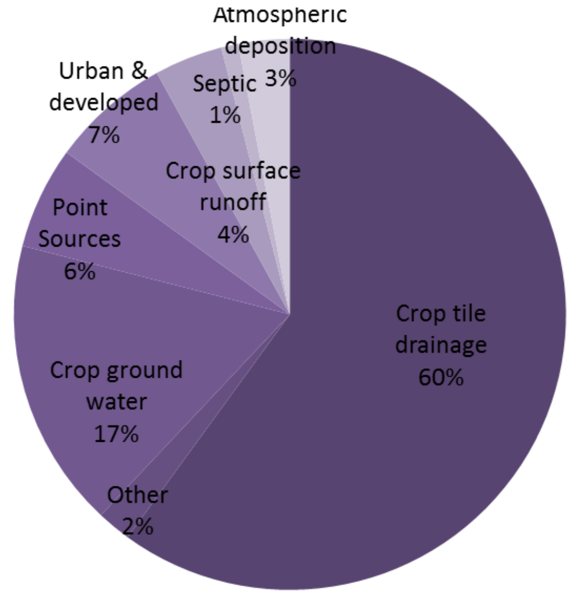


Figure 30: Nitrogen contributions to water bodies in the Hawk Watershed are dominated by agricultural sources. Nitrogen dissolves in water and moves easily through tile and subsurface pathways.

2.2.4.3 Goal & 10-year Target

To set a watershed-wide reduction goal, data from the Hawk Creek Watershed outlet was compared to the proposed River Eutrophication Standard (MPCA 2015i) of 4.9 mg/L. The Minnesota Nutrient Reduction Strategy (MPCA 2015j), which calls for a 45% total and a 20% interim (by 2025) TN reduction from the Minnesota River Basin, was also considered. Based on this standard, the statewide strategy, and the relative yields of TN of Minnesota River major watersheds, a 45% reduction in the baseline 2009 through 2013 FWMC and load is the selected goal for the watershed. This represents a drop in the FWMC from 9.2 mg/L to 4.9 mg/L. This goal is revisable and will be revisited in the next iteration of the Watershed Approach. The goals and impairments are illustrated in Figure 31. The selected 10-year target for nitrogen is a 12% reduction. Strategies and methods to prioritize regions to address nitrogen are summarized in Section 3.

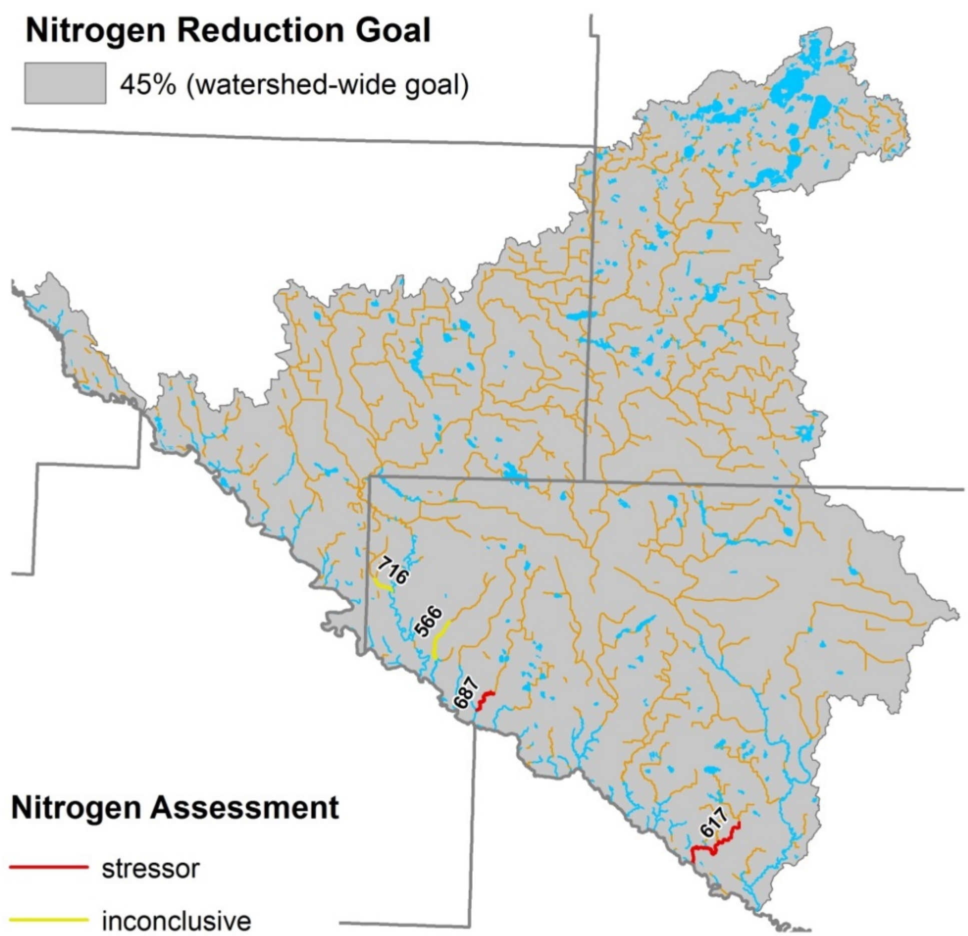


Figure 31: A nitrogen reduction goal was developed for the watershed as a whole (45% reduction) using the WPLMN data.

2.2.5 Fecal Bacteria

Fecal bacteria (*Escherichia coli* (*E. coli*) or fecal coliform) are indicators of animal or human fecal matter in waters. Fecal matter can make aquatic recreation unsafe because contact with fecal material can lead to potentially severe illnesses.

2.2.5.1 Status

Of the streams monitored to assess if bacteria is a pollutant, all were impaired (Table 8). Unlike nutrients and sediment, statewide bacteria monitoring is not done by the WPLMN; therefore, statewide results are not readily available for comparison.

Table 8: Stream reaches assessed for bacteria

Stream	Reach (AUID-3)	Assessment
Timms Creek	525	x
Sacred Heart Creek	526	x
Beaver Creek	528	x
Beaver Creek, W Fork	530	x
Palmer Creek (CD 68)	534	x
Hawk Creek	568	x
Chetomba Creek	577	x
Beaver Creek, E Fork	586	x
Hawk Creek	587	x
Unnamed ditch	589	x
Middle Creek	615	x
Smith Creek (CD 125A)	617	x
Unnamed creek (CD 119)	648	x
County Ditch 119	687	x
County Ditch 11	689	x

x = impaired

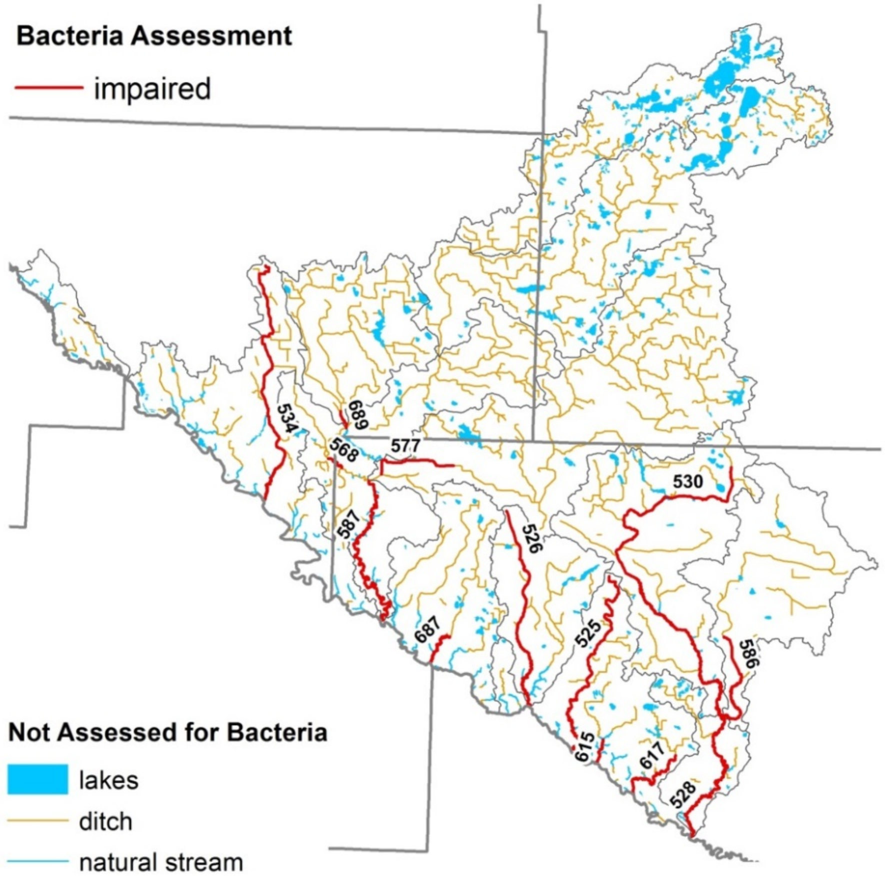


Figure 32: Stream reaches assessed for fecal bacteria and the assessment results

2.2.5.2 Sources

Fecal bacteria contributions are dominated by nonpoint sources. However, specific source assessment is difficult due to the dynamic and living attributes of bacteria. Emmons & Olivier Resources (2009) conducted a *Literature Summary of Bacteria* for the MPCA. The literature review summarized factors that have either a strong or a weak positive relationship to fecal bacterial contamination in streams (Table 9).

Chandrasekaran et al. (2015) conducted DNA fingerprinting of *E. coli* in sediment and water samples from Seven Mile Creek, located in south-central Minnesota. This study traced substantial numbers of bacteria to cattle sources, while no samples could be traced to human sources. The authors postulated that bacteria could be reproducing in the study region, but no solid conclusions were made regarding the amount of sampled bacteria that was from in-stream reproduction versus recent bacteria contamination. Because there is currently a lack of ample study on in-stream reproduction and fecal matter poses significant risks to human health, the percent of the bacterial load attributed to this source is conservatively estimated at zero for this analysis.

A numeric estimate of the Hawk Watershed's fecal bacteria sources is presented in Figure 33; the identification of sources and amount of each source was determined through best professional judgment and local knowledge by WRAPS workshop attendees in the process described in Section 2.1.3. Based upon this source assessment, the single largest fecal bacteria source was estimated to be crop surface runoff where manure was applied but not incorporated into the soil. For further information on how the source assessment was determined for bacteria please refer to Appendix 5.13, 5.14 and 5.19.

The size of the feedlot facilities, the types of animals housed at the facility, and knowledge of common local farming practices can provide useful information for prioritizing and targeting work to address feedlot-originated manure management. A map illustrating the size and types of feedlot animals is presented in the Sources Overview section. Additional information to consider includes: application location and timing, proximity to surface water, field slope, and infield practices (e.g. tillage and resulting residue cover). Refer to Appendix 5.19 for additional interpretation of feedlot statistics useful for prioritizing and targeting.

Table 9: Bacteria sourcing can be very difficult due to the bacteria's ability to persist, reproduce, and migrate in unpredictable ways. Therefore, the factors associated with bacterial presence provide some confidence to bacterial source estimates.

Strong relationship to fecal bacterial contamination in water	**Weak** relationship to fecal bacterial contamination in water
· High storm flow (the single most important factor in multiple studies) · % rural or agricultural areas greater than % forested areas in the landscape (entire watershed area) · % urban areas greater than % forested riparian areas in the landscape · High water temperature · Higher % impervious surfaces · Livestock present · Suspended solids	· High nutrients · Loss of riparian wetlands · Shallow depth (bacteria decrease with depth) · Amount of sunlight (increased UV-A deactivates bacteria) · Sediment type (higher organic matter, clay content and moisture; finer-grained) · Soil characteristics (higher temperature, nutrients, organic matter content, humidity, moisture and biota; lower pH) · Stream ditching (present or when increased) · Epilithic periphyton present · Presence of waterfowl or other wildlife · Conductivity

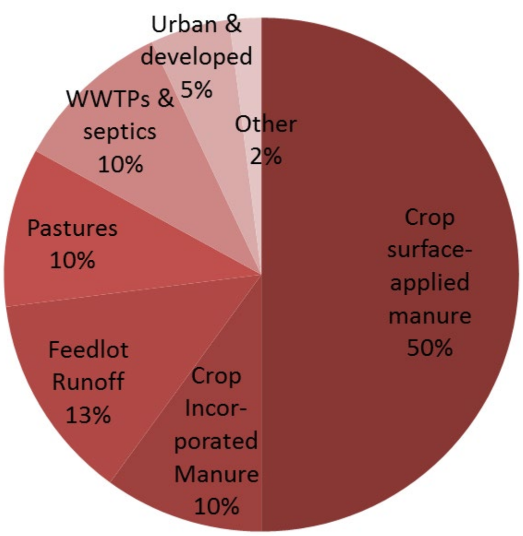


Figure 33: The single largest source of fecal bacteria in the Hawk Watershed is domesticated animal manure, which is estimated to contribute roughly 85% of bacteria to streams.

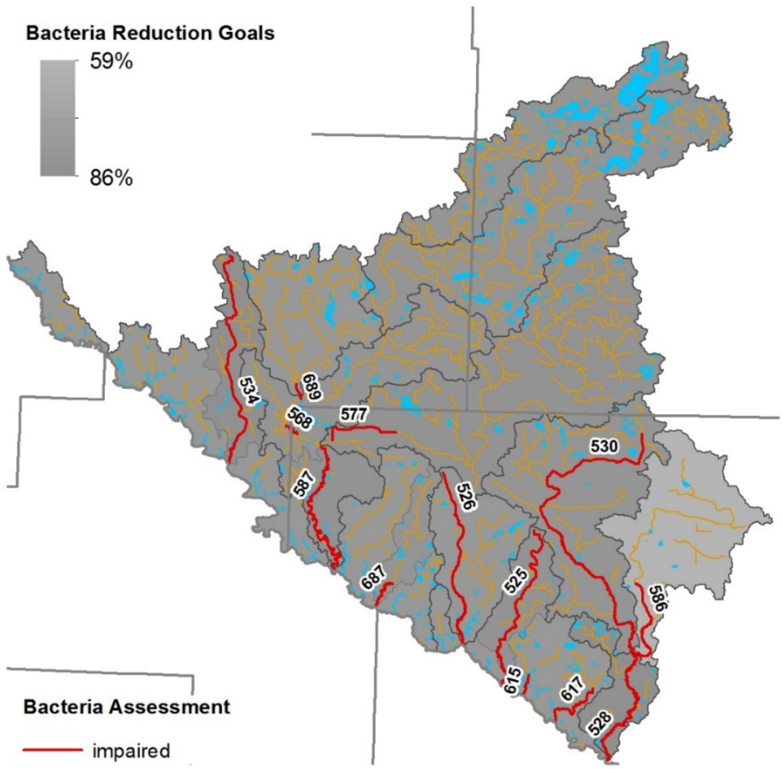


Figure 34: A bacteria reduction goal was developed for the watershed as a whole (80% reduction) by averaging the reductions from impaired reaches.

2.2.5.3 Goal & 10-year Target

The watershed-wide goal for fecal bacteria reduction was calculated by averaging the individual bacteria reduction goals. The watershed goal is to reduce fecal bacteria by 80%. These individual reduction goals were calculated by comparing the observed monthly geomean of bacteria concentrations to the *E. coli* water quality standard (of 126 colony forming units per 100 mL). Goals and impairments are illustrated in Figure 34. Strategies and methods to prioritize regions to address bacteria are summarized in Section 3.

2.2.6 Habitat

Degraded habitat impacts aquatic life by reducing the amount of suitable habitat needed for all aspects of aquatic life: feeding, shelter, reproduction, etc.

2.2.6.1 Status

Of the bio-impaired stream reaches, degraded habitat was identified as a stressor in all four (Table 10). The specific habitat components identified for each of the reaches is identified in Table 11.

Table 10: Streams assessed for habitat

Stream	Reach (AUID-3)	Assessment
Unnamed creek	566	x
Smith Creek (CD 125A)	617	x
County Ditch 119	687	x
County Ditch 36	716	x

x = stressor

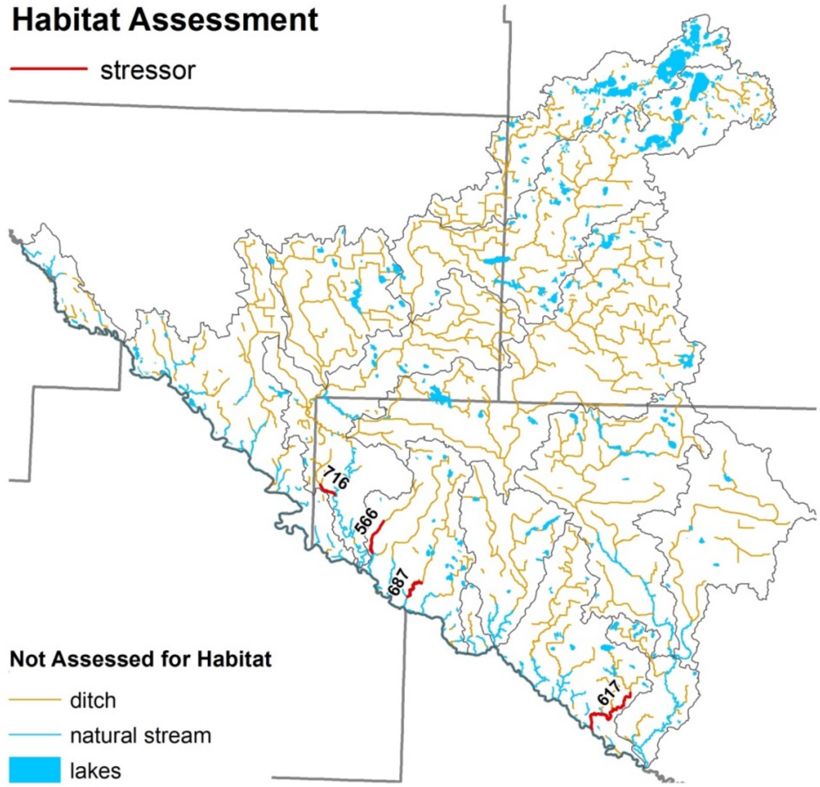


Figure 35: Stream reaches assessed for habitat and the assessment results

2.2.6.2 Sources

The habitat component issues show a complex, interconnected set of factors that are primarily driven by two stressors.

Excessive sedimentation and/or channel instability was identified in all four streams; additional issues such as stream bank erosion, excessive silt, and a lack of riffles and pools are closely related to channel instability and sediment issues. This stressor is primarily the result of altered hydrology, which causes bank instability and increased channel migration, which then chokes streams with excess sediment, limiting or eliminating necessary habitat.

Table 11: Habitat problems of bio-impaired stream reaches as identified in the SID Report

AUID-3	Identified problem
716	Poor upstream land use and lack of riparian buffer, excessive stream bank erosion/channel instability
687	Poor land use and riparian buffer, stream bank erosion/channel instability, excessive silt in stream bed, lack of riffles and pools
617	Poor land use and riparian buffer, stream bank erosion/channel instability, excessive silt in stream bed, upstream cattle accessing stream/trampling stream bank/riparian
566	Poor land use and riparian buffer, stream bank erosion/channel instability, excessive silt in stream bed, lack of riffles and pools

Poor land use, such as intensive row crop agricultural practices directly abutting streams or inappropriate grazing practices in riparian areas, and lack of riparian buffer were also identified in the SID report for all four habitat-impaired streams. Without an adequate riparian buffer, other issues such as excessive flow – which causes streambank erosion - are magnified because the stream lacks the strength to resist erosion. Furthermore, cattle trampling stream banks can contribute to excessive erosion and over-widening of streams.

In summary, most of the habitat problems are driven by altered hydrology and poor riparian land uses.

2.2.6.3 Goal & 10-year Target

Currently, the [MPCA Stream Habitat Assessment] (MSHA {MPCA 2014d}) scores in the watershed range from 17 to 88 (Figure 36), with an average score of 46. The selected goal for habitat is for the average MSHA score in the watershed to be greater than 66 (“good”). This goal represents a 45% increase in the average MSHA score. The 10-year target is a 9% increase in the average MSHA to a score of 50. Since low habitat scores are mostly due to altered hydrology and degraded riparian zone, addressing altered hydrology and improving riparian land use should be the focus of restoration and protection efforts to meet the goal and 10-year target. Strategies and methods to prioritize regions to address habitat are summarized in Section 3.

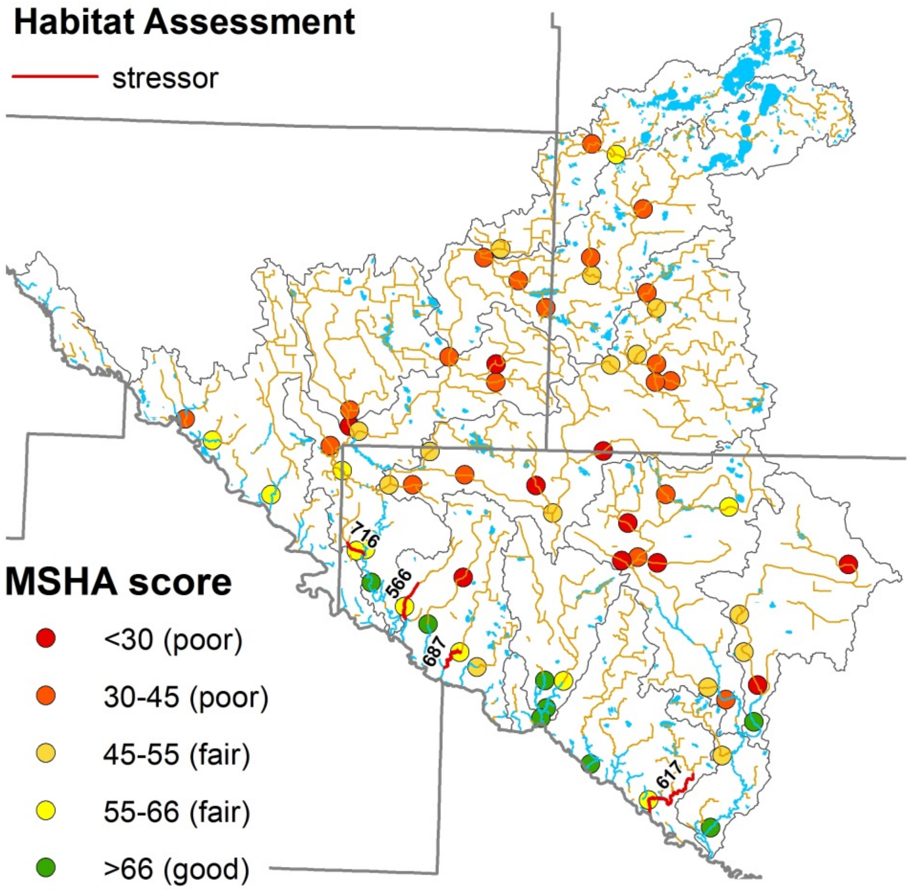


Figure 36: Poor habitat was found to stress all four bio-impaired reaches in the Hawk Watershed. Habitat is only investigated as a stressor when a bio-impairment is identified. MSHA scores tend to be fair to poor with good scores in the Minnesota River zone of the watershed.

2.2.7 Dissolved Oxygen

Low DO impacts aquatic life primarily by limiting respiration, which contributes to stress and disease and can cause death.

Table 12: Stream reaches assessed for DO

Stream	Reach (AUID-3)	Assessment
Timms Creek	525	?
Sacred Heart Creek	526	x
Beaver Creek	528	√
Beaver Creek, W Fork	530	x
County Ditch 37	531	x
Palmer Creek (CD 68)	534	?
Unnamed creek	566	x
Beaver Creek, E Fork	586	?
Hawk Creek	587	?
Unnamed ditch	589	?
Middle Creek	615	?
Smith Creek (CD 125A)	617	√
Unnamed (CD 119)	648	?
County Ditch 45	676	√
County Ditch 59	677	x
County Ditch 119	687	x
County Ditch 11	689	?
County Ditch 36	716	x
Unnamed ditch	739	?

√ = supporting/not a stressor
? = inconclusive (need more data)
x = impaired/stressor

2.2.7.1 Status

Of the stream reaches monitored to assess if DO does not meet standards: four were impaired, one was supporting the standard, and eleven were inconclusive (Table 12). Of the bio-impaired stream reaches, DO as a stressor was identified in three and ruled out in one.

2.2.7.2 Sources

Low DO in water bodies is caused by: 1) excessive oxygen use, which is often caused by the decomposition of algae and plants, whose growth is fueled by excess phosphors and/or 2) too little re-oxygenation, which is often caused by minimal turbulence or high water temperatures. Low DO levels can be exacerbated in shallow, over-widened channels because these streams move more slowly and have more direct sun warming.

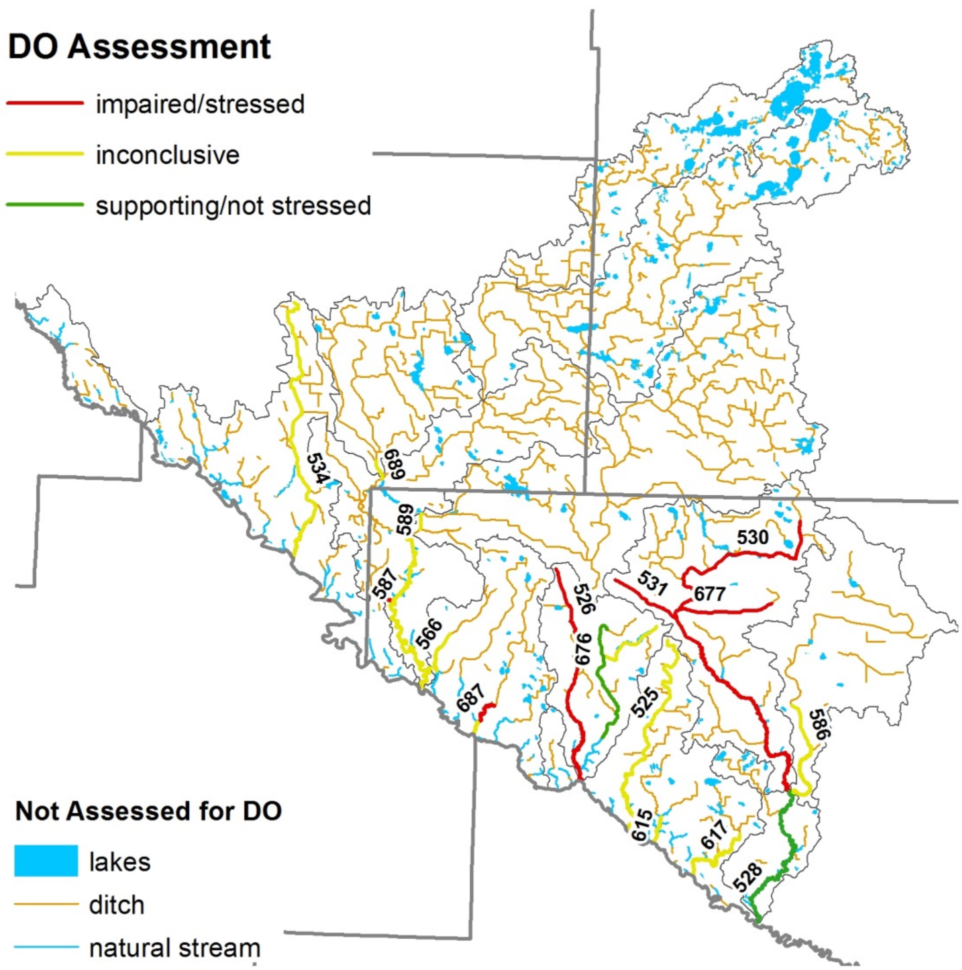


Figure 37: Stream reaches assessed for DO and the assessment results

2.2.7.3 Goals & 10-year Targets

The goal for DO is to reach the minimum standard of 5 mg/L. Because DO is primarily a response of other stressors, the effective goal and 10-year target for DO are to meet the altered hydrology, phosphorus, and habitat goals/10-year targets, since these are the primary drivers of DO problems in the watershed. This goal is revisable and will be revisited in the next iteration of the Watershed Approach. Strategies and methods to prioritize regions to address altered hydrology and phosphorus are summarized in Section 3.

3 Restoration & Protection

This section summarizes scientifically-supported strategies to restore and protect waters, and information on the social dimension of restoration and protection. This section and report culminate in the "Strategies Table", a tool intended to provide high-level information on the changes necessary to restore and protect waters within the Hawk Watershed. Using the Strategies Table, local conservation planning staff can prioritize areas and spatially target best management practices (BMPs) or land management strategies using GIS or other tools, as encouraged by funding entities and Clean Water Legacy legislation on WRAPS (ROS 2013).

3.1 Scientifically-Supported Strategies to Restore and Protect Waters

This section summarizes studies and data on land management and BMP effects on water quality. This information is more technical in nature, but these summaries may be helpful to landowners, decision makers, and citizens to understand the impact of various strategies and BMPs on water quality.

To address the widespread water quality impairments in agriculturally-dominated watersheds such as the Hawk Watershed, comprehensive and layered BMP suites are likely necessary. A conceptual model displaying this layered approach is presented by Tomer et al. (2013; Figure 38). Another model to address widespread nutrient problems is presented in the *Minnesota Nutrient Reduction Strategy* (MPCA 2015j), which calls for four major steps involving millions of acres statewide: 1) increase fertilizer use efficiencies, 2) increase and target living cover, 3) increase field erosion control, and 4) increase drainage water retention. A third example of a comprehensive, layered approach is being demonstrated with a "Treatment Train" approach in the Elm Creek Watershed (ENRTF 2013), which has demonstrated layered strategies including: 1) upland: cover crops and nutrient management, 2) tile treatment: treatment wetlands and controlled drainage, and 3) in-stream: woody debris and stream geomorphology restoration.

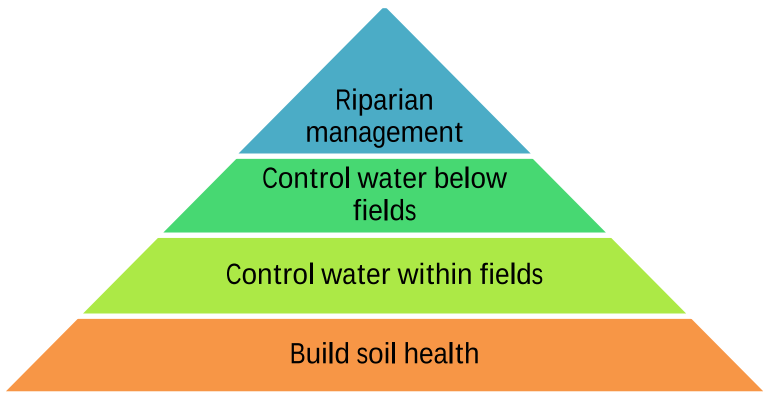


Figure 38: This conceptual model to address water quality in agricultural watersheds uses 1) soil health principles as a base: nutrient management, reduced tillage, crop rotation, etc., then 2) in-field water control: grassed waterways, controlled drainage, filter strips, etc., then 3) below-field water controls: wetlands, impounds, etc., and then 4) riparian management: buffers, stabilization, restoration, etc.

3.1.1 Agricultural BMPs

Since the Hawk Watershed land use and pollutant source contributions are generally dominated by agriculture, reducing pollutant/stressor contributions from agricultural sources is a high priority. A comprehensive resource for agricultural BMPs is *The Agricultural BMP Handbook for Minnesota* (Miller et al. 2012). Hundreds of field studies of agricultural BMPs are summarized in the handbook, which has been summarized in Appendix 5.16: The effectiveness values listed in the table are estimates based on research. Long-term effectiveness depends on proper maintenance of each practice. For clarifications, the reader should reference the handbook. The *Minnesota Agricultural Water Quality Certification Program* (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Those who implement and maintain approved farm management practices will be certified through the Minnesota Department of Agriculture for managing the land within their operation in a way that protects water quality. As a conservation resource, a Cropland Grazing Exchange program was recently launched by the MDA, which is intended to match up livestock farmers with crop farmers who have forage to harvest. Incorporating livestock into a cropping rotation can benefit both the crop and livestock farmer in numerous ways (http://www.mda.state.mn.us/cge).

Additional field data has been compiled by Iowa and Minnesota for review in their respective state nutrient reduction strategies. This information is included in Appendix 5.17.

3.1.2 Urban and Residential BMPs

Cities and watershed residents also impact water quality. A comprehensive resource for urban and residential BMPs is the *Minnesota Stormwater Manual* (MPCA 2014b). This resource is in electronic format and includes links to studies, calculators, special considerations for Minnesota, and links regarding industrial and stormwater programs. Failing and unmaintained septic systems can pollute waters. Information and BMPs for Septic Systems is provided by EPA (2014b).

3.1.3 Stream and Ravine Erosion Control

By-and-large, widescale stabilization of eroding stream banks and ravines is cost-prohibitive. Instead, first addressing altered hydrology (e.g. excessive, concentrated flows) from the landscape can help decrease wide-scale stream and ravine erosion problems, as discussed in *the Minnesota River Valley Ravine Stabilization Charrette* (E&O 2011) and the Minnesota River Basin Sediment Reduction Strategy (MPCA 2015h). Improving activities directly adjacent the stream/ravine (e.g. buffers) can also decrease erosion as summarized in *How to Control Streambank Erosion* (IA DNR, 2006). In some cases, however, property may need to be protected or a ravine/stream bank may be experiencing such severe erosion that stabilization of the stream bank or ravine is deemed necessary.

3.1.4 Lake Watershed Improvement

Strategies to protect and restore lakes include both strategies to minimize pollutant contributions from the watershed and strategies to implement adjacent and in the lake (refer to summary in Appendix 5.18). Strategies to minimize pollutant contributions from the watershed focus mostly on agricultural and/or stormwater BMPs, depending on the land use and pollutant contributions of the watershed. The DNR (2014) supplies detailed information on strategies to implement adjacent and in the lake via Shoreland Management guidance.

3.1.5 Computer Model Results

Computer models provide a scientifically-based estimate of the pollutant reduction effectiveness of land management and BMPs. Models represent complex natural phenomena with equations and numeric estimates of natural features, which can vary substantially between models. Because of these varying assumptions and estimates, each model has its strengths and weaknesses and can provide differing results. For these reasons, multiple model results were used as multiple lines of evidence by the WRAPS Workshops attendees. The table presented in Appendix 5.20 summarizes several model analyses of the Hawk Watershed and the Minnesota River Basin, generally. The reader is encouraged to refer to the linked reports (in table) for more details.

3.2 Social Dimension of Restoration and Protection

Because most changes that must occur to improve and protect water resources are voluntary, communities and individuals ultimately hold the power to restore and protect waters in the Hawk Watershed. For this reason, the Clean Water Council (MPCA 2013b) recommended that agencies integrate civic engagement in watershed projects (MPCA 2010a).

A growing body of evidence detailed in *Pathways for Getting to Better Water Quality: The Citizen Effect* (Morton and Brown 2011) suggests that to achieve clean water in the voluntary-adoption system in place, a citizen-based approach is likely the most feasible means to success. Specifically, the transition to more sustainable practices must be developed, demonstrated, and spread by trusted leaders within the community. When leaders embrace a transition, communities are more likely to accept and adopt the transition. When leaders and communities develop solutions, they are likely to intertwine financial security and environmental stewardship - instead of viewing them as conflicting goals. In this way, the community is more likely to improve water quality while securing sustainable farms and cities for future generations. If this pathway to water body improvement is to be embraced, however, one of the most important uses for limited resources is to further develop and support local leaders to take on this challenging work.

Several civic engagement opportunities were sponsored by the HCWP and the MPCA. The HCWP created and distributed four newsletters from 2010 to 2016 with Watershed Approach information to watershed citizens. The HCWP also hosted 15 public meetings from 2010 to 2016 to present information on and to provide opportunities for citizens to provide input on the Watershed Approach. Within these meetings, citizens and conservation staff provided local knowledge and priorities to help identify priority areas and practices using two different modeling programs: Zonation Analysis and HSPF.

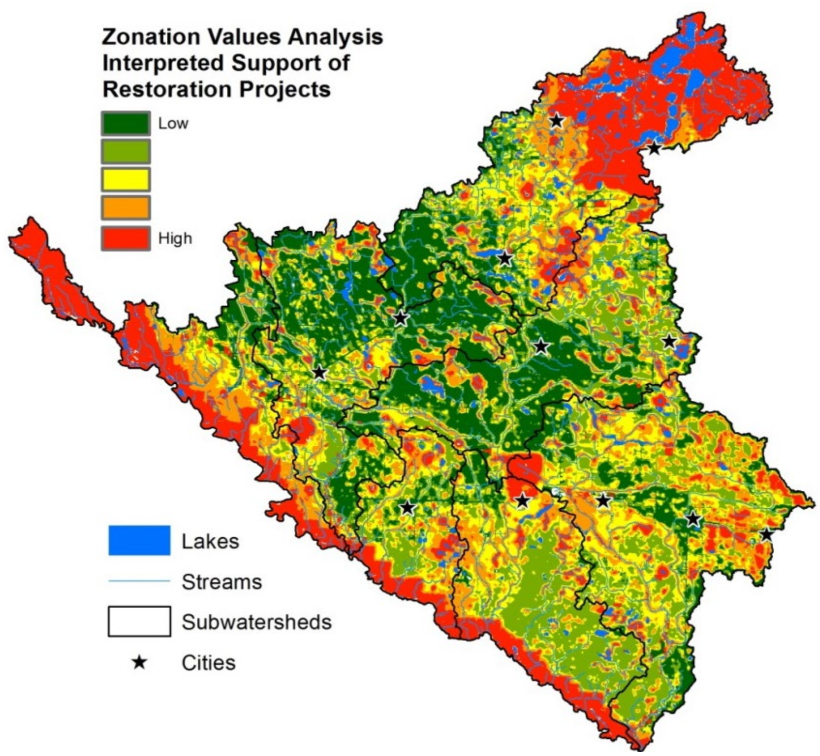
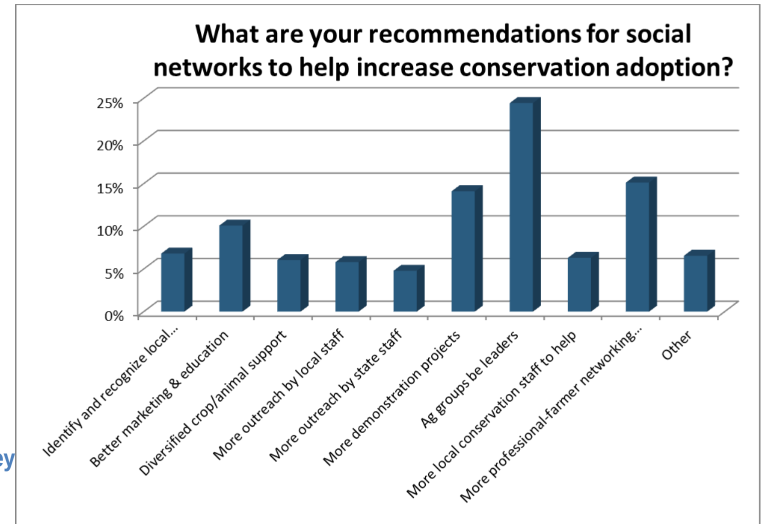
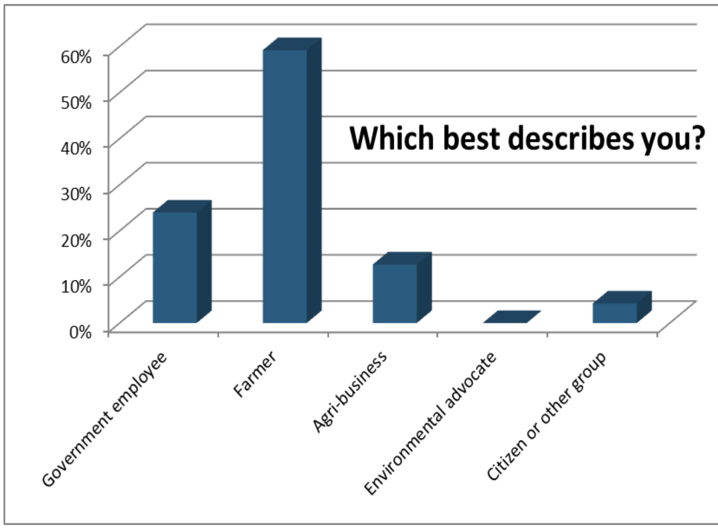
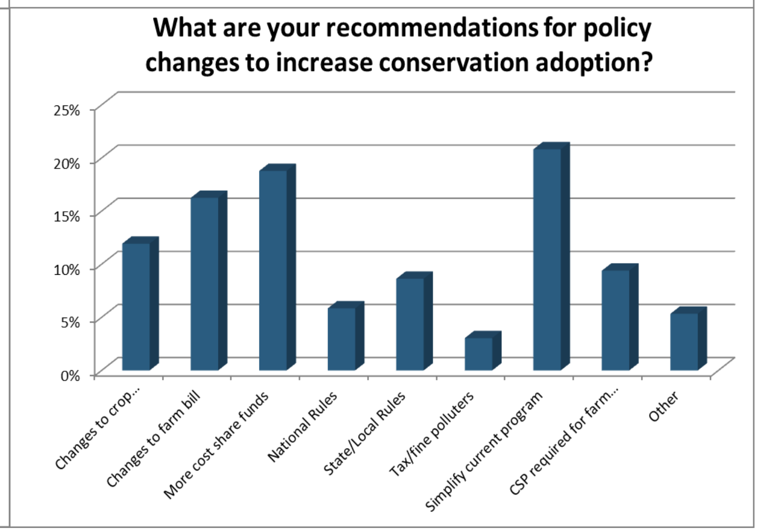


Figure 39: The zonation analysis is able to interpret the conservation values of people by surveying them. Then, the zonation model translates the values represented in the surveys to the landscape using many GIS data sets.

Figure 40: Of the 80 people who attended WRAPS workshop four, farmers made up more than 50% (below). To address social network constraints to higher conservation adoption, workshop four attendees most favored agricultural groups being leaders, having more demonstration projects, and more professional-to-farmer networking opportunities (upper right). To address policy constraints to higher conservation adoption, workshop four attendees most favored simplifying current programs, having more cost-share funds available and making changes to the Farm Bill (lower right). See additional survey results and participant answers in Appendix 5.22.







The Zonation (University of Helsinki 2015) analysis process (results illustrated in Figure 39) used a survey to solicit values to identify priority areas to restore. The results of this analysis show the highest general support is for the restoration of lake regions. Other high value regions (red areas) were identified in the Minnesota River Valley and other scattered areas throughout the watershed.

Three HSPF modeled scenarios were selected by local conservation staff after review of eight pre-developed scenarios. The analysis and results of these scenarios were reported by Tetra Tech (2015) and summarized in Appendix 5.20.

Four technical workshops were held between September 2015 and January 2016 to allow conservation staff and the public to provide local knowledge and feedback on the WRAPS report. Approximately 15 people, primarily conservation staff, attended workshops 1 and 2. Workshops 3 and 4 were attended by approximately 50 and 80 people, respectively, with high attendance from agricultural producers and industry professionals. Much of the information collected in these workshops is embedded in this report, as local knowledge was used to help identify pollutant sources and preferred conservation practices, for example. Furthermore, information on attitudes and values was collected and is useful for understanding conservation adoption opportunities and constraints. Select results from workshop 4 are illustrated in Figure 40; full results are available in Appendix 5.22.

3.3 Selected Strategies to Restore and Protect Waters

The strategies presented in Table 14 show the types of practices and associated adoption rates estimated to meet the water quality goals and 10-year targets. The parties responsible for making, facilitating, and overseeing the changes associated with the 10-year targets were identified by the WRAPS Workshops attendees. In other words, the strategies provide “what” to do and “who” should do it. These strategies need to be refined in local planning processes to determine “how” the strategies will get done and “where” the practices need to go.

As far as where practices need to go to meet water quality goals, the presented strategies need to be implemented across the watershed. However, the adoption rates in any one region will not necessarily match the watershed-wide adoption rates due to regional differences. Furthermore, not all strategies are appropriate for all locations. The strategies and regional adoption rates should be customized during locally-led prioritizing and targeting work (see Prioritizing and Targeting Section below for more guidance) in local water planning efforts.

Data and models indicate that comprehensive and integrated BMP suites are necessary to bring waters in the Hawk Watershed into supporting status. However, there are current limitations in BMP adoption, some technologies are not yet feasible, and the approximate timeframe for these comprehensive changes is 50 years. For these reasons, recommending specific suites of strategies capable of cumulatively achieving all water quality goals is not practical and would likely need substantial future revision. Strategies Table 14A presents a rough narrative estimate of the landscape and pollutant source changes that are necessary for all waters to meet long-term water quality goals.

For immediate planning and other local needs, specific strategies estimated to meet the 10-year water quality targets are presented in Strategies Table 14B. These strategies and the relative adoption rates were selected by the WRAPS Workshops attendees. With the next iteration of the watershed approach, progress towards these targets can be assessed and new targets for the following decade can be created. In Table 14B, pollutant/stressor-specific suites of strategies apply watershed-wide; because 81% of the watershed is in agricultural lands, these strategies apply mostly to agricultural lands. However, there are additional suites of strategies specifically for cities/residents, lake watersheds, etc. since these locations have specialized concerns and opportunities.

3.3.1 Protection Considerations

Water bodies that meet water quality standards should be protected to maintain or improve water quality. Furthermore, water bodies that have not been assessed should not be allowed to degrade. The strategies presented in Table 14 – set at the whole watershed scale - are intended to not only restore but also protect waters in the watershed. Similar to customizing regional adoption rates of the watershed-wide strategies, strategies and adoption rates should reflect the relative amount of protection needed and any site-specific considerations.

Six lakes in the watershed were identified as meeting the water quality standards, therefore, are in need of protection. Some lakes were identified as having physical properties (depth and small watershed) that generally result in higher water quality. However, other lakes appear to meet standards due to water quality friendly management practices and zoning enforcement. For instance, local conservation professionals cited good education and conservation practice adoption in the watersheds of supporting lakes. Local conservation professionals also identified management practices that should be protected to maintain water quality: Lake Henderson has a good vegetated buffer, and East Twin and West Twin Lakes have zoning ordinances established and minimal development. By protecting these management practices, and with the continued adoption of additional conservation practices, the five supporting lakes should maintain good water quality.

Areas in the watershed that have maintained or restored natural conditions tend to produce areas that meet water quality standards and should be protected. Examples of these areas include: 1) Smith Creek, which is not channelized allowing more natural habitat and flow regimes, and also has pastured areas for grass fed beef, which benefits water quality due to the positive impacts of perennial vegetated cover; 2) areas of Beaver Creek have natural channel qualities including meanders, tree cover, and a better stream bed habitat (less sediment deposition); and 3) the downstream reach of Limbo Creek has a higher quality buffer and meandering channel, according to local conservation professionals, which allows this reach to establish better habitat, mitigating impacts of upstream impairments. Protecting and increasing natural areas within the watershed are key factors to protecting water quality.

Programs focused on minimizing pollutant contributions have helped streams and lakes support water quality standards and should be protected. Examples of programs that have helped water bodies improve include: 1) the Feedlot Program helped address a feedlot problem in Smith Creek Watershed; 2) agricultural BMP programs encourage better tillage and buffers, which have protected some upstream reaches from excessive surface runoff; 3) through the Municipal Wastewater Program, improvements to Willmar's WWTP reduced pollutants to Hawk Creek; 4) the Wellhead Protection Program improved nitrogen fertilizer use in areas of the watershed. Well-organized programs are a vital element to protecting the water within the Hawk Watershed. Maintaining and improving programs will ensure water bodies supporting beneficial water uses maintain water quality.

Additional protection concerns in the watershed relate to groundwater protection. The MDH provided a groundwater vulnerability assessment in Appendix 5.24. The main supply of drinking water to the residents and businesses in the Hawk Watershed is groundwater – either from private wells, community wells, or a rural water supplier. Public water suppliers in the watershed that have undergone wellhead protection planning have identified some areas where the groundwater supply is not directly influenced by surface water in the watershed. The public water supplies have low vulnerability to contamination, which means that deep aquifers are fairly protected. The communities of Danube, Raymond, Renville, and Willmar have vulnerable drinking water systems. Contaminants on the surface can move into the drinking water aquifers more quickly in these areas. There is also the potential for contamination through unused and abandoned wells. Ensuring abundant and high quality supplies of groundwater is critical; especially in light of altered hydrology and the impacts on groundwater recharge.

3.3.2 Prioritizing and Targeting to Identify Critical Areas

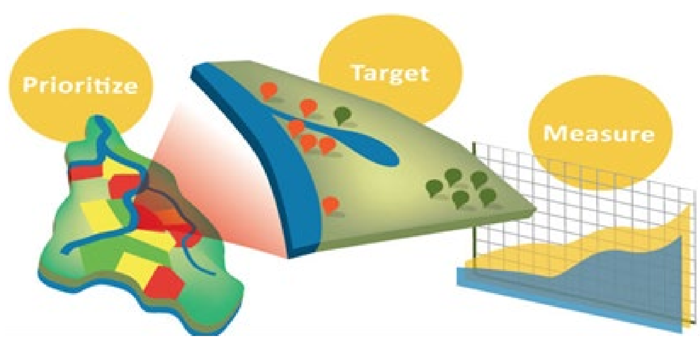


Figure 41: "Prioritized, targeted, and measurable" plans are more likely to improve water quality and have a better chance to be funded compared to those that are less strategic.

Conservation implementation plans (i.e. 1W1P, EPA Clean Water Act Section 319 work plans, etc.) that are developed subsequent to the WRAPS report should ***prioritize*** and ***target*** the strategies presented in Table 14 to develop ***critical areas*** and set ***measurable*** goals. Figure 41 (BWSR 2014a) represents the prioritized, targeted, and measurable concepts.

Prioritizing is the process of selecting priority areas or issues based on justified water quality, environmental, or other concerns. Priority areas can be further refined by considering additional information: other water quality, environmental, or conservation practice effectiveness models or concerns; ordinances and rules; areas to create habitat corridors; areas of high public interest/value; and many more that can be selected to meet local needs. This report has identified several priority areas (Table 13).

Targeting is the process of strategically selecting locations on the land (within a priority area) to implement strategies to meet water quality, environmental, or other concerns (that were identified in the prioritization process). The WRAPS report is not intended to target practices; rather, the work done as part of the larger Watershed Approach should empower local partners to target practices that satisfy local needs.

"Measurable" means that implementation activities should produce measurable results. Work plans should include information on how the results of their proposed work will be measured.

Table 13: Priority areas are identified throughout this WRAPS report. Priority areas should be further customized and focused during local planning efforts.

Priority Areas	Refer to:
Contributing areas of impaired streams and lakes - prioritized by reduction goals, number of impairments, etc.	Goals maps: Figures 18, 23, 27, 31, 33
Highly hydrologically-altered subwatersheds	Figure 16, Appendix 5.4
High HSPF model-estimated contributing subwatersheds	Appendix 5.11

Critical areas are identified as the result of prioritizing and targeting efforts, and are high priority locations to implement practices to help achieve the needed pollutant and stressor reductions. Critical areas should be developed in conjunction with those who will be implementing the plans using one or more of many tools and/or applicable data layers. The critical area development process (i.e. prioritizing and targeting) should be logical and defensible - in that it obviously identifies at-risk, high-priority or other conservational-important areas - but does not need to be an identical process for every plan since different plans may have different local priorities and goals. Refer to Appendices 5.25 and 5.26 for available tools and data layers for critical area development.

A hypothetical example of developing critical areas is illustrated in Figure 42. This example illustrates how the group Conservation Partners (CP) developed priority areas and targeted practices to identify critical areas for one practice, nutrient management. Additional strategies could be included on the same work plan, with a process identified and used to identify critical areas for each practice.

Select Stratetgy

- Based on their work with producers in the area, CP thinks that fertilizer tends to be over applied in the watershed. The WRAPS report also calls for a substantial amount of new acres to use nutrient management. Therefore, CP selects nutrient management as one strategy to implement in this work plan.

Prioritize

- The strategies table notes that nutrient management is most effective for N and P. Therefore, CP uses the WRAPS N and P reduction maps, condition maps, and modeled yield maps to identify higher priority areas - or areas that are contributing to impairments and have higher modeled yields. They consider what and who they know in the watershed to select five subwatersheds to focus on. These five are their priortiy areas to implement nutrient management for this work plan.

Target

- CP chooses to use the EBI water quality layer to identify specific locations within the selected priority areas to target. They use GIS to identify these locations and add in all other fields that are within 1,000 ft of a water body with N or P identified as a pollutant or stressor. These areas are the critical areas for nutrient management for this work plan. CP sends letters asking to meet with landowners and follows-up with phone calls. They meet in-person with many of the landowners and have several who are willing to participate.

Measure

- CP will measure progress using a few criteria. First, they will track the number of acres applying nutrient management and they will document the before and after nutrients applied on each field. They also plan to use the bio-monitoring and other data from the next round of WRAPS work to track any changes in water quality.

Figure 42: A hypothetical example of how CP decided to prioritize and target nutrient management in a work plan shows a physical and social science-based approach that uses a logical and defensible process to identify critical areas.

This process may not always be linear and does not need to be the same process for the same practice in different work plans. For instance, CP may have been particularly interested in showing changes in water quality. They may have started by identifying locations in the watershed that have smaller watersheds (easier to show changes with the same number of acres changed) and that have a long term data set and planned continued monitoring (to be able to measure changes in water quality). Another example of how this could vary is that CP could have started with identifying priority areas before selecting the strategies. In that case, they would have reviewed the maps and tables in the WRAPS report to identify which strategies would best meet the unique set of pollutant and stressor issues in that priority area. Again, using an identical process is less important than it is to use a logical and defensible process that also meets local needs.

Table 14A: This portion of the strategies table summarizes the conditions discussed in Section 2 of the WRAPS report: the pollutants/stressors of concern, the current water quality conditions for each pollutant/stressor, and the watershed-wide water quality goals and targets. This table also presents the primary sources and the estimated years to meet the goal (both developed by the WRAPS Workshop Team) and an estimate of the strategies and adoption rates needed to meet water quality goals. This information will be revisited and revised in future iterations of the Watershed Approach. Specific practices, adoption rates, and responsibilities to meet the 10-year target are identified in Table 14B.

Pollutant/ Stressor		Current Known Status	Goal at watershed outlet or average of individual reductions needed	10-yr target to meet by 2026	Sources of Pollutant/Stressor: Land use	Sources of Pollutant/Stressor: Pathway	General Strategies: Concept	General Strategies: Rough Estimate of Needed Adoption (All= >90% Most= >60% Many/much= >30% Some= >10% Few= <10%)	Years to goal from 2015
Altered Hydrology	High Flow	▪3 stream reaches stressed ▪Flow reductions needed to meet downstream needs ▪Downstream waters impacted	25% reduction in annual river flow, 25% reduction in 2yr peak	5% reduction	Crops, tiled	Tile drainage	Increase ET by making vegetation changes and by creating permanent water storage capacity in the landscape	All drainage projects are fully hydrologically mitigated to protect from further degradation. Most fields improve vegetation by using cover crops, buffers, grasses, etc.. Many fields have increased soil water holding capacity from increased soil organic matter due to conservation/no tillage, increased vegetation, etc. Most field drainage incorporates conservation drainage principles and/or is intercepted by ponds, wetlands, etc. that ET and infiltrate. Most drainage and ditch projects incorporate multi-benefits including maintaining vegetation and natural stream features. Some non-ag land use areas add wetlands, perennial vegetation, and urban/ residential stormwater management.	50
					Crops, all	Surface runoff			
					Developed	All			
	Low Flow		increase dry season river base flow (groundwater)	increase	Crops, not tiled	Groundwater	Shift flow timing to dry season by increasing infiltration and permanent water storage capacity in the landscape		25
					Crops, tiled	Groundwater			
					All other land use	All			
Sediment		▪14 stream reaches stressed/impaired ▪6 stream reaches not stressed/supporting ▪Downstream waters impacted	50% reduction in river sediment concentrations/loads (FWMC from 130 to 65 mg/L)	10% reduction	Stream bank erosion		Address altered hydrology, stabilize where economically necessary	First, control hydrology in contributing areas as discussed above. Stabilize few stream banks/ravines - those that threaten high value property.	40
					Ravine erosion				
					Crops, not tiled	Surface runoff	1) Reduce concentration by improving treatment or management and/or 2) reduce polluted water volume	Most fields use surface sediment controls to prevent erosion including conservation tillage, removing open intakes, cover crops, etc. Many fields trap/settle eroded sediment at edge of field with buffers, sediment basins, etc.	
					Crops, tiled	Surface runoff & open tile intakes			
					Developed	All from land use			
Phosphorus		▪3 stream reaches and 6 lakes stressed/impaired ▪1 stream reach and 5 lakes supporting ▪Downstream waters impacted	60% reduction in river 50% reduction in lake concentrations/loads (stream FWMC from 0.39 to 0.15 mg/L and lake average concentration from 0.17 to 0.09 mg/L)	10% reduction for rivers, 20% reduction for lakes	Crops, all	Surface runoff	1) Reduce concentration by improving treatment or management and/or 2) reduce polluted water volume	All fields incorporate nutrient management principles for fertilizer and manure use. Sediment practices as discussed above are implemented. Many fields treat tile drainage water to remove phosphorus using treatment wetlands, vegetative filters, etc. Some ditch/stream water has improved treatment via stream/ditch vegetative improvements. Much of the urban/residential runoff is prevented or treated. Most failing SSTSs are fixed. Some WWTPs upgrades to reduce phosphorus are made.	40
					Crops, all	Tile & groundwater			
					Pasture (overgrazed)	Surface runoff			
					Developed	Urban Stormwater			
					Developed	Failing SSTS			
					Developed	WWTPs			
					Stream bank erosion		Address altered hydrology, stabilize where economically necessary	Sediment practices for stream banks/ravines as discussed above are implemented.	
Nitrogen		▪2 stream reaches stressed ▪Downstream waters impacted	45% reduction in river concentrations/loads (FWMC from 9.2 to 4.9)	12% reduction	Crops, tiled	Tile drainage	1) Reduce concentration by improving treatment or management and/or 2) reduce polluted water volume	All fields incorporate nutrient management principles for fertilizer and manure use. Hydrology practices as discussed above are implemented, including design parameters for nitrogen removal. Sediment practices as discussed above are implemented , including design parameters for nitrogen removal. Much of the urban/residential runoff is prevented or treated.	40
					Crops, all	Groundwater			
					Crops, all	Surface runoff			
					Developed	City/Res Stormwater			
Bacteria		▪15 stream reaches impaired	80% reduction in river concentrations/loads (averaged monthly geomean from 600 to 126 cfu/100mL)	25% reduction	Crops w surface manure	Surface runoff	1) Reduce concentration by improving treatment or management and/or 2) reduce polluted water volume	All manured fields incorporate best manure management practices. Many manured fields incorporate infield and edge of field vegetative practices to capture manure runoff including cover crops, buffer strips, etc. Most manure feed lot pile runoff is controlled. Most failing SSTSs are fixed. Some WWTPs upgrades to reduce bacteria are made.	35
					Developed	Feedlot/stockpile runoff			
					Pasture (overgrazed)	Pasture runoff			
					Crops w subsurface manure	Surface runoff			
					Developed	Failing SSTS			
					Developed	WWTPs			
Habitat		▪4 stream reaches stressed	45% increase in average MSHA score (score from 48 to 66)	9% increase	Degraded Riparian		Improve riparian	Hydrology practices as discussed above are implemented. All streams have adequate buffer size and vegetation to meet shading, woody debris, geomorph, and other habitat needs. Few channel restorations.	50
					Altered hydrology		Address hydrology		
DO		▪7 stream reaches stressed/impaired ▪3 stream reaches not stressed/not impaired	increase to 5 mg/L, minimize fluctuation	Meet Q & P targets	Phosphorus, altered hydrology, and degraded riparian		Address P, altered hydrology, riparian, and in-stream conditions	Address hydrology, phosphorus, and habitat practices as discussed above.	50

Table 14B: This portion of the table presents information most relevant for local planning efforts including the specific strategies and actions, adoption rates, and responsibilities to meet the 10-year target. Information on the conditions, goals, and total timelines is presented in Table A. Refer to the key for notes and information.

Land use/Source Type	Watershed Restoration and Protection Strategies estimated to meet 10-year target at specified adoption rates	Adoption Rate: % watershed to newly treat	Adoption Rate: Acres to newly treat	Practice Effectiveness: Flow	TSS	Phosphorus	Nitrogen	Bacteria	Habitat‡	Responsibility: Farm Owners	Farm Operators	Residents	Conservation Non-prof	Businesses	Municipalities	Ag Industry/Groups	Hawk Creek Wat Proj	Drainage Auth	SWCD	P&Z/Environ.	Feedlot Staff	Elected Officials	Transportation Auth.	MPCA	DNR	BWSR	MDA	MDH	UofM Extension	USDA	USFWS	Corps of Engin.
Cultivated Crops	Nutrient management (for P & N)	7%	43,800			o	x			√	√					√			√					√		√	√		√	√		
	Cover crops	5%	31,300	x	x	o	x	X	-	√	√					√			√						√	√	√		√	√		
	Reduced tillage	5%	31,300	o	x	o	x	o	-	√	√					√			√							√	√		√	√		
	Crop rotation (including small grain)	4%	25,000	o	-	-	o		-	√	√					√			√		√					√	√		√			
	Buffers, border filter strips*	3%	18,800	-	o	-	-	o	-	√	√	√	√			√	√	√	√	√		√		√	√	√	√		√	√	√	
	Alternative tile intakes*	2%	12,500		x	x		o		√	√					√	√	√	√		√			√		√	√		√	√		
	Treatment wetland (for tile drainage system)*	2%	12,500	-		o	x		-	√	√	√	√		√		√	√	√			√		√	√	√	√	√	√	√	√	
	Improved manure application	1%	6,300	o		o	x	X	-		√					√					√			√			√		√	√		
	Conservation cover	1%	6,300	X	x	x	X	x	-	√	√		√				√		√			√		√	√	√	√			√	√	
	Grassed waterway*	1%	6,300	-	o	-	-		-	√	√								√					√		√	√			√		
	WASCOBS, terraces, flow-through basins*	1%	6,300	-	o	-	-	-	-	√	√								√					√		√	√			√		
	Controlled drainage, drainage design*	1%	6,300	-		-	x		-	√	√						√	√	√							√	√			√		
	Saturated buffers*	1%	6,300	-		-	x		-	√	√						√	√	√							√	√			√		
	Wood chip bioreactor*	1%	6,300			-	x			√	√						√	√	√							√	√			√		
	Livestock integration	1%	6,300	x	x	x	X	X	-																		√					
	Wetland Restoration	1%	6,300	X	x	x	X	x	-	√	√		√				√	√	√						√	√	√			√	√	√
	Wind Breaks*	1%	6,300		-	-																										
	In/near ditch retention/treatment*	1%	6,300		o	-				√	√		√		√	√	√	√	√							√				√		
	Retention Ponds	0.1%	600	X	x	x	X	x	-																							
	Contour strip cropping (50% crop in grass)	0.1%	600	x	x	x	x	x	-	√	√					√	√		√							√	√		√	√		
	Mitigate new ag drainage projects†	All new projects		n/a (protection)																							√					
	Maintain existing BMPs, CRP, RIM, etc. †	All current BMPs		n/a (protection)																												
Pastures	Rotational grazing	0.1%	600			x		X	-	√	√						√		√								√			√		
	Livestock exclusion and watering facilities	0.1%	600			x		X	x	√	√						√		√								√			√		

* = strategy footprint is much smaller than treated area
† = strategy is important for protection and in some cases reflects preventing current condition degradation

Practice Effectiveness Key
calculated % of goal addressed if 1% new watershed adoption
X = >2% x = >1% o = >0.5% - = >0% <blank> = ~0%

‡ Practices with some impact on flow are assumed to have a minimal impact on habitat, while those that are directly applicable to riparian areas are assumed very effective

Land use/Source Type	Watershed Restoration and Protection Strategies estimated to meet 10-year target at specified adoption rates	Adoption Rate	Pollutants/Stressor addressed by strategy: Flow	TSS	Phosphorus	Nitrogen	Bacteria	Habitat	Responsibility: Farm Owners	Farm Operators	Residents	Conservation Non-prof	Businesses	Municipalities	Ag Industry/Groups	Hawk Creek Wat Proj	Drainage Auth	SWCD	P&Z/Environ.	Feedlot Staff	Elected Officials	Transportation Auth.	MPCA	DNR	BWSR	MDA	MDH	UofM Extension	USDA	USFWS	Corps of Engin.
Cities & Yards	Nutrient/fertilizer and lawn mgt.	sufficient to reduce current city and residential contributions by 20%	√	√	√	√	√	√	√		√		√	√				√	√		√										
	Infiltration/retention ponds, wetlands										√	√	√	√					√		√	√									
	Rain gardens, rain barrels													√		√		√													
	Street sweeping & storm sewer mgt.													√							√										
	Trees/native plants										√	√	√	√				√						√				√		√	
	Snow pile management										√		√	√					√		√										
	Golf course nutrient mgt.										√	√	√	√					√				√	√	√						
	Permeable pavement for new construction										√		√	√																	
	Construction site erosion control										√		√	√							√	√	√								
Streams, ditches, & ravines	Protect and restore buffers, natural features†	buffers per law; no loss of natural features	√	√	√	√	√	√	√	√	√	√	√	√		√		√	√		√	√		√	√						
	Reduce or eliminate ditch clean-outs	all ditches		√	√			√								√	√	√	√		√			√							
	Bridge/culvert design	all new projects		√	√			√										√			√	√		√							√
	Streambank stabilization	as needed to protect property or for extreme erosion		√	√			√	√	√		√		√	√	√	√	√				√		√							
	Ravine/stream (grade) stabilization			√	√			√								√		√						√	√						√
	Stream channel habitat, shape, pattern, and slope restoration	priority projects	√	√	√	√	√	√	√	√		√		√	√	√	√	√				√		√	√						√
Lakes, wetland	Protect and restore near-water vegetation†	sufficient to reduce/consume 2% of P load	√	√	√	√	√	√											√	√				√	√						
	In-water management and species control				√														√					√	√						
Forest, prairie	Protect and restore areas in these landuses, increase native species populations†	all forests and prairies	√	√	√	√	√	√	√	√	√	√						√	√		√			√	√						
SSTS	Maintenance and replacement/upgrades	sufficient to reduce current contributions by 20%			√		√		√		√					√		√	√		√		√		√	√	√				
Feed lots	Feedlot runoff controls including: buffer strips, clean water diversions, etc.				√	√	√		√	√					√			√	√	√	√										√
Social Dimension (strategies other than physical practices)	Facilitate relationship-building between ag producers and conservation professionals	sufficient to address barriers to adopting all other strategies at specified adoption rates	no direct impacts to pollutants and stressors. however, these strategies are critical to get the physical practices adopted						√	√	√				√	√	√	√	√	√	√		√		√	√		√			
	Facilitate relationship-building between ag industry and conservation professionals									√		√			√	√		√			√		√	√	√	√		√	√	√	
	BMP education programs: ag soil health and altered hydrology, residential stormwater, septic system, manure management								√	√	√		√	√	√	√	√	√	√	√	√		√	√	√	√		√			
	Networking and educational opportunities for agricultural producers, demo projects								√	√	√				√	√	√	√	√	√	√		√	√	√	√		√	√		
	Change Farm Bill to: support alternative crops, small farms, perennials, rural communities; remove incentives that result in environmental damage								√	√	√	√	√	√	√	√		√	√		√					√			√		
	Restructure funding and crop insurance to: ensure income for farmers when transitioning - and eliminate obstacles - to implementing sustainable practices								√	√		√			√						√								√		
	New ordinances/ordinance review (septic compliance upon property transfer, well head protection)								√	√	√		√	√	√		√	√	√	√	√			√	√		√				
	Existing ordinance compliance/enforcement: manure application, shoreland†								√	√	√			√	√		√	√	√	√	√			√	√						
	Permit compliance for regulated sources†								√	√			√	√	√					√	√		√		√	√			√		

Strategy Description and Additional Notes

Strategy/BMP	NRCS code	Description/Notes
Bridge/culvert design		New projects evaluate and address biological connectivity, sediment transport, and/or hydrology alterations
Conservation cover	327, 643	Native vegetation including grasses, trees, shrubs
Conservation tillage	329, 345, 346	No till, strip till, or reduced till with high residue to protect surface soil
Construction site erosion control	570	Silt fence, etc. to prevent sediment runoff, turf reinforcement
Cover crops	340	Must meet NRCS specs (very short term does not). A key soil health principle. Can be hard to be successful. Work with experienced users/professionals to implement.
Crop rotation	328	Consider in conjunction with cover crops and conservation tillage
Extended retention		See Ag BMP handbook (no NRCS code). Intended to slow discharge. Design must consider fish passage needs.
Feedlot runoff control	635, 362	Vegetated treatment area provides a controlled release of nutrient rich wastewater. Diverting runoff water.
Field buffers, borders, filter strips	393, 386, 332	Edge-of-field or within field
Grassed waterways	412, 342	Establishes permanent vegetation on flow pathways on erodible soils, slopes
Improved manure management	590	Improved training and application management
In/near ditch retention and treatment	410, 587	Includes any practice where the ditch itself is incorporated in to practice: 2-state ditch, side inlet control, weirs and berms, etc. Designs must consider multi-benefits to avoid unanticipated negative impacts
In-lake management and species control		Prevention of invasive species, restore diverse fish populations to control rough fish, increase habitat diversity
Livestock exclusion	382, 472, 614	Exclusion from water bodies, can help to create watering station
Livestock integration		Replace annual crop with cover crop or grasses and use proper grazing practices to integrate livestock
Minimize ditch clean-outs		Ditches often revert to more natural channels - highly vegetated and with a "2-stage" appearance (small meander at low flow with a bench). Do not disturb when this happens.
Near-water vegetation		Maintain/install native/perennial buffer zone at shoreline, using natural materials as wave breaks, restore/maintain emergent veg, woody debris
Nutrient (including manure) management	590	Considers amount, source, form, timing, etc..
Ravine/stream (grade) stabilization	410	First address hydrology before costly stabilization
Restored wetlands	657, 643, 644	Restoring wetland (where one was historically located)
Pond, retention or infiltration	378	Designed to hold and/or infiltrate water
Protect/restore buffers, natural features		Healthy streams need perennial vegetative buffers and have features such as meanders and floodplains.
Rotational grazing	528	Improvements to grazing that lead to improved vegetation
Saturated buffers	739	Vegetated subsurface drain outlet for nutrient removal
SSTS (Septic systems)	313	Maintenance and replacement when needed to ensure clean effluent, meeting typical SSTS s
Streambank stabilization	580	Using bioengineering techniques as much as possible
Strip cropping	332, 585	Alternating erosion susceptible crops with erosion resident crops perpendicular to water flows
Tile system design; controlled drainage	554	Managing for less total runoff; includes alternative tile intakes
Treatment wetlands	656, 658	Specifically designed to treat tile drainage and/or surface runoff
Water and sediment basins, terraces	638, 600	Managing for extended retention and settling
Woodchip bioreactors	747	Reducing the level of nitrogen in drainage systems

***** The strategy footprint is only a fraction of the treated acres, which should be considered when comparing adoption rates. For example: grassed waterway will not take 6,300 acres out of production, but will treat 6,300 acres. It is intended to treat the water from many more acres than the strategy footprint. So the actual acres converted to grassed waterways would be a fraction (e.g. 1/20th or 1/100th) of the treated acres.

See the NRCS design guidance and/or the Ag BMP handbook for additional information. The Ag BMP practices and NRCS codes listed in the table may not be the only available practices in which to select from.

Strategies do not supersede or replace permit requirements. If you are a regulated party, work with that MPCA regulatory program staff to ensure compliance and that adopted strategies will meet permit requirements.

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5 Appendix

5.1 Assessment for Beneficial Use, Parameters, and Stressors by Reach

				Aquatic Life											Aq Rec		Lim Use	
					Parameters				Stressors							Par		Par
AUID-3	Stream	Reach	Class	Assessment	F-IBI	M-IBI	DO	TSS	Q	P	N	DO	Hab	TSS	Assessment	Bacteria	Assessment	DO
510	Hawk Creek	T117 R37W S6, north line to Chetom	2B, 3C	-	-	-		X										
525	Timms Creek	Headwaters to Minnesota R	2C	?	√	X	?	X							X	X		
526	Sacred Heart Creek	Headwaters to Minnesota R	2B, 3C	?	X	X	X	X							X	X		
528	Beaver Creek	E Fk Beaver Cr to Minnesota R	2B, 3C	X	√	√	√	X							X	X		
530	Beaver Creek, West Fork	Headwaters to E Fk Beaver Cr	2B, 3C	-	-	-	X	X							X	X		
531	County Ditch 37 (1)	Headwaters to W Fk Beaver Cr	2B, 3C	-	-	-	X	√										
532	County Ditch 37 (2)	Headwaters to W Fk Beaver Cr	2B, 3C	?				√										
534	Palmer Creek (County Ditch 68)	Headwaters to Minnesota R	2C	?	√	√	?	X							X	X		
566	Unnamed creek	Unnamed cr to Unnamed cr	2B, 3C	X	X	X	?	X	X	X	?	X	X	?				
568	Hawk Creek	Unnamed cr to Unnamed cr	2B, 3C	X	-	-		X							X	X		
572	Unnamed creek	Unnamed cr to CD 31	2B, 3C	?				√										
577	Chetomba Creek	T116 R37W S7, east line to Unname	2C	X	X										X	X		
586	Beaver Creek, East Fork	T115 R35W S35, north line to W Fk B	2B, 3C	?	X	X	?	X							X	X		
587	Hawk Creek	Spring Cr to Minnesota R	2B, 3C	X	√	√	?	X							X	X		
589	Unnamed ditch	Chetomba Cr to Spring Cr	2B, 3C	X			?	X							X	X		
602	Unnamed creek (Eagle Lake Inlet)	Unnamed cr to Eagle Lk	2B, 3C	?				X										
608	Unnamed ditch	Unnamed ditch to Chetomba Cr	2B, 3C	?				√										
610	Brafees Creek	T116 R40W S1, north line to Minnes	2C	√	√	√		√										
615	Middle Creek	CD 120 to Minnesota R	2C	?			?	?							X	X		
617	Smith Creek (County Ditch 125A)	T113 R35W S4, north line to Minnes	2C	X	√	X	?	√	√	√	X	√	X	√	X	X		
623	Judicial Ditch 16	Headwaters to Chetomba Cr	2B, 3C	-	-	-		?										
640	Unnamed creek (Hawk Creek)	Eagle Lk to Swan Lk	2B, 3C	?				?										
642	Unnamed creek (Hawk Creek)	Swan Lk to Willmar Lk	2B, 3C	?				?										
648	Unnamed creek (County Ditch 119)	Unnamed cr to Minnesota R	2B, 3C	?			?	X							X	X		
653	Unnamed creek	Unnamed lk (34-0131-00) to Unnam	2B, 3C	?				?										
654	Unnamed creek	Headwaters to Unnamed cr	2B, 3C	?				?										
656	Unnamed creek	Headwaters to Unnamed cr	2B, 3C	?				?										
657	Unnamed creek	Unnamed cr to Eagle Lk	2B, 3C	?				?										
675	County Ditch 45	T114 R36W S7, north line to Sacred	2B, 3C	√	X	√												
676	County Ditch 45	T115 R36W S7, east line to T114 R3	7	-	-	-											?	√
677	County Ditch 59	Unnamed cr to W Fk Beaver Cr	2B, 3C	-	-	-	X	?										
678	County Ditch 17A	Unnamed ditch to W Fk Beaver Cr	2B, 3C	-	-	-		?										
682	County Ditch 36A	Unnamed cr to Minnesota R	2B, 3C	√	√			?										
684	County Ditch 116	named ditch to T115 R37W S8, east l	2B, 3C	-	-	-		?										
685	County Ditch 119	Headwaters to Unnamed ditch	2B, 3C	?				?										
687	County Ditch 119	Unnamed ditch to Unnamed cr	2B, 3C	X	X	X			X	X	X	X	X	X	X	X		
689	County Ditch 11	Unmnamed ditch to Hawk Cr	2B, 3C	-	-	-	?	X							X	X		
716	County Ditch 36	Unnamed cr to Hawk Cr	2B, 3C	X	X	X			X	X	?	X	X	?				
739	Unnamed ditch	T115 R36W S10, north line to CD 45	7														?	?

Beneficial Use Assessment*

X	= impaired
-	= not assessed
?	= insufficient data
√	= supporing

*benefical use assessment considers the status of multiple parameters and professional judgement

Parameter/Stressor Assessment

X	= failing standard/stressing
-	= data collected but not assessable until standards for channelized streams are developed
if	= insufficient data to make a finding
√	= supporting standard/not stressing

5.2 TMDL Summary

Lake	Estimated P reduction
Long	74%
Olson	45%
Ringo	71%
St. John's	55%
Swan	30%
W Solomon	36%
average	52%

Reach AUID #	Estimated bacteria reduction
07020004-528	86%
07020004-525	85%
07020004-526	81%
07020004-530	82%
07020004-534	86%
07020004-568	83%
07020004-586	59%
07020004-587	85%
07020004-589	85%
07020004-648	82%
07020004-689	81%

Reach AUID #	Estimated TSS Reduction
07020004-528	48%
07020004-589	35%
07020004-568	31%
07020004-587	56%

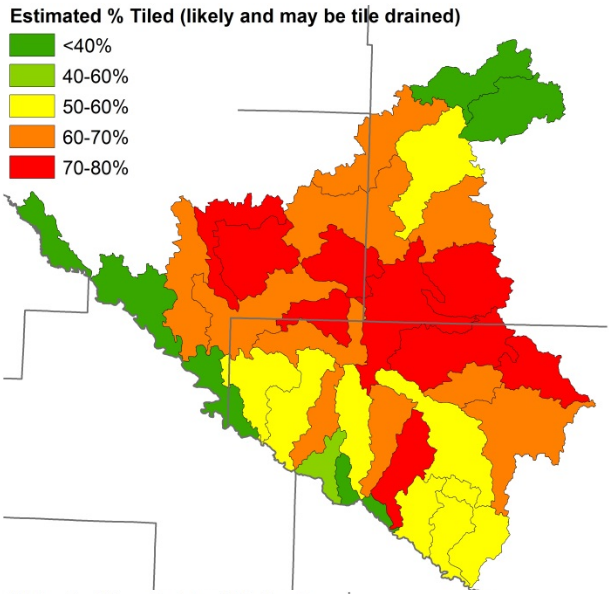
5.3 EPA 9 Minimum Elements

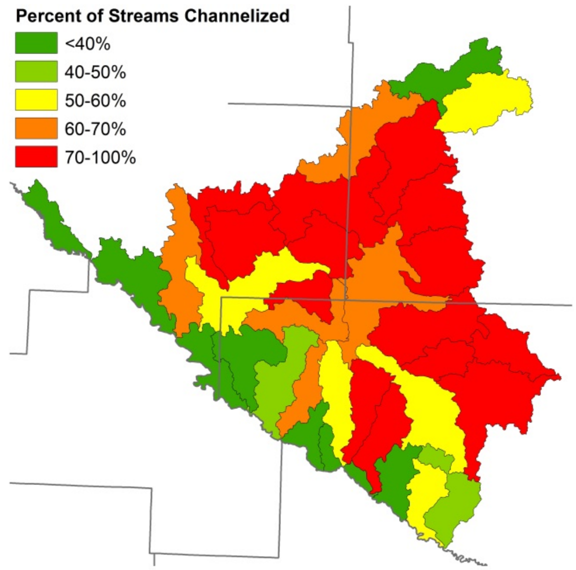
See full elements at: https://www3.epa.gov/region9/water/nonpoint/9elements-WtrshdPlan-EpaHndbk.pdf

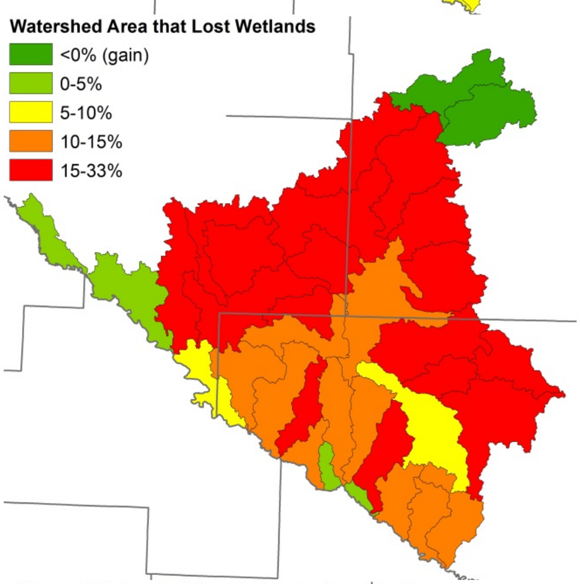
Element	Element Summary	Location
A	Causes of impairments and sources of pollutants and stressors	Section 2.2, Status and Sources subsections
B	Estimate of the load reductions from management measures	Section 3.3, Table 14B, Effectiveness Column. See also Appendix 5.16
C	Nonpoint source management measures and critical areas	Section 3.3, Table 14 and Section 3.3, Prioritizing and Targeting subsection
D	Technical and financial assistance needed and authorities	Section 3.3, Table 14B and TMDL Section 8.3
E	Information and education	Section 3.2, Social Dimensions
F	Implementation schedule	Section 3.3, Table 14A, Years to goal column
G	Milestones	Section 3.3, Table 14B (10 year)
H	Criteria to establish progress	Section 3.3, Table 14A, Current Conditions and Goals column
I	Monitoring	Section 1.3, Monitoring Plan subsection

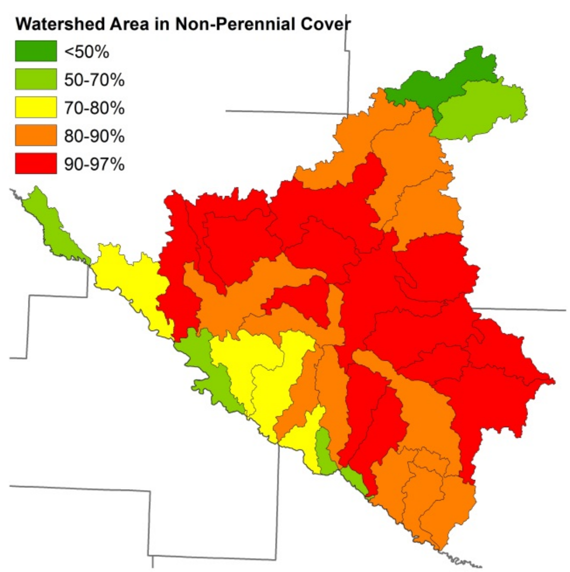
5.4 Altered Hydrology GIS Analysis

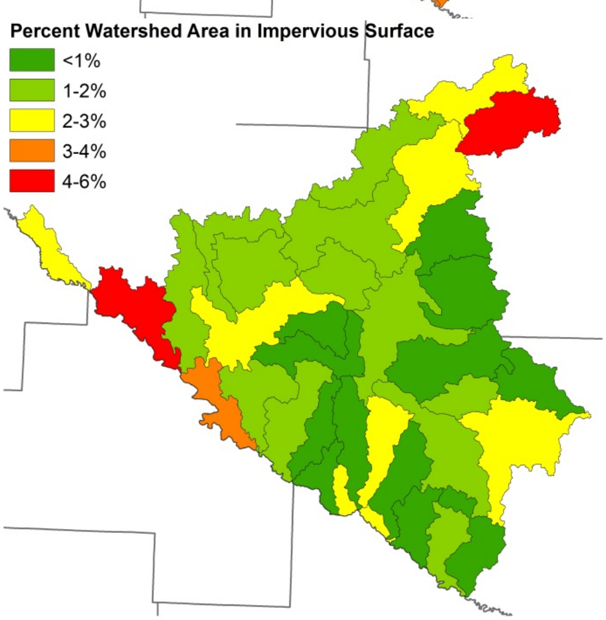
1) the estimated percentage of land area that is tile drained, 2) the percentage of stream length that is channelized/artificially straightened, 3) the percentage of watershed area where wetlands were drained, 4) the percentage of land in non-perennial vegetation, 5) the percentage of land covered in impervious surfaces, and 6) the number of road crossings per stream length.

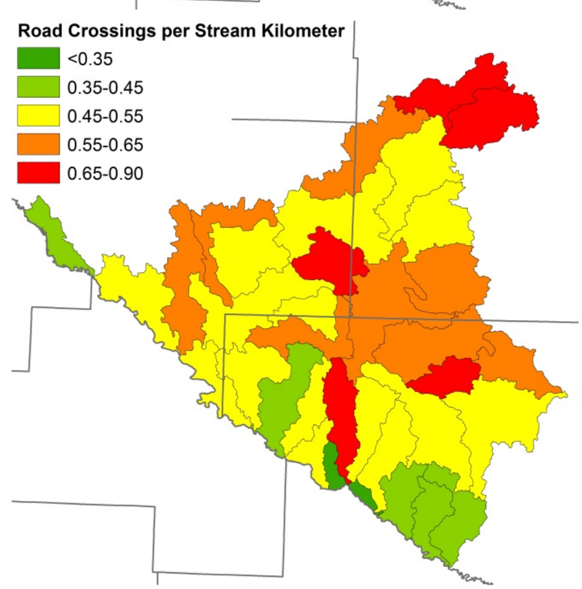




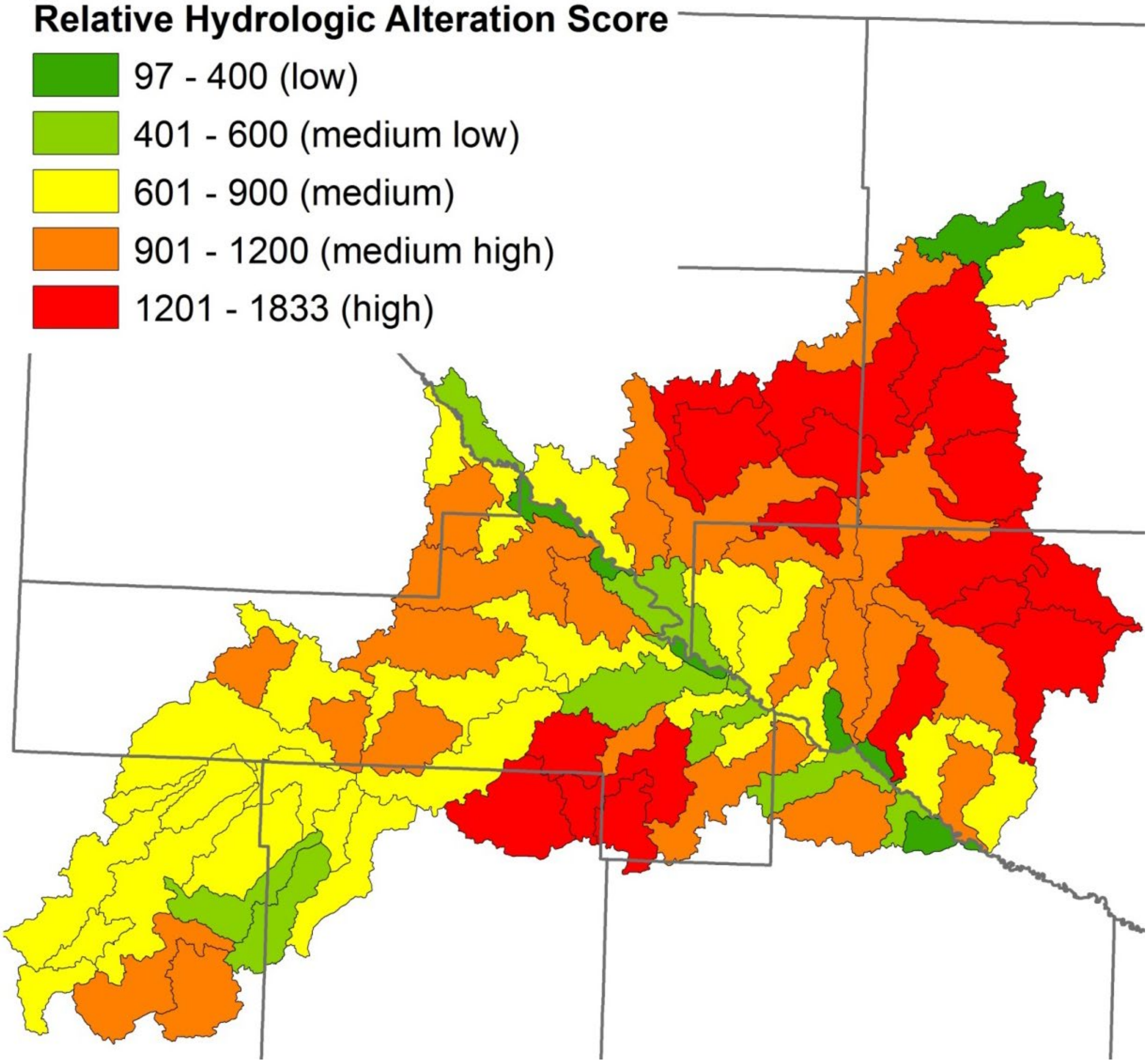








5.5 Altered Hydrology Comparison (shows entire Minnesota River – Yellow Medicine Watershed)



5.6 GIS Tile Estimate

The following assumptions were used to identify the likelihood of tile:

Likely Tile Drained – Land use in cultivated crops, poorly or very poorly drained soils, and 0% to 3% slope

May be Tile Drained – Land use in cultivated crops, any soil type except for well drained, 0% to 3% slope

Not Likely Tile Drained – Land use other than cultivated crops OR cultivated crops with greater than 3% slope or well-drained soil

Figure 14 shows apparent differences in tiled likelihood for Chippewa County versus the other counties. This seeming difference is due to differences in soil types as recorded by the soil surveyor. Often times, different soil surveyors were assigned different counties. As with other scientific professions, sometimes professional judgement varies between individuals. Therefore, the seeming difference in tiled likelihood between counties is most likely due to having different soil surveyors assessing the counties.

5.7 Rate of Ditching Calculation

Watershed	ALTERED (ditch) MILES	NATURAL MILES	IMPOUNDED MILES	no defined channel (NDC) MILES	TOTAL MILES	total-ndc	ACRES	ALTERED MILES per 1,000 acres	% of all stream miles that are altered (ditches)	% of stream miles with a definable channel that are altered/ditched
Upper Minnesota	357	235	137	145	873	729	501,350	0.7	41%	49%
Cottonwood	808	769	14	392	1983	1590	840,751	1.0	41%	51%
Redwood	487	373	3	90	952	862	447,339	1.1	51%	56%
Middle Minnesota	803	539	27	294	1664	1370	862,244	0.9	48%	59%
Le Sueur	738	400	37	91	1266	1175	711,614	1.0	58%	63%
Blue Earth	707	369	16	165	1257	1092	777,818	0.9	56%	65%
Lac Qui Parle	688	341	7	474	1509	1036	486,651	1.4	46%	66%
Watonwan	603	248	22	275	1148	873	559,162	1.1	53%	69%
Hawk-Yellow Medicine	1736	699	23	577	3035	2458	1,332,453	1.3	57%	71%
Lower Minnesota	1651	471	30	416	2569	2152	1,175,135	1.4	64%	77%
Chippewa	1291	265	98	801	2455	1654	1,329,918	1.0	53%	78%
Hawk (only)	770	150	4	284	1208	924	625,655	1.2	64%	83%
Pomme De Terre	580	80	34	206	900	694	559,965	1.0	64%	84%
MN RIVER BASIN	**10448.3**	**4787.7**	**446.9**	**3925.7**	**19608.6**	**15683**	**9,584,401**	**1.1**	**53%**	**67%**

5.8 Minnesota State Nutrient Reduction Strategy

https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf

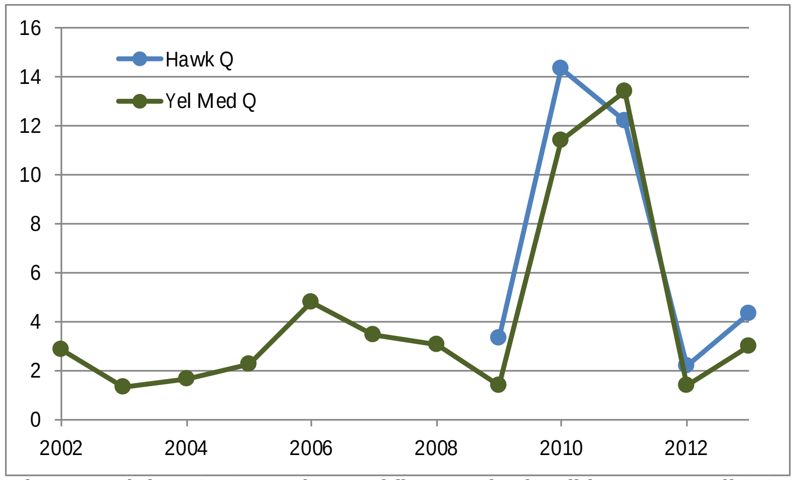
The phosphorus strategy calls for an additional 12% reduction (in addition to the already reached 33% reduction) between a 1980 through 1996 baseline period and 2025. To calculate what percent-reduction this equates to between the current (2014) loads and the total goal, the 33% reduction already made must be factored into the reduction calculation.

The percent reduction calculation is illustrated by assigning the baseline period a load equal to 100 units. The total goal is to reduce this by 45% (45 units), which means the goal is to reach 100 units – 45 units = 55 units. Since a 33% (33 unit) reduction in baseline levels was already achieved, the 2014 load equals 100 units – 33 units = 67 units. The reduction from 2014 to the final goal is (67 units – 55 units) / 67 units = 18% reduction. This goal is for the Mississippi River Basin as a whole, whereas the Minnesota River Basin is a much higher yielding area, Therefore, the total goals for major watersheds in the Minnesota River Basin will likely be higher than the that the Mississippi River Basin reduction goal.

5.9 Baseline Flow Calculation

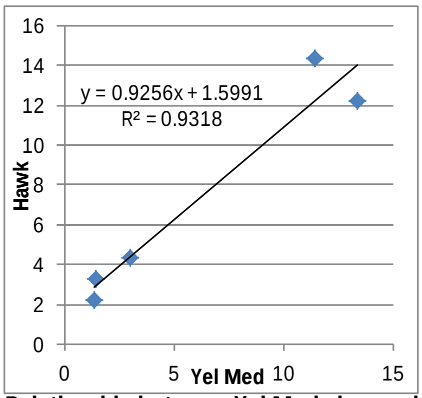
Hawk Creek has annual flow records dating back to only 2009. Many other watersheds in the area have much more extensive flow records available, including some that date back to the early 20th century. When setting flow goals, the historic record is important. The historic record is compared to more recent records to determine how much change has occurred. Then, a period of record that reflects recent conditions is selected as a baseline. The baseline is used to calculate a goal so that in future years, progress towards the goal can be evaluated. Since data for both Hawk and Yellow Medicine showed two very high flow years in 2010 and 2011, using years 2009 through 2013 as a baseline would overestimate the typical flows. Instead, a 10-year baseline was selected to reduce the influence of the two very high years. Since data was only available for the last five years in the Hawk Creek Watershed, the relationship between Hawk Creek and Yellow Medicine flows was used to estimate flows for 2004 through 2008. Then, the 2004 through 2013 years are used for the baseline.

(shaded) = estimated			
	Hawk Q in	Yel Med Q in	ratio
2002	4.24	2.85	
2003	2.86	1.36	
2004	3.17	1.70	
2005	3.71	2.28	
2006	6.03	4.79	
2007	4.84	3.50	
2008	4.43	3.06	
2009	3.31	1.43	
2010	14.32	11.42	
2011	12.20	13.39	
2012	2.22	1.40	
2013	4.32	3.04	
5 yr avg	7.28	6.13	1.19
10 yr avg	5.86	4.18	1.40

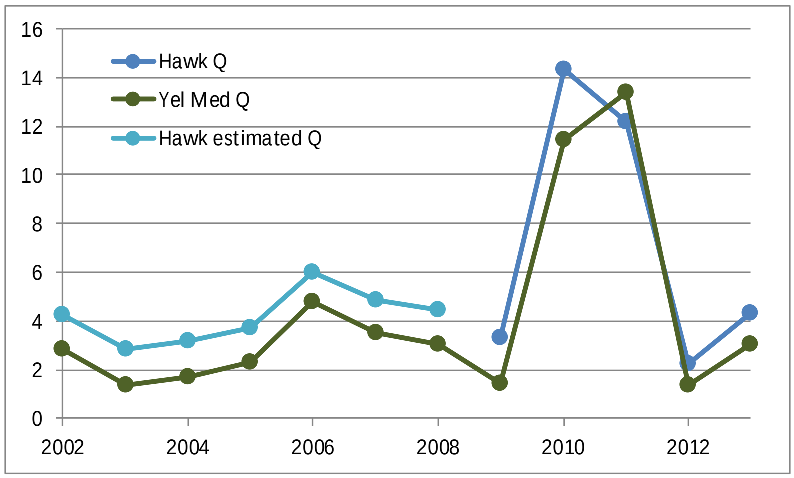


Flow record since 2002 - Hawk annual flow monitoring did not start until 2009

Goal
25% red = 4.39



Relationship between Yel Med observed flow and Hawk observed flow



Annual flow records including the estimated portion of the Hawk's record

5.10 ET Rate Data & Calculation

The presented ET rates are from the following sources/methodologies:

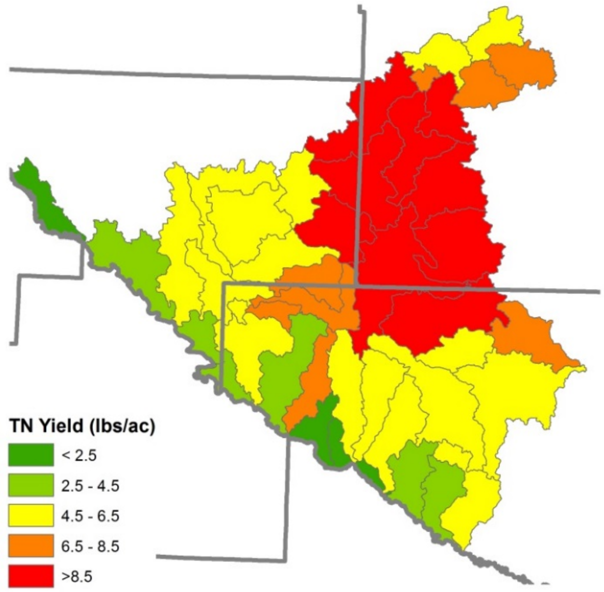
ET rate	Formula/specifics	Reference	Applicable Data
Wetland	$ET_W = 0.9 * ET_{pan}$	Wallace, Nivala, and Parkin (2005)	Waseca station pan ET 1989-2008 average
Lake	$ET_L = 0.7 * ET_{pan}$	Dadaser-Celik and Heinz (2008)	
Crops	Crop ET, Climate II	NRCS (1977)	Table from source

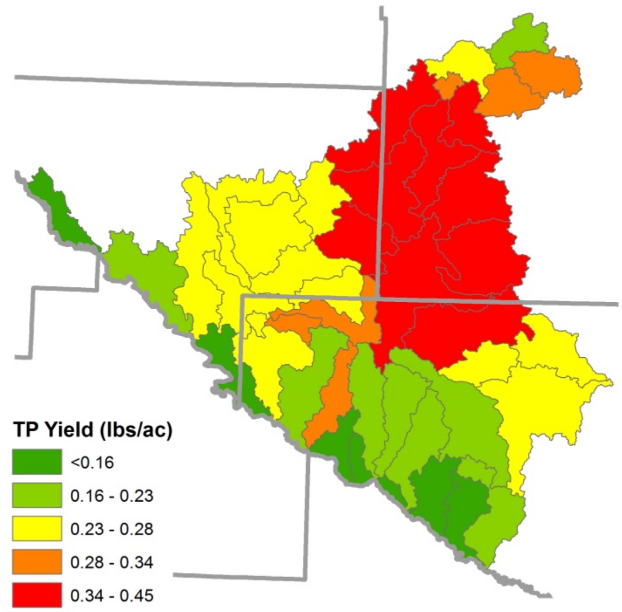
The NRCS crop ET source, despite the source age, was selected because it provided the highest estimates of crop ET. To illustrate this point, the seasonal corn ET rates, as determined from several sources, are presented below:

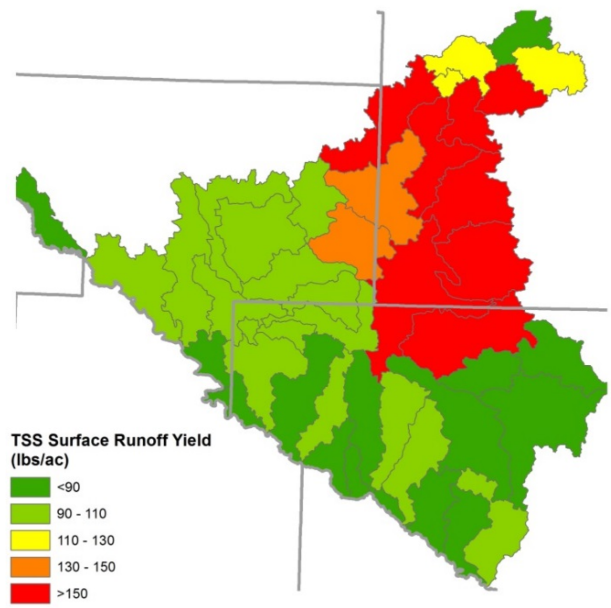
Methodology, data	Source	May-September Corn ET
1. Irrigation table	NRCS (1977)	64 cm
2. SWAT modeling in the Lake Pepin Full Cost Accounting	Dalzell et al. (2012)	54 cm
3. MN Irrigation Scheduling Checkbook, Waseca station temp	NDSU (2012)	42 cm
4. MN Crop Coefficient Curve for Pan ET, Waseca station pan ET	Seeley and Spoden (1982)	39 cm

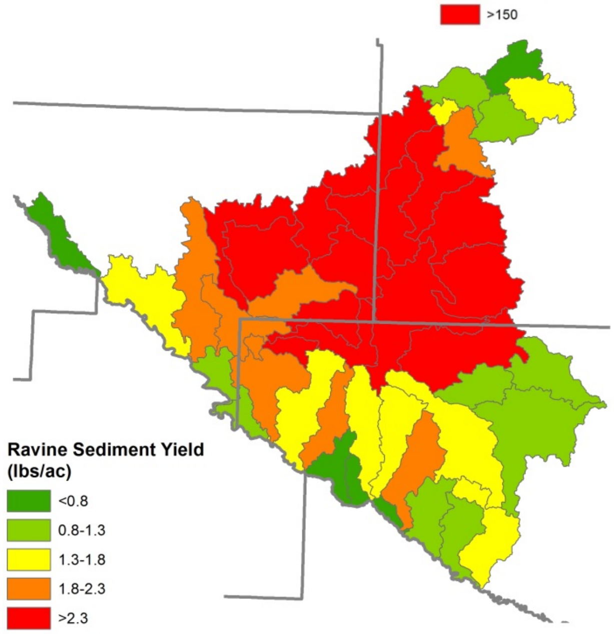
Using the highest crop ET rates for comparison was desired for multiple reasons: 1) pan coefficients were developed using older data sets and it is likely that corn, with higher crop densities and larger plant sizes, uses more water today than it did when the coefficients were determined, 2) using lower crop ET rates may appear to exaggerate the difference between crop and non-crop ET rates was exaggerated, and 3) error associated with pan ET rates could result in exaggerated differences between estimated wetland/lake ET and crop ET. More information on calculating ET rates is available here: http://deepcreekanswers.com/info/evaporation/ET_water_surf.pdf.

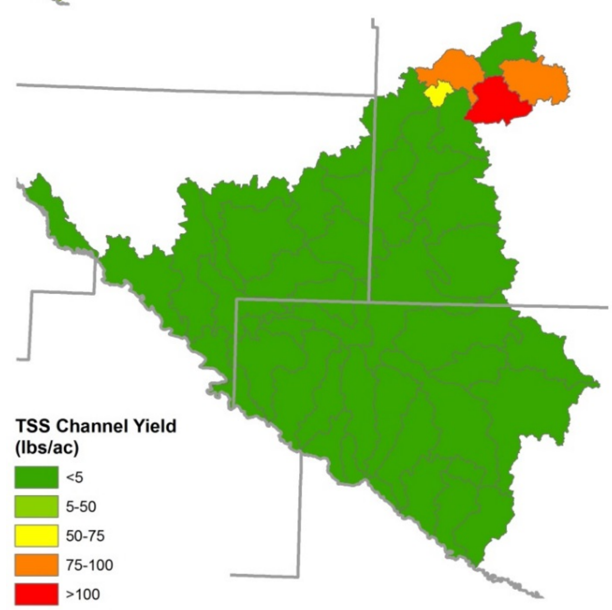
5.11 HSPF Estimated Subwatershed Yields



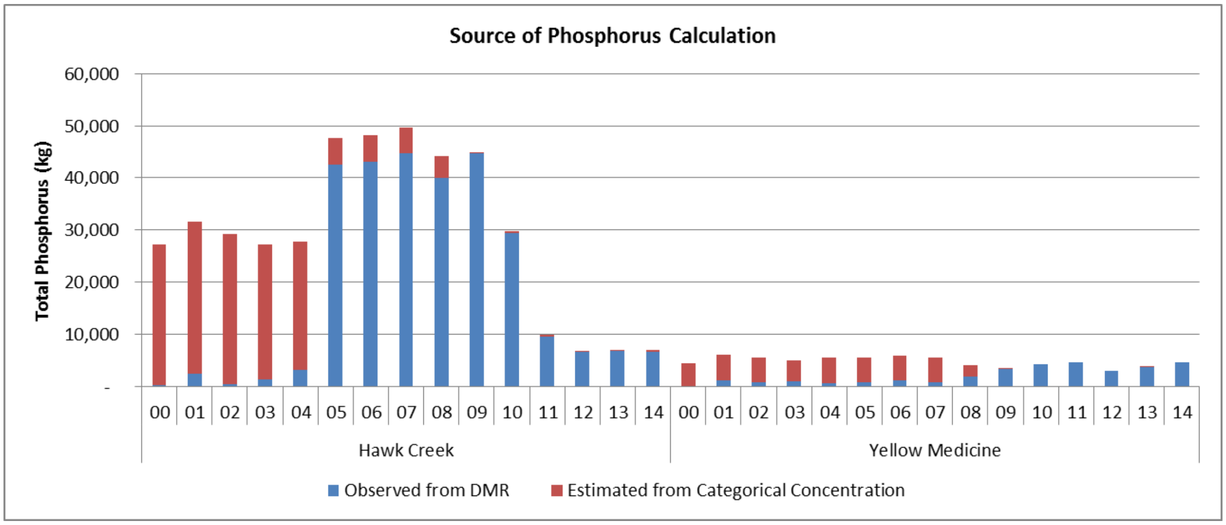


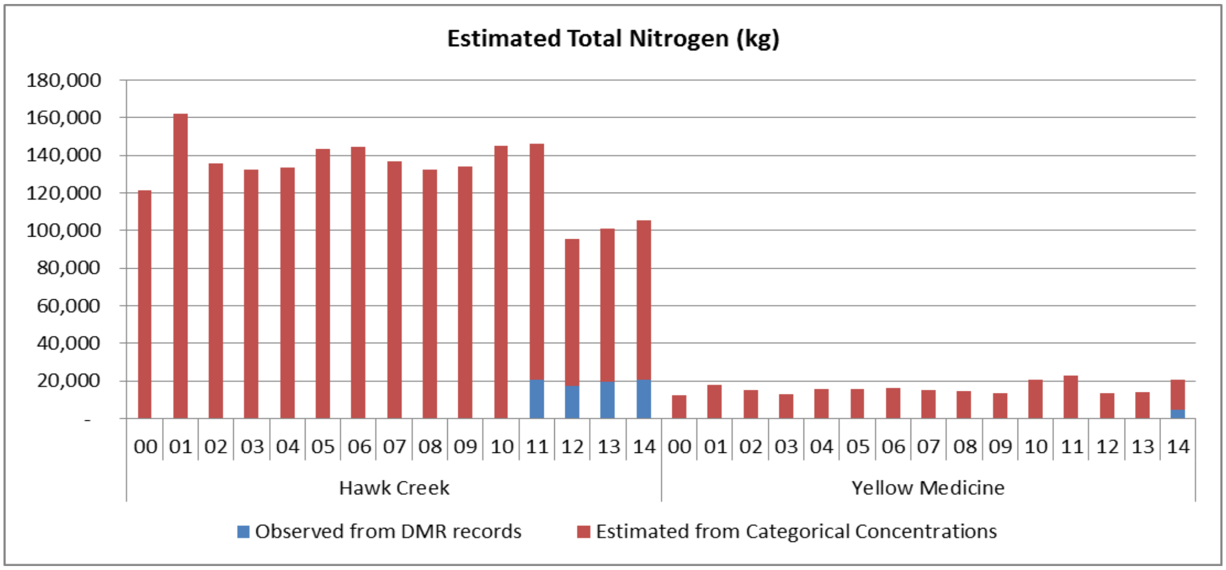


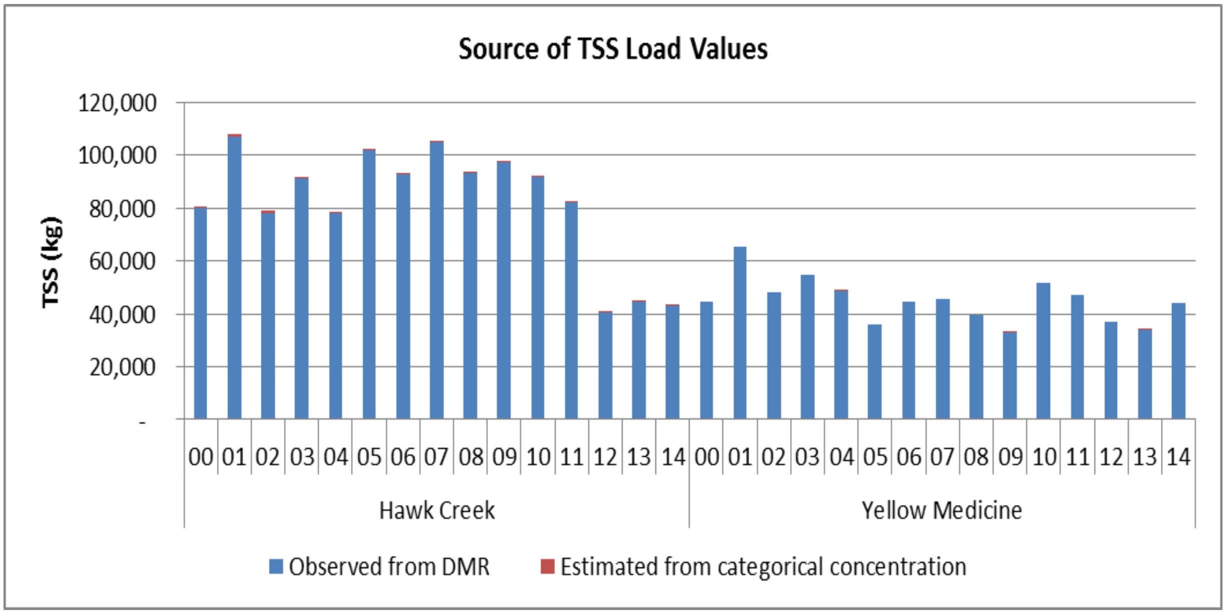




5.12 Point Source Data Summary



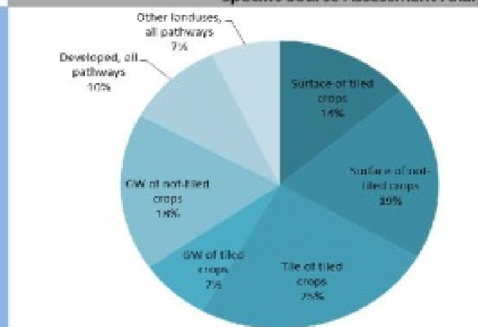




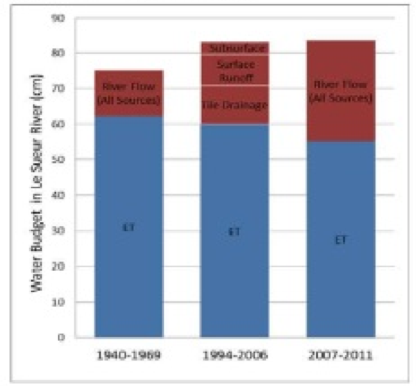
5.13 Source Assessment Lines of Evidence

Specific Source Assessment Analyses (including source and applicable area)	HSPF Source Assessment for Hawk (model years 1996-2012)	2011-2013 Discovery Farms Data for the tiled farms that monitored both tile and suface (BE1, ST1, DO1,	2009-2013 Watershed Pollutant Load Monitoring Network Data	2009-2013 Point Source Total vs Scaled WPLMN

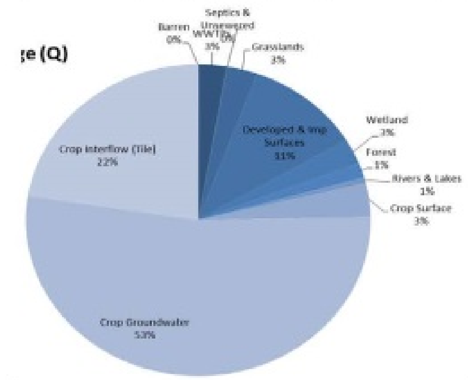
Q

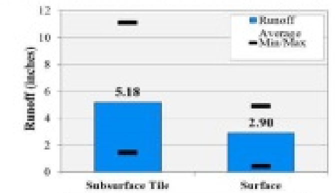


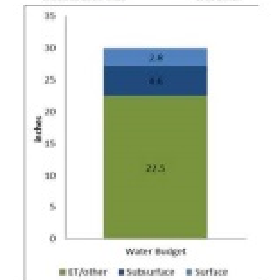
water portioning calculator (boettcher), assumes 40% of watershed tiled

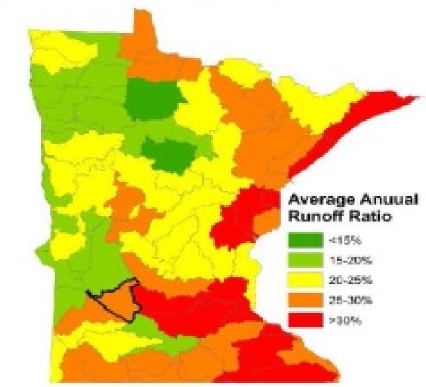


Middle bar of water budget: SWAT modeling of water budget by Fol



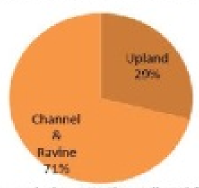




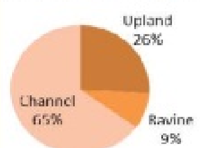


	WPMN measured river flow			
	Vol (acre ft)	inches	5yr avg	3yr avg
2009	89,444	2.83	6.21	5.33
2010	386,391	12.22		
2011	329,248	10.42		
2012	59,986	1.90		
2013	116,631	3.69		

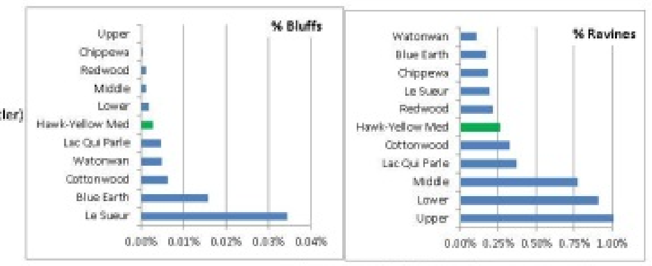
TSS



finger-printing, MN River tribs US from mid mn (schottler)

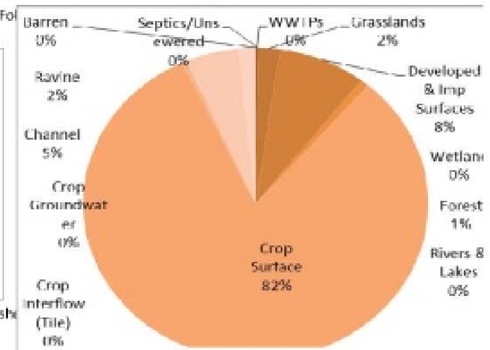


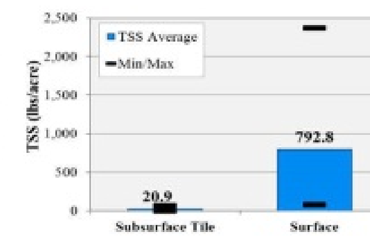
Gran Sediment Budget for Le Sueur River

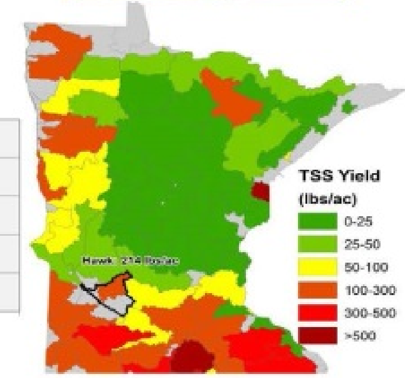


Mulla estimate of bluff and ravine areas per major watershe

MN River Basin Near Stream Sediment Sources (Mulla, 2010)

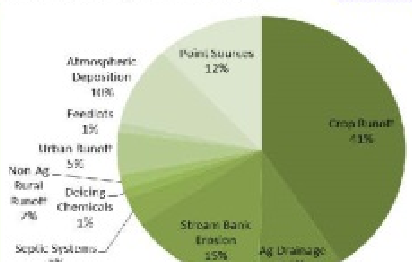






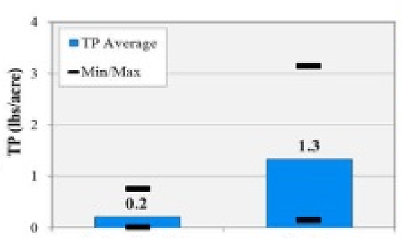
TSS	POINT kg	WPLMN kg	adjusted for whole watershed kg	annual % point	5-year average % point
09	97,977	26,011,880	50,257,776	0.19%	0.23%
10	92,014	41,983,550	81,116,776	0.11%	
11	82,894	45,365,590	87,651,244	0.09%	
12	40,493	12,284,680	23,735,335	0.17%	
13	44,879	32,256,920	62,323,871	0.07%	

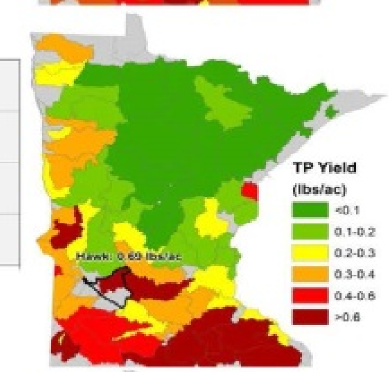
P



Detailed Assessments of Phosphorus Sources to Minnesota Watersheds

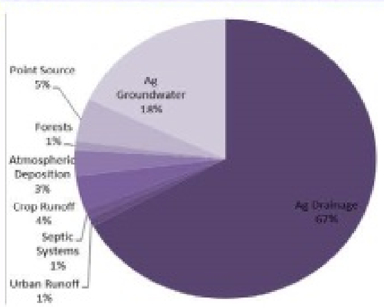
Barr Engineering and the PCA (2003 with 2007 up



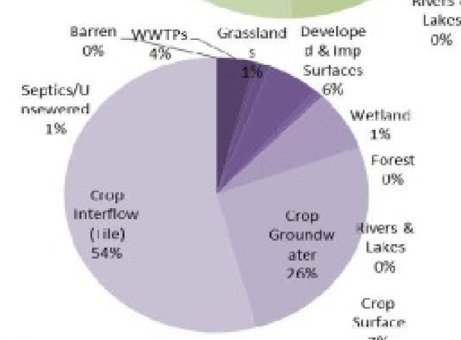


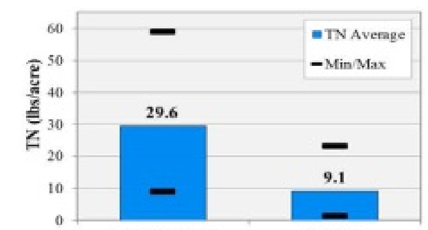
TP	POINT kg	WPLMN kg	adjusted for whole watershed kg	annual % point	5-year average % point
09	45,011	96,856	187,136	24%	21%
10	29,835	160,460	310,026	10%	
11	9,966	126,492	244,396	4%	
12	6,801	23,615	45,627	15%	
13	7,018	68,418	132,191	5%	

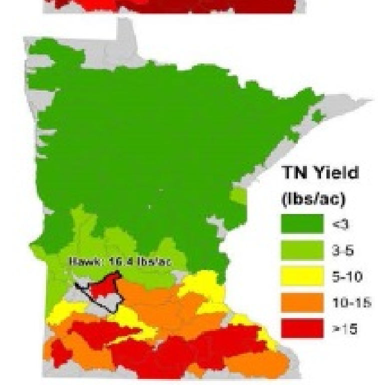
TN



PCA Assessment for MN Basin, avg yr

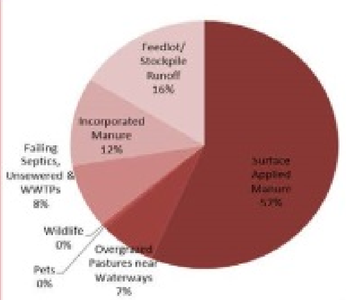






TN	POINT kg	WPLMN kg	adjusted for whole watershed kg	annual % point	5-year average % point
09	133,796	1,076,489	2,079,894	6.4%	5.6%
10	145,002	4,131,870	7,983,221	1.8%	
11	146,040	3,660,003	7,071,523	2.1%	
12	95,274	737,673	1,425,264	6.7%	
13	101,091	1,527,469	2,951,236	3.4%	

Bacteria



South Branch Yellow Medicine River Fecal Coliform TMDL

Assumed 90% wet,10% dry conditions

Strong relationship to fecal bacterial contamination in water	Weak relationship to fecal bacterial contamination in wate.
• High storm flow (the single most important factor in multiple studies) • % rural or agricultural areas greater than % forested areas in the landscape (entire watershed area) • % urban areas greater than % forested riparian areas in the landscape • High water temperature • Higher % impervious surfaces • Livestock present • Suspended solids	• High nutrients • Loss of riparian wetlands • Shallow depth (bacteria decrease with depth) • Amount of sunlight (increased UV-A deactivates bacteria) • Sediment type (higher organic matter, clay content and moisture; finer-grained) • Soil characteristics (higher temperature, nutrients, organic matter content, humidity, moisture and biota; lower pH) • Stream ditching (present or when increased) • Epilithic periphyton (plants and microbes that grow on stones in a stream) present • Presence of waterfowl or other wildlife • Conductivity

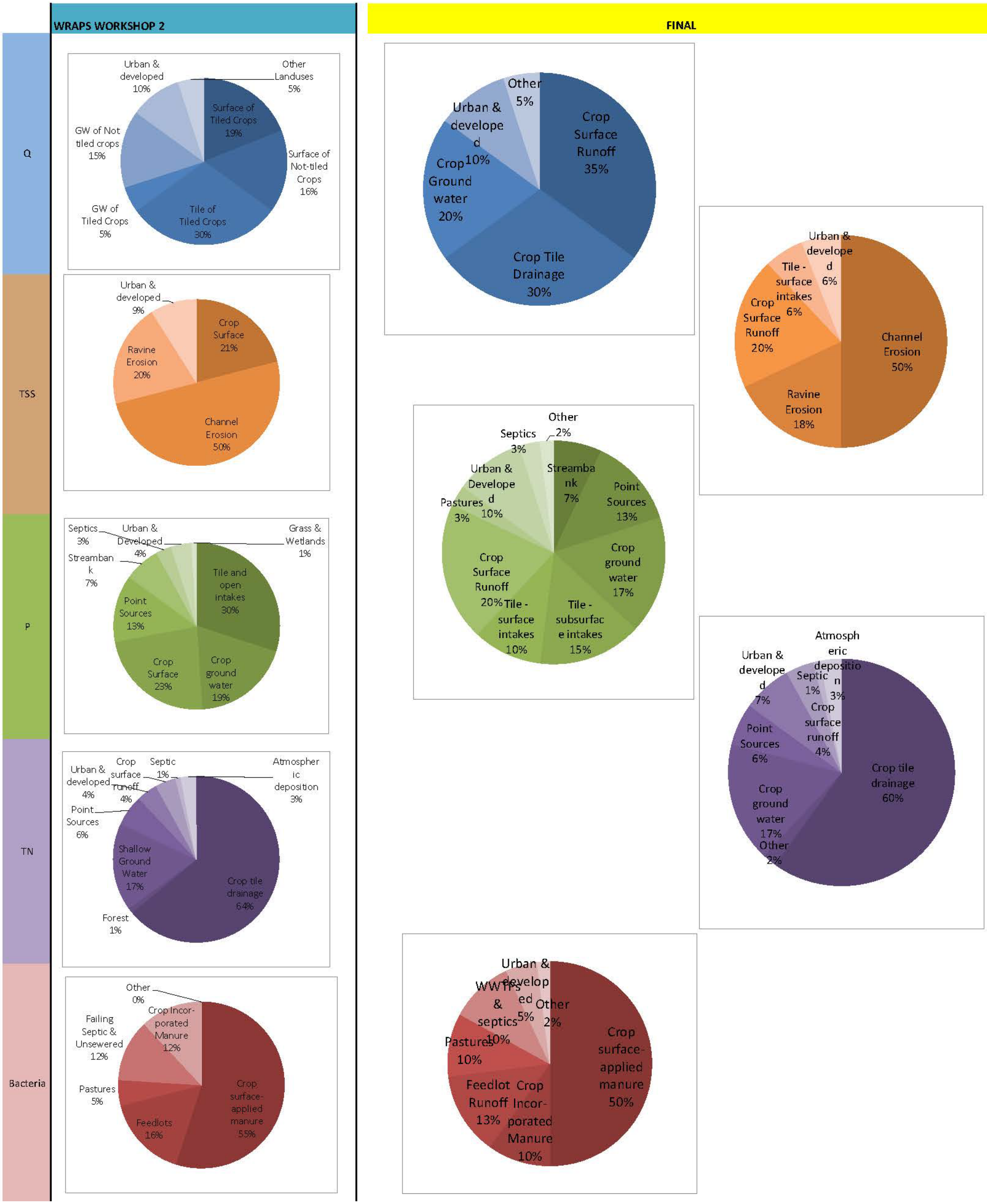
PCA/Emmons & Oliver literature summary of bacteria coorelation

Hawk
Bacteria "producers" in watershed
150,000 livestock animal units
2,000 wildlife animal units
35,000 people

note: animal unit is a roughly 1000 lb animal

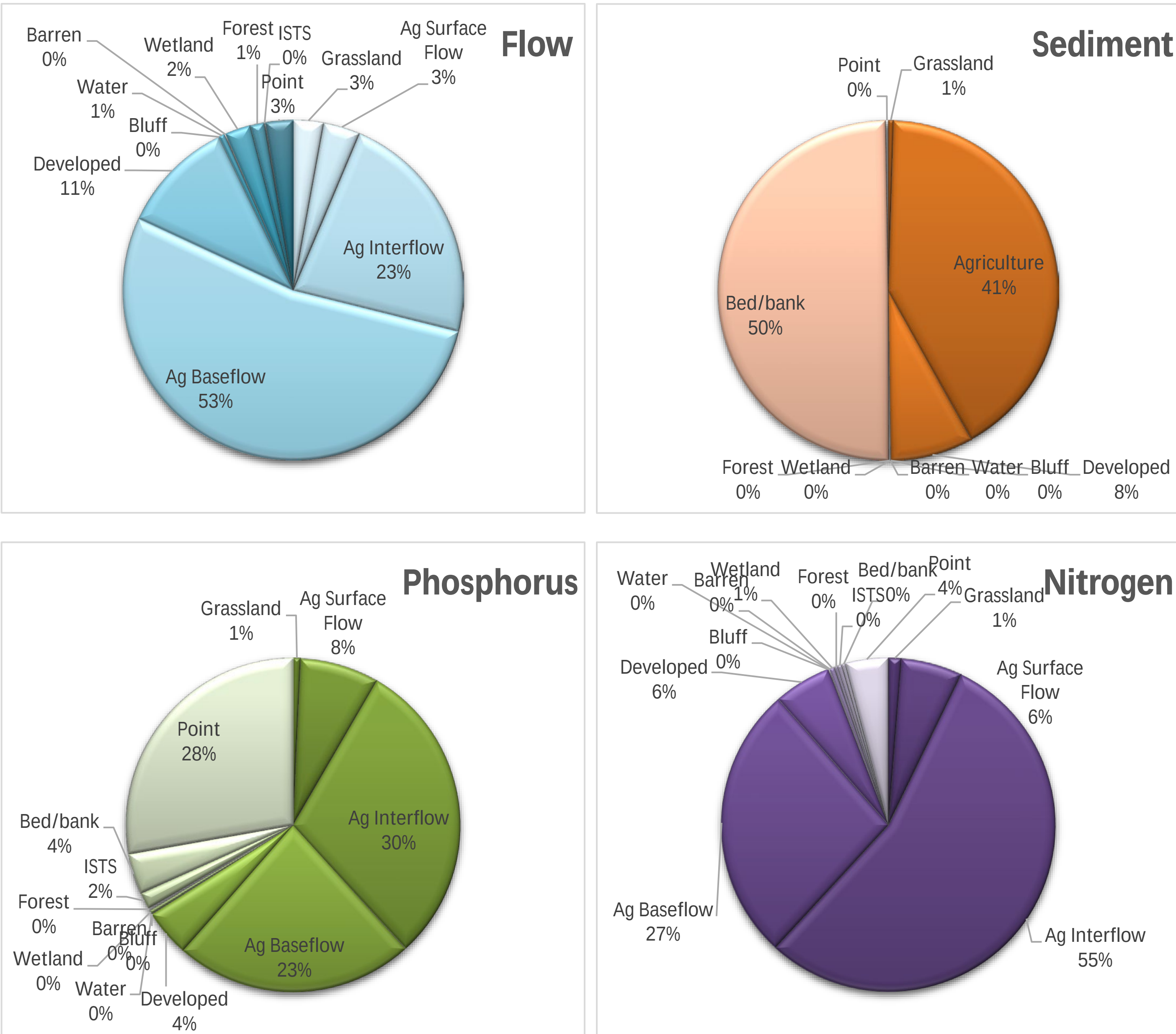
Yel Med
Bacteria "producers" in watershed
150,000 livestock animal units
2,000 wildlife animal units
15,000 people

5.14 Workshop and Final Source Assessment Results



5.15 Updated HSPF Source Assessment –

Updates to the Minnesota Basin HSPF model occurred after the Hawk Watershed source assessment work. Figure 4.15 shows the revised HSPF source assessment.



5.16 Agricultural BMP Summary Table

Conservation Practice			Relative Effectiveness, Summarized Effectiveness Data, and Level of Study - by Pollutant/Stressor							
Practice "group"		Individual Practices (Ag BMP Handbook page#)	Sediment (from upland/field)	Phosphorus (Total, dissolved, or particulate)	Nitrogen (Total, nitrate, or dissolved)	Pesticides (one or more)	Bacteria (fecal and/or e. coli)	Hydrology	Habitat	Sediment (from bank, bluff, channel or ravine)
Restore to natural/ minimal management		Conservation Cover (22) land out of production, into vegetation	*	*	10mg/L in streams with 3% of watershed in practice **					
		Restored Wetland (151) (previously drained; typically larger)	>75% reduction *	0-50% TP reduction *	68- >85% TN reduction *					
Improve soil health and/or vegetation	General (can do anywhere)	Cover Crops (36)	32-92% reduction	54-94% TP reduction 7-63% dP reduction	13-64% TN reduction 66% TN reduction**	40% reduction		11% reduction in volume of tile drainage		
		Conservation Tillage (94) (no-till or high residue)	90% reduction 6-99% reduction **	57% dP reduction 59-91% TP reduction **	-3-91% TN reduction **			56%-99% reduction in surface runoff		
		Nutrient Management (48)	15-65% reduction after adding manure**	50% dP reduction 14-91% TP reduction**	10-40% TN reduction**			2-62% reduction in runoff volume after adding manure		
		Crop Rotation (26) including perennial or small grains	32-92% reduction	53-67% TP reduction	59-62% TN reduction 66-68% TN reduction *					
		Pest Management (60)				17-43% reduction 40-50% (5 years) 70-80% (10 years)*				
	Site-specific	Contour Buffer Strips (28) applies only to steep fields	83-91% reduction 30-94% reduction*	49-80% TP reduction 20-50% dP reduction	27-50% TN reduction 18-49% dN reduction	53-77% reduction*	43-74% reduction			
		Grassed Waterway (84) for concentrated surface flows/gullies	94-98% reduction 77-97% reduction **			70-96% reduction **		2-20% reduction in surface runoff (modeled)		
		Contour Stripcropping (72) 50% or more of field in grass, etc..	43-95% reduction	70-85% TP reduction 8-93% TP reduction	20-55% TN reduction					
		Terrace (113) applies only to steep fields	80-95% reduction	70-85% TP reduction	20-55% TN reduction					
		Contour Farming (33) applies only to steep fields	28-67% reduction	10-62% TP reduction	25-68% TN reduction					
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Alternative Tile Intakes (67) replacing open intakes	70-100% reduction*	*						
		Tile System Design (63) shallower and wider pattern			40-47% NO_3 reduction					
		Saturated Buffers (not in handbook) intercepting tile drainage water								
		Controlled Drainage (75)		50% TP reduction 63% dP reduction *	20-61% NO_3 reduction *			15-50% reduction in volume of tile drainage		
		Woodchip Bioreactor (156) (for tile drainage water)		*	30-50% NO_3 reduction *	*	*			
		Treatment Wetland (146) (constructed; typically smaller)	75% reduction in urban settings *	59% TP reduction * 49-56% dP reduction 71-74% TP	40-43% TN reduction 64% TN reduction					
	Surface water	Filter Strips, Field Borders (125)	76-91% reduction 0-99% reduction **	38-96% TP reduction 50% dP reduction 2-93% TP	27% TN reduction 1-93% NO_3 reduction **	45-78% reduction *	*			
		Sediment Basin (134)	60-90% reduction 77% reduction	34-73% TP reduction 72% TP reduction	30% TN reduction 82% NO_3 reduction		70% reduction			
		Side Inlet Control to Ditch (137) for grade stabilization and retention								
		Extended Retention (80) created by culvert/road design						11-41% reduction in 10-yr peak flow for drainage area		
		Water & Sediment Basin (143)	64 (modeled) - 99% reduction	74% organic P 80% sediment-bound P (modeled)						
Improve riparian areas		Riparian and Channel Veg (99) intercepting surface runoff	53-99.7% reduction 55-95% reduction	41-93% TP reduction 63% pP reduction	58-92% TN reduction 37-57% TN reduction					
		Streambank Stabilization (109) using bioengineering techniques								
		Two Stage Ditch (115) replacing trapezoidal ditch			5-15% TN reduction*					*
		Grade Stabilization (40) of headcut in ravine or small channel								75-90% reduction
Improve livestock and/or manure management		Rotational Grazing (103) replacing row crops/continuous graze	49% reduction compared to row crop	75% reduction compared to row crop	62% reduction compared to row crop		consistently lower than continuous graze			
		Livestock Exclusion (45) applies only to livestock operations		75% TP reduction	62% TN reduction 32% NO_3 reduction					49% reduction 82-84% reduction
		Waste Storage Facility (91) improved from leaky structure		25-90% TP reduction	29-80% TN reduction*					
		Feedlot Runoff Control (121) improvements to system with runoff	79% reduction 35-95% reduction *	83% TP reduction * 30-85% TP reduction	84% TN reduction 10-45% TN reduction *		Up to 99% removal *	67% reduction in surface runoff		

Notes: Numeric effectiveness and level of study from the MN Ag BMP Handbook (Miller et al., 2012). Relative effectiveness (shades) estimated by local conservation professionals. Refer to the handbook for additional details and before selecting a BMP to ensure its applicability, siting and design criteria. Rev date: 4/29/14 JB

Relative Effectiveness
- very effective BMP
- somewhat effective BMP
- minimally effective BMP
- not effective BMP

Level of Study in Upper Midwest
- ** well studied
- * some study

5.17 Nutrient BMP Summary Info from Minnesota and Iowa State Reduction Strategy Reports

MN: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nutrient-reduction-strategy.html

IA: http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRS2-141001.pdf

Table 1. Effectiveness of hydrological management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% Reduction in NO_3-N loss
Drainage	Sands et al. (2006)	Minnesota	15%
	Nangia et al. (2010)	Minnesota	59 to 78%
	Kalita and Kanwar (1993)	Iowa	39%
	Lalonde et al. (1996)	Quebec, Canada	62 to 96%
	Drury et al. (1996)	Ontario, Canada	49%
	Drury et al. (2009)	Ontario, Canada	31 to 44%
	Thorp et al. (2009)	Midwestern U.S.	31%
	Tan et al. (1998)	Ontario, Canada	14 to 26%
	Fausey (2005)	Ohio	46%
	Feser 2012	Minnesota	25%
	Ng et al. (2002)	Ontario, Canada	36%
	Woli et al. (2010)	Illinois	70%
	Range of % reduction		**14 to 96%**
Bioreactors	Blowes et al. (1994)	Ontario (field)	99%
	Roberson and Cherry (1995)	Canada (septic systems)	58 to 96%
	Schipper and Vojvodić-Vuković (1998)	New Zealand (field)	60 to 88%
	Schipper and Vojvodić-Vuković (2001)	New Zealand (field)	>95%
	Greenan et al. (2009)	Laboratory experiment	30 to 100%
	Greenan et al. (2006)	Laboratory experiment	80 to 96%
	Chun et al. (2009)	Laboratory experiment	10-40 to 100%
	Chun et al. (2010)	Illinois (field)	47%
	Christianson et al. (2011)	Iowa (field)	30-70%
	Verma et al. (2010)	Illinois (field)	42 to 98%
	Woli et al. (2010)	Illinois (field)	33%
	van Driel et al. (2006)	Ontario (field)	33 to 53%
	Jaynes et al. (2008)	Iowa (field)	55%
	Robertson et al. (2000)	Ontario (field)	58%
	Ranaivoson et al. (2012)	Minnesota (snowmelt+ rainfall-field)	31 to 74%
	Ranaivoson et al. (2012)	Minnesota (field)	47%
	Range of % reduction		**10 to 99%**

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Table 2. Effectiveness of N management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% of Reduction in NO_3-N loss
N rates	Buzicky et al. (1983)	Minnesota	28%
	Nangia et al. (2005a)	Minnesota (model)	12 to 15%
	Gowda et al. (2006)	Minnesota (model)	11 to 14%
	Jaynes et al. (2004a)‡	Iowa	30%
	Baksh et al. (2004)	Iowa	17%
	Nangia et al. (2010)	Minnesota (model)	23%
	Kladivko et al. (2004)†	Indiana	70%
	Range of % reduction		**11 to 70%**
N application time and Inhibitors			
	Smiciklas and Moore (1999)	Illinois	58%
	Randall and Mulla (2001)	Minnesota	36%
	Gowda et al (2006)	Minnesota	34%
	Nangia et al. (2005b)	Minnesota	6%
	Randall et al (2003)	Minnesota	17 to 18%
	Randall and Vetsch (2005)	Minnesota	10 to 14%
	Range of % reduction		**10 to 58%**
	Randall et al. (2003)	Minnesota	13%
Split applications	Jaynes et al. (2004)	Iowa	30%
	Range of % reduction		**13 to 30%**

† This reduction also includes the effect of changing crop rotation and adding cover crops plus changing N rate over time.
‡ This reduction is also related to changing time of application.

Table 3. Effectiveness of landscape diversification management practices to reduce nitrate (NO_3-N) concentrations.

Type of study	Reference	Site	% Reduction NO_3-N
Riparian Buffers*	Barfield et al. (1998)	Kentucky	95 to 98%
	Blanco-Canqui et al (2004a)	Missouri	94%
	Blanco-Canqui et al (2004b)	Missouri	47 to 69%
	Dillaha et al (1989)	Virginia	54 to 77%
	Magette et al. (1989)	Maryland	17 to 72%
	Schmitt et al. (1999)	Nebraska	57 to 91%
	Lowrance and Sheridan (2005)	Georgia	59 to 78 %
	Duff et al (2007)	Minnesota	67 to 99%
	Range of % reduction		**17 to 99%**
Wetlands	Appelboom and Fouss (2006)		37 to 83%
	Kovacic et al. (2000)	Illinois	33 to 55%
	Crumpton et al. (2006)	Iowa	25 to 78%
	Hunt et al. (1999)	North Carolina	70%
	Xue et al. (1999)	Illinois	19 to 59%
	Iovanna et al. (2008)	Iowa	40 to 90%
	Range of % reduction		**19 to 90%**

*Note: none of the riparian buffer studies referenced here were at sites with subsurface tile drainage.

Table 4. Effectiveness of landscape diversification management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% Reduction in NO_3-N loss
Alternative cropping systems	Randall et al. (1997)	Minnesota	7 to 98%
	Boody et al. (2005)	Minnesota	51 to 74%
	Simpkins et al. (2002)	Iowa	5 to 15%
	Range of % reduction		**5 to 98%**
Cover crops			
	Kladivko et al. (2004)	Indiana	<60%
	Feyereisen et al. (2006)	Minnesota	11 to 30%
	Strock et al. (2004)	Minnesota	13%
	Jaynes et al. (2004b)	Iowa	60%
	Kaspar et al. (2007)	Iowa	61%
	Range of % reduction		**11 to 60%**

Table 2. Nitrogen reduction practices – potential impact on nitrate-N reduction and corn yield based on literature review.

	Practice	Comments	% Nitrate-N Reduction[+]	% Corn Yield Change++
			Average (SD*)	Average (SD*)
Nitrogen Management	Timing	Moving from Fall to Spring Pre-plant Application	6 (25)	4 (16)
		Spring pre-plant/sidedress 40-60 split Compared to Fall Applied	5 (28)	10 (7)
		Sidedress - Compared to Pre-plant Application	7 (37)	0 (3)
		Sidedress – Soil Test Based Compared to Pre-plant	4 (20)	13 (22)
	Source	Liquid Swine Manure Compared to Spring Applied Fertilizer	4 (11)	0 (13)
		Poultry Manure Compared to Spring Applied Fertilizer	-3 (20)	-2 (14)
	Nitrogen Application Rate	Reduce to Maximum Return to Nitrogen value 149 kg N/ha (133 lb N/ac) for CS and 213 kg N/ha (190 lb N/ac) for CC	10‡	-1‡‡
	Nitrification Inhibitor	Nitrapyrin – Fall - Compared to Fall-Applied without Nitrapyrin	9 (19)	6 (22)
	Cover Crops	Rye	31 (29)	-6 (7)
		Oat	28 (2)**	-5 (1)
	Living Mulches	e.g. Kura clover - Nitrate-N reduction from one site	41 (16)	-9 (32)
Land Use	Perennial	Energy Crops Compared to Spring- Applied Fertilizer	72 (23)	-100[ˠ]
		Land Retirement (CRP) Compared to Spring- Applied Fertilizer	85 (9)	-100[ˠ]
	Extended Rotations	At least 2 years of alfalfa in a 4 or 5 year rotation	42 (12)	7 (7)
	Grazed Pastures	No pertinent information from Iowa - Assume similar to CRP	85***	NA
Edge-of-Field	Drainage Water Mgmt.	No impact on concentration	33 (32)^	
	Shallow Drainage	No impact on concentration	32 (15)^	
	Wetlands	Targeted Water Quality	52†	
	Bioreactors		43 (21)	
	Buffers	Only for water that interacts with active zone below the buffer - a small fraction of all water that makes it to a stream.	91 (20)	

+ A positive number is nitrate concentration or load reduction and a negative number is increased nitrate.
++ A positive corn yield change is increased yield and a negative number is decreased yield. Soybean yield is not included as the practices are not expected to affect soybean yield.
* SD = standard deviation.
‡ Reduction calculated based on initial application rate for each Major Land Resource Area (MLRA).
‡‡ Calculated based on the Maximum Return to Nitrogen (MRTN) relative yield at the given rates.
** Based on 1 study with 3 years of corn and 2 years of soybean.
*** This number is based on the Land Retirement number – there are no observations to develop a SD.
^ These numbers are based on load reduction since there is no impact on concentration with these practices
† Based on one report looking at multiple wetlands in Iowa (Helmers et al., 2008a).

Table 3. Practices with the largest potential impact on phosphorus load reduction.
Notes: Corn yield impacts associated with each practice also are shown as some practices may be increase or decrease corn production. See text for information on value calculations.

	Practice	Comments	% Phosphorus Load Reduction[a]	% Corn Yield Change[b]
			Average (SD[c])	Average (SD[c])
Phosphorus Management Practices	Phosphorus Application	Applying P based on crop removal - Assuming optimal soil-test P level and P incorporation	0.6[d] [70[e]]	0[f]
		Soil-Test P – Producer does not apply P until soil-test P drops to the optimal level	17[g] [40[h]]	0[f]
		Site-specific P management		0[f]
	Source of Phosphorus	Liquid swine, dairy, and poultry manure compared to commercial fertilizer – Runoff shortly after application	46 (45)	-1 (13)
		Beef manure compared to commercial fertilizer – Runoff shortly after application	46 (96)	
	Placement of Phosphorus	Broadcast incorporated within one week compared to no incorporation – Same tillage	36 (27)	0[f]
		With Seed or knifed bands compared to surface application without incorporation	24 (46) [35[i]]	0[f]
Erosion Control and Land Use Change Practices	Tillage	Conservation till – chisel plowing compared to moldboard plowing	33 (49)	0 (6)
		No till compared to chisel plowing	90 (17)	-6 (8)
	Crop Choice	Extended rotation	[j]	7 (7)[k]
	Perennial	Energy crops	34 (34)	NA
		Land retirement (CRP)	75	NA
		Grazed pastures	59 (42)	NA
	Terraces		77 (19)	
Edge-of-Field Practices	Wetlands	Targeted water quality	[l]	
	Buffers		58 (32)	
	Sediment Control	Sedimentation basins	85	

a - A positive number is phosphorus reduction and a negative number is increased phosphorus.
b - A positive corn yield change is increased yield and a negative number is decreased yield. Practices are not expected to affect soybean yield.
c - SD = standard deviation.
d - Maximum and average estimated by comparing application of 200 and 125 kg P_2O_5/ha, respectively, to 58 kg P_2O_5/ha (corn-soybean rotation requirements) (Mallarino et al., 2002).
e - This represents the worst case scenario as data is based on runoff events 24 hours after P application. Maximum and average were estimated as application of 200 and 125 kg P_2O_5/ha, respectively, compared to 58 kg P_2O_5/ha (corn-soybean rotation requirements), considering results of two Iowa P rate studies (Allen and Mallarino, 2008; Tabbara, 2003).
f - Indicates no impact on yield should be observed.
g - Maximum and average estimates based on reducing the average STP (Bray-1) of the two highest counties in Iowa and the statewide average STP (Mallarino et al., 2011a), respectively to an optimum level of 20 ppm (Mallarino et al., 2002). Minimum value assumes soil is at the optimum level.
h - Estimates made from unpublished work by Mallarino (2011) in conjunction with the Iowa P Index and Mallarino and Prater (2007). These studies were conducted at several locations and over several years but may, or may not, represent conditions in all Iowa fields.
i - Numbers are from a report by (Dinnes, 2004) and are the author's professional judgment.
j - There is scarce water quality data for P loss on extended rotations in Iowa compared to a corn-soybean rotation.
k - This increase is only seen in the corn year of the rotation – one of five years.
l - Specific conditions are important in wetlands with regards to P as with changing inflow loads.

Table 28. Example Statewide Combination Scenarios that Achieve the Targeted Nitrate-N Reductions, Associated Phosphorous Reductions and Estimated Equal Annualized Costs based on 21.009 Million Acres of Corn-Corn and Corn-Soybean Rotation.
Notes: Research indicates large variation in reductions from practices that is not reflected in this table. Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

Name	Practice/Scenario**	Nitrate-N	Phosphorus	Cost of N Reduction from baseline ($/lb)	Initial Investment (million $)	Total EAC* Cost (million $/year)	Statewide Average EAC Costs ($/acre)
		% Reduction from baseline					
NCS1	Combined Scenario (MRTN Rate, 60% Acreage with Cover Crop, 27% of ag land treated with wetland and 60% of drained land has bioreactor)	42	30	2.95	3,218	756	36
NCS2	Combined Scenario (MRTN Rate, 100% Acreage with Cover Crop in all MLRAs but 103 and 104, 45% of ag land in MLRA 103 and 104 treated with wetland, and 100% of tile drained land in MLRA 103 and 104 treated with bioreactor)	39	40	2.61	2,357	631	30
NCS3	Combined Scenario (MRTN Rate, 95% of acreage in all MLRAs with Cover Crops, 34% of ag land in MLRA 103 and 104 treated with wetland, and 5% land retirement in all MLRAs)	42	50	4.67	1,222	1,214	58
NCS4	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 85% of all tile drained acres treated with bioreactor, 85% of all applicable land has controlled drainage, 38.25% of ag land treated with a wetland)	42	0	0.88	4,810	225	11
NCS5	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 65% of all tile drained acres treated with bioreactor, 65% of all applicable land has controlled drainage, 29.25% of ag land treated with a wetland, and 15% of corn-soybean and continuous corn acres converted to perennial-based energy crop production)	41	11	5.58	3,678	1,418	67
NCS6	Combined Scenario (MRTN Rate, 25% Acreage with Cover Crop, 25% of acreage with Extended Rotations, 27% of ag land treated with wetland, and 60% of drained land has bioreactor)	41	19	2.13	3,218	542	26
NCS7	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with wetland, and 70% of all agricultural streams have a buffer)	42	20	0.95	4,041	240	11
NCS8	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with a wetland, and 70% of all agricultural streams have a buffer) - Phosphorus reduction practices (phosphorus rate reduction on all ag land, Convert 90% of Conventional Tillage CS & CC acres to Conservation till and Convert 10% of Non-No-till CS & CC ground to No-Till)	42	29	***	4,041	77	4

Table 26. Example Statewide Combination Scenarios that Achieve Targeted P Reductions and Associated Nitrate-N Reductions

Notes: Estimated EAC based on 21.009 Million Acres of Corn-Corn and Corn-Soybean Rotation.
Research indicates large variation in reductions. Some practices interact such that the reductions are not additive.
Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

Name	Practice/Scenario**	Phosphorus	Nitrate-N	Cost of P Reduction $/lb (from baseline)	Total EAC Cost* (million $/year)	Average EAC Costs ($/acre)
		% Reduction (from baseline)				
BS	Baseline					
PCS1	Phosphorus rate reduction on all ag acres (CS, CC, EXT, and pasture); Conservation tillage on all CS and CC acres; Buffers on all CS and CC acres	30	7	-18.03	-182.7	-$8
PCS2	Phosphorus rate reduction on 56% of all ag acres (CS, CC, EXT, and pasture); Convert 56% of tilled CS and CC acres to No-Till; Buffers on 56% CS and CC acres	29	4	-4.41	-43.0	-$2
PCS3	Phosphorus rate reduction on 53% of all ag acres (CS, CC, EXT, and pasture); Convert 53% of tilled CS and CC acres to No-Till; Cover crops on No-till CS and CC acres	29	14	45.76	449.9	$20
PCS4	Phosphorus rate reduction on 63% of ag acres (CS, CC, EXT, and pasture); Convert 63% of tilled CS & CC acres to No-till and cover crops on No-till crop acres except for MLRAs 103 and 104	29	9	19.55	189.5	$8
PCS5	Phosphorus rate reduction on 48% of ag acres (CS, CC, EXT, and pasture); Convert 48% of tilled CS and CC acres to No-till with Cover Crop on No-till acres; Buffers on 48% CS and CC acres	29	16	-3.41	-33.2	-$1

***EAC stands for Equal Annualized Cost (50-year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing the practice. Average cost based on 21.009 million acres, costs will differ by region, farm and field.**

****These practices include substantial initial investment costs.**

5.18 Lake Restoration and Protection Strategies

This is a summary of strategies and not an exhaustive list. Not all strategies are applicable or appropriate for all lakes or regions.

Watershed Strategies – These strategies reduce the phosphorus that is delivered to a lake and are the basis for any restoration work.

- **Manage nutrients** – carefully planning for and applying phosphorus fertilizers decreases the total amount of phosphorus runoff from cities and fields
  - Examples: crop nutrient management, city rules on phosphorus fertilizer use, etc.
- **Reduce erosion** – preventing erosion keeps sediment (and attached phosphorus) in place
  - Examples: construction controls, vegetation (see below)
- **Increase vegetation** – more vegetative cover on the ground uses more water and phosphorus and decreases the total amount of runoff coming from fields and cities
  - Examples: cover crops, grass buffers, wetlands, prairie gardens/restorations, channel vegetation, etc.
- **Install/restore basins** – capturing runoff and decreasing peak flows in a basin allows the sediment (and attached phosphorus) to settle out
  - Examples: water and sediment control basins, wetlands, etc.
- **Improve soil health** – soils that are healthy need less fertilizer and hold more water
  - Examples: reduce/no-till fields, diversified plants in fields and yards

Lake Shore-specific Strategies – These strategies are a subset of watershed strategies that can be directly implemented by lake-shore residents.

- **Eco-friendly landscaping** – poor landscape design and impervious surfaces increase runoff and loading of nutrients into lakes
  - Examples: aerate, rain barrels or cisterns, rain gardens, permeable pavers, sprinkler and drainage systems, maintain septic systems, etc.
- **Manage upland buffer zone vegetation** – Upland buffer zone vegetation selection can greatly affect nutrient absorbance, watering needs, erosion potential, need for drainage, etc.
  - Examples: properly landscape, maintain canopy and address terrestrial invasive species that may prevent re-generation of native trees, proper turf grass no mow lawns in highly utilized areas and planting native grasses and forbs with deep root systems in underutilized areas of lawn, reduce watering needs, controlled fertilization and grass clippings
- **Naturalize transition buffer zone** – a natural transition buffer zone increases absorption of nutrients and decreases erosion potential of the water-shore interface
  - Examples: balance natural landscaping by minimizing recreational impact area, utilize natural materials for erosion control bioengineering using wood or biodegradable materials in combination with stabilizing native vegetation to restore a shoreline, minimize beach blankets, draw down water levels for consecutive seasons to allow existing seed banks to develop deep rooted native vegetation or plant diverse mixes of grasses, sedges, forbs, shrubs, and trees to create a complex root mass to hold the bank

soils, preserve and restore native emergent aquatic vegetation sedges, rushes, forbs, shrubs, and trees, do not remove natural wood features that supply cover and food sources for aquatic species and invertebrates while serving as a wave break along the shoreline

- **Preserve aquatic buffer zone** – The aquatic buffer zone is difficult to restore, so the best approach is preservation and providing best opportunity for aquatic plants through watershed improvements to increase water quality. Draw down water levels to allow natural seed banks of emergent and aquatic vegetation to establish naturally, supplement more plant diversity with lower water levels as restoration of emergent and aquatic vegetation have higher success rates
    - Examples: reduce recreational impact area, minimize control of aquatic plants, reduce dock footprint, preserve and/or restore native emergent, and floating-leaf aquatic plants

In-Lake Strategies – These strategies use, remove, or seal internal phosphorus (from within the lake). These strategies are only effective if external phosphorus sources are first minimized to the point that water quality of incoming water is not the limiting factor in order to meet water quality standards. Incorporating Lake Shore specific strategies is also essential for long term success.

- **Biomanipulation** – changing the fish population. Rough fish are generally bottom feeders and through feeding activity re-suspend sediments and decrease water clarity; thus, removing rough fish through mechanical or biological methods can improve water clarity, increase aquatic vegetation, and improve water quality overall.
    - Examples: commercial netting (not a standalone tool, implement in conjunction with other fisheries management methods to augment reduced populations for a short term period allowing desirable fish populations to develop adequate size to manage rough fish populations), balanced fish management increasing fish species diversity for a balanced fish population and introducing large predator fish populations, preserve and restore diverse spawning, cover, and feeding habitat that favors specific fish species that maintain a diverse fish population, reclamation (kill all fish and start over) inlets for rough fish should be considered when planning reclamation to prevent immediate re-introduction. In lake shore strategies are essential to incorporate to develop habitat for desirable species of fish once the rough fish population is removed.
- **Invasive species control of plants and/or animals** – invasive species alter the ecology of a lake and can decrease diversity of habitat. Removing native vegetation or incorporating non-native vegetation into landscaping can allow invasive species to establish and spread taking over larger blocks of native species that maintain the natural systems health. Therefore, reducing disturbance to near shore habitat is important.
    - Examples: prevention, early detection, lake vegetation management plan (LVMP)
- **Chemical treatment to seal sediments** – re-suspension of nutrients through wind action can cause internal nutrient loading.
    - Examples: alum treatments. Consider the long term effectiveness in shallow lakes that experience wind driven turning, where stratification of the lake does not occur. Incorporating establishment of lake shore habitat is important to absorb phosphorus in the lake as part of a long term approach to phosphorus level management.
- **Dredging** – Sedimentation after years of poor watershed practices increases nutrient laden sediments and decreases depth. Dredging should only be considered when the source of the sediment and the banks of the lake are stable to prevent sediment from redepositing. Dredging can: create channels for access, increase habitat diversity, and accommodate recreational use.

5.19 Interpretation of the Feedlot Statistics

This interpretation was provided by the MPCA feedlot staff.

- Surface applied manure generally tends to come from smaller feedlots or "smaller" dairies or poultry
- 70% of the number of feedlots are under 300 AUs (268 facilities) - these sites generally have limited manure storage so manure application occurs on a more frequent basis and are not required to have a manure management plan or test their soils for P.
- 156 of these sites are under 100 AUs, which have even less restrictions under the feedlot rules.
- 20% of the AUs in the watershed are poultry, representing 4,648,533 head of chickens or turkeys - this is much higher percentage than most watersheds probably because of the close proximity to Willmar and its processing plant located there. Poultry litter does not follow the general rule of being spread close to the facility as it is often brokered out to area crop farmers who are willing to pay for the manure. Because of the higher nutrient value and ease at which it can be hauled in a semi, this type of manure is more "mobile" than other manures. Implications:
    - Most of the manure is surface applied unlike a watershed where swine is the dominant animal with mostly incorporated manure.
    - Generally, manure from these facilities is sold to non-livestock farmers.
    - Barns are cleaned out when barns are emptied of mature birds so tends to lead a significant amount of temporary manure stockpiles in field which can have their own issues (they must meet setback requirements but generally do not have runoff controls like permanent stockpile sites) since they are exposed to weather extremes.
- Most feedlots have to keep records of manure application and the MPCA and/or delegated counties have the authority to request these records but because of lack of staffing generally do not request them. The NPDES permitted sites have to submit annual reports with their manure records but lack of staffing does not allow comprehensive tracking of the acres.

5.20 Modeled BMPs

Model(s) & Report	Summary & Notes	Scen	Modeled Landscape/BMP(s)	Parameter Load Reduction: Sediment	Parameter Load Reduction: hosphoru	Parameter Load Reduction: Nitrate/N	Cost
Nitrogen BMP Spreadsheet Minnesota Watershed Nitrogen Reduction Planning Tool (Lazarus et al., 2013)	The BMPs outlined here were developed using the N-BMP spreadsheet tool with inputs specifically for the Hawk-Yellow Medicine watershed. This represents just one of endless scenarios than can be analyzed with this tool. Total cumulative nitrogen reduction for all BMPs applied is 25%. Reductions for individual BMPs are listed under the Parameter Reductions columns. Parameter Reductions do not add up to the cumulative reduction because some practices are mutually exclusive and therefore, less acres are available for practices.	Individual or All (see notes)	40% of area (67% of corn fields) receives target N application rate (30% less)			12.9%	**$-4.6/lb**
			10% of area (50% of fall appliers) switches to spring N application			5.1%	**$-0.4/lb**
			10% of area (50% of fall appliers) switches to 70% side-dress, 30% preplant			5.5%	$2.0/lb N
			10% or area (50% of fall appliers) use N inhibitor			2.3%	$0.6/lb N
			13% of area (14% of corn and beans) plants rye cover crop (90% success)			3.9%	$22/lb N
			3.6% of area (50% of short season crops) uses cover crops on short season crops			1.2%	$20/lb N
			1.4% of area is in riparian buffer (50% of 100' on all streams in watershed)			1.2%	$23/lb N
			1% of area restored to (treatment) wetlands			0.5%	$2/lb N
			1.8% of area converted to perennial grass			1.5%	$6/lb N
			1.1% of area has bioreactors			0.1%	$20/lb N
			1.1% of area has saturated buffers			0.4%	$3.2/lb N
			1.1% of area has controlled drainage			0.3%	$4.3/lb N
Phosphorus BMP Spreadsheet (Lazarus et al, draft version of tool used)	The BMPs outlined here were developed using the P-BMP spreadsheet tool with inputs specifically for the Hawk-Yellow Medicine watershed. This represents just one of endless scenarios than can be analyzed with this tool. Total cumulative phosphorus reduction for all BMPs applied is 25%. Reductions for individual BMPs are listed under the Parameter Reductions columns. Parameter Reductions do not add up to the cumulative reduction because some practices are mutually exclusive and therefore, less acres are available for practices.	Individual or All (see notes)	39% of area (80% of feasible area) receives target/reduced P fertilizer rate		5.1%		
			15% of area (80% of fall appliers in wheat/corn) switch to preplant fertilizer		0.5%		
			45% of area (80% of fields not currently using) adopt reduced tillage with >30% residue		7.0%		
			1.4% of area is in riparian buffer (50% of 100' on all streams in watershed)		5.9%		
			34% of area uses cover crops		3.5%		
			1% of area uses controlled drainage		2.2%		
			16% of area (80% of open intakes) use conservation/alternative intakes		0.0%		
			3.4% of area (80% of fields not currently doing so) inject or incorporate manure		1.5%		
HSPF Hawk Scenarios (Tetra Tech, 2015)	Three different scenarios were selected by the local work group and modeled. Analysis on Yellow Medicene River mouth for year 1996-2012.	1	Water basins to store 1" of runoff per rain event from ag land surface runoff and tile drainage	12.8%	6.1%	0.7%	
		2	12,000 acres/1.7% of watershed (top EBI scores) converted from agriculture/barren to perenial veg	0.9%	0.7%	1.0%	
		3	27/79 stream reaches have 20% reduction in scour rate (roughly approx. stream bank stabilization)	1.4%	0.0%	0.0%	
SPARROW The Minnesota Nutrient Reduction Strategy (draft) (PCA, 2013i)	Statewide nutrient reduction goals and strategies are developed for the three major drainage basins in Minnesota. For the Mississippi River basin, the milestones (interim targets) between 2014 and 2025 are 20% reduction in N and 8% reduction in P	2025 Milesto	43% of total area (80% of suitable area) uses target N fertilizer rates 6% of total area (90% of suitable area) uses P test and soil banding 1% of total area (10% of suitable area) in cover crops 1% of total area (25% of suitable area) in riparian buffers 25% of total area (91% of suitable area) in conservation tillage 4% of total area (18% of suitable area) uses wetlands or controlled drainage		8%	20%	
HSPF Minnesota River Basin Turbidity Scenario Report (Tetra Tech, 2009)	5 scenarios (BMP suites) evaluated for effect on TSS and TP in MN River tributaries and mainstem. Scenarios 1, 2 were minimally effective. HSPF capable of modeling stream dynamics. Analysis on 2001-2005 data.	3	20% land in pasture (perennial veg), targeting steepest land 75% of >3% slope land in cons. tillage (30% residue), cover crop 50% of surface inlets eliminated Comprehensive nutrient management Drop structures installed on eroding ravines Effluent max P of 0.3mg/L for mechanical facilities For MS4 cities, install ponds to hold and treat 1" of runoff	~20% (Le Sueur water shed)	17% (MN basin)		
		4	All BMPs in Scenario 3 with these additions: Target (20% land in) pasture to knickpoint regions as well Increase residue (on 75% of >3% slope land) to 37.5% Increase eliminated surface inlets to 100% Controlled drainage on land with <1% slope Water basins to store 1" of runoff Minor bank/bluff improvements Eliminate baseflow sediment load	50% (Yellow Med)	26% (MN basin)		
		5	All BMPs in Scenario 4 with these additions: Improved management of the pasture land (CRP) Very major bluff/bank improvements Urban (outside MS4s) source reductions of 50-85%	87% (MN basin)	49% (MN basin)		

Model(s) & Report	Summary & Notes		Scen	Normal til	Cons til	1/2 P fert	Pasture	Grass	Forest	Wetland	Water	Urban	Sediment	hosphoru	Nitrate/N	Cost
SWAT, InVEST, Sediment Rating Curve Regression, and Optimization Lake Pepin Watershed Full Cost Accounting (Dalzell et al., 2012)	Models 6 BMPs in the 7-mile Creek watershed either: **1**) placed by rule of thumb recommendations (not optimal) or **2**) to maximize TSS reduction for dollars spent (optimal). Completed economic analyses including: **A**) current market value only (using 2011 $) and **B**) integrated, which adds a valuation of ecosystem services (relatively modest value). Does not allow multiple BMPs on same pixel of land. Scenarios are described by	Land uses:														
		Baseline		83%	0%	0%	2%	0%	4%	5%	1%	5%	0%	0%		0%
		2A	A	3%	14%	64%	3%	1%	5%	5%	1%	5%	4%	-1%		**-4%**
			B	35%	1%	38%	10%	1%	4%	5%	1%	5%	25%	22%		4%
			C	8%	0%	35%	32%	10%	4%	5%	1%	5%	50%	46%		21%
			D	2%	0%	10%	43%	29%	4%	5%	1%	5%	76%	69%		51%
		2B	a	30%	1%	44%	2%	0%	11%	5%	1%	5%	15%	19%		-8%
			b	26%	0%	41%	13%	1%	7%	5%	1%	5%	25%	28%		-7%
			c	13%	0%	29%	38%	2%	7%	5%	1%	5%	50%	48%		0%
			d	3%	0%	8%	68%	3%	6%	5%	1%	5%	76%	70%		19%
		1A	F	25m grass buffers around waterways									3%	3%		4%
			G	250m grass buffers around waterways									15%	15%		28%
			H	Converting highly erodible lands to grasslands									15%	17%		10%

5.21 Additional Workshop Participants

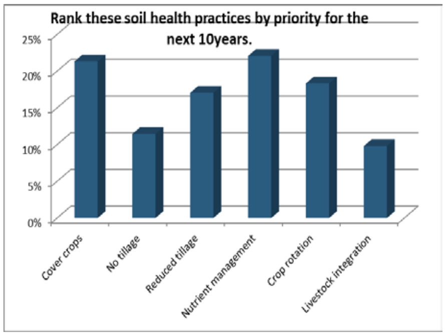
Attended only one workshop. Participants who attended 2, 3, or 4 meetings are reflected in the front cover.

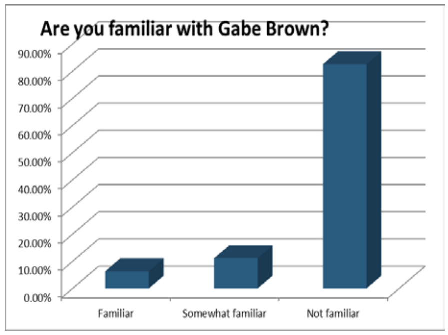
Amanda Strommer	MDH
Andrew Bristle	Farmer
Barry Schwitters	Farmer
Bob Schwitters	Farmer
Brad Melberg	Farmer
Bryan Spindler	MPCA
Chad Tatati	
Charles Melberg	Farmer
Chris Bosch	Farmer
Chris Dunsmore	Southern MN Beet Sugar Cooperative
Chris Jaenisch	Farmer
Chris Schwitters	Farmer
Chuck DeGrote	Farmer
Cody Bakker	Southern MN Beet Sugar Cooperative
Collette Lehti	Home Owner
Cory Erickson	Farmer
David Ludowese	Farmer
Dennis Harguth	Farmer
Doug Erickson	Farmer
Doug Reese	Kandiyohi County Commissioner
Dr. Kathryn K. Kelly	Reville SWCD Supervisor
Gary Terwisscha	Farmer
Greg Schwitters	Farmer
Jerry Schwitter	Farmer
Jason Rice	Farmer/Agronomist
Jason Taatjes	Farmer
Jeff Brouwer	Farmer
Jeff Carlson	Southern MN Beet Sugar Cooperative
Jeff Rice	Farmer
Jim Radermacher	Agronomist
John Bristle	Farmer
Josie Oliver	Clara City Herald
Keith Beito	Farmer
Keith McNamara	Farmer
Kevin Lengh	
Kyle Knotts	Farmer
Kyle Slifka	Kandiyohi NRCS
Lane Schwitters	Farmer
Larry Kidrowski	Farmer/Contractor
Lee Bosch	Farmer
Lenny Schwitters	Farmer
Marc Stevens	Chippewa County Water Plan
Mark Olson	Farmer
Matt Condon	Farmer
Michael Bristle	Farmer
Mike Hagen	Advanced Drainage Systems
Mike Schjenken	Southern MN Beet Sugar Cooperative
Molly Jaenisch	Farmer
Nick Ludowese	Farmer
Noah Hultgren	Farmer
Paul Wallert	
Phil Pieper	Farmer
Ralph Thissen	Farmer
Rick Reimer	Kandiyohi SWCD
Ron Suter	Farmer
Shane Mille	Farmer
Steve Sederstrom	Farmer
Tim Gunter	Chippewa County
Tim Jansen	Farmer
Todd Erickson	Farmers Coop Oil
Tom Bakker	Prinsco Tiling
Tom Warner	Chippewa SWCD
Tony Jaenisch	Farmer
Wayne Formo	Farmer
Zach Bothun	Chippewa County SWCD

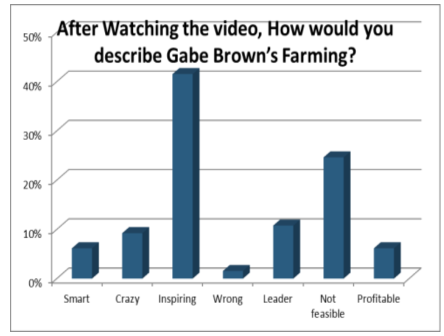
5.22 Feedback Workshop Results

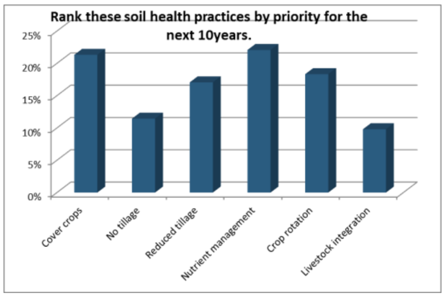
1. What conservation is getting done; what conservation isn't getting done?		For conservation that is getting done, how is it supported by consistent, straightforward, well-targeted policies? For conservation that isn't getting done, how could it better be supported by policies?		For conservation that is getting done, how is it reinforced through social networks, norms, and support structures? For conservation that isn't getting done, how could it be better reinforced through social networks, norms, and support structures?		For conservation that is getting done, how is it compatible with priorities, profitability, practices, and technology? For conservation that isn't getting done, how could it be more compatible with priorities, profitability, practices, and technology?	
Conservation Tillage Variable fertilizer rates Cover crops	No Till Water Retention on rural landscape Correct Use of Lawn fertilizer	Cost Sharing	Policies that include grower input	Discussed at Coop Level Stories shared among growers	Conference that provide info on conservation practices Fear of failure and mandates	Economics, Max efficency Benefits of new technology Sense of personal Responsibility	Lack of Responsibilitiy Resist change Change can be expensive
Conservation Tillage, less plowing Precise nutrient management Increased stormwater projects for homes and ponds	Lackiing control of wind erosion Wastewater not being installed with enough frequency	No	More livestock and more pasture land available Lee	CSP programs aiding adoption of conservation Programs	NA	Input related conservation work	More controlled drainage Drain smarter Manage water levels
Cover crops Nutrient management Drinking water plans for cities Hunting areas being maintained	Increased/Enhanced cover crops Buffer strips Manure management	Beet Coop promotes practices that improve---> health and water quality Crop rotations to bring nutrients down shallow wells protected	NA	Communication between farmers about their practices and what works and what doesn't	NA	Producers willing to look at options to build soil health Build soil nutrient plans with producers	Not willing to change past practices Conservation based on profitability
Spring cover crops Fall cover crops Small water retention projects Cattle exclusion projects	Water retention Paper work, policy, and programs too complicated to create and restore wetlands and water reduction projects	Funding is working	Too many layers to the programs and policies that cover funding	Funding is providing the facts about monitoring	Goals are not clear and forced from government agencies	Accessability of supporting data for priorities, practices, profitability and technology	New legislation priorities do not meet the landscape needs in many areas
Pattern tile in fields Not plowing or less tillage Cover crops for sugar beats More fertility testing	Erosion control in waterways	Good support for manure structures and application	Need more support to close small drainage ditches	Discussing between neighbors Farmers are communicating with one another	Demonstrate scientifically valid projects Make sure the projects are completed properly	NA	Meets the need of the individual Needs to make sense for agriculture production
CRP/CREP/RIM easements production	Marginal land conservation	Local watersheds BWSR	More information to the public on what is available	Local water treatment facility involvment in local community water managent practices Septic systems	More community education	Somewhat compatible but not very profitable	A lot more compatible
Marginal ground in CRP CSP programs Better land management	High risk areas are treated the same as low risk	Local government agencies have information and reccomendations implement strategies on land	More projects with available cost share	Improvement to water treatment facilities	Residential fertilizer programs	CRP/CREP/CSP Cost share wind breaks Local government assistance resolving erosion problems	Ground that is in production that is considered high risk Need assistance to offset cost's to get willing land owners
NA	Leave more lawns natural (less mowing) Nitrates in well water	Consistent messages from SWCD on conservation practices	More education for the public on current programs and opportunites	Family/Neighbor/Friends influence	NA	NA	NA
Cover crops (summer& winter) less tillage Better water usage Effective fertilizer Buffer strips	Soil test on lawns in town Buffer strips in town Less irregation in golf course in cities Lake front prokects and what they are doing	Cover crops--volunteer Buildings for livestock	More policy on the water run off lawns and cities	Farmers are looked down on More communication from Ag groups	Give both sides of the story Social media distorts the facts	For profit less money stuck in fertilizer Better technologies in tractors and equipment Better rotation of crops Don't over graze	Due to labor shortages we're having a hard time keeping up with changes and regulations
Street sweeping Buffer along water ways	New develoment/constuction not regulated enough (i.e. sediment fence) Road salt is over used in town	City ordinance Self-monitored	Planning and zoning enforcment Education--> MNDOT/County Hwy Dept	In small town everyone can see it	Taking ownership of community and reporting violations to appropriate authority	Aesthetic value in town Fills schedule for employees No other land use possible	Education
NPDES Permits--> Mandatrory Incorp, manure testing, 12 month mandatory storage,	SDS permits Little man testing uncontrolled application rates Application for 12 months a year	Local plan&zone Water plan SWCD/MPCA--> education	Cost Small is better Phasing operations	Peer pressure Education Networking with neighboring farms	Costing profit for not following BMPs Peer pressure	NA	NA
Buffer strip on drainage ditches Residue management Constuction tillage	Cover crops (i.e. Fall) Drainage water retention on fields	NRCS/SWCD Govenor office Hawk creek watershed office	Watershed district SWCD	Media (i.e. Ag groups)	Crop loss is negative $ Norm to get rid of water No time during harvest to plant cover crops Cover crops cost $	Lower value land Residue using less fuel/labor	Fall cover crops Restoration to justify cost Use existing residue to slow surface runoff Use pattern tiling to control runoff
Cover crops fall Buffer strips Control basins Nutrient management	Gullies and ravines More buffers Nutrient management To much bare soil Crop rotation	Good policy for erosion control	Need more policy for rotation and cover crop More support for creative conservation	NRCS-soil SWCD-field days	Having more example of good practices	Meet the need of the farmer	Meet individual needs
Conservation tillage Crop rotation Water retention basins Rotational grazing of cattle Field wind breaks	Buffers on ditches Perennials Wind breaks taken out	RIM program funded Farm program CSP Improvements in farm insurance	Price pressures for actions Getting in the way of crop rotations	Legacy grant support Farm organization support Sportsman organization encourage and work with farmers Use of natural areas	Norm is more targeted to production instead of conservation	Looking at diversification for long-term profitability Finding crops to fit seasons	Better manure management Not suitable land use
Cover crops Improvements in septic systems water quality monitoring Better crop management	Wind breaks going down Data to generalized	There is communication between people and government Scienc e is used	Rules change to fast Inconsistant rule enforcement Too many rules Not enough time to innovate	Farm profit & nonprofit orginizations emphasis Chruches and other community orginizations support conservations	More honest discussion	Reduce inputs and get more profit Most producers adopt for conservation	The anti GMO movement is a set back for conservation Fear of govt reprisal
Less fall tillage Tile instead of surface drainage	Not control Surface runoff Lack of shelter belts	NA	NA	NRS support with new projects Available media and papers	NA	NA	NA
Precision fertilizer application CRP Minimal tillage	Lacking buffer strips Controlled drainage/holding water back Cover crops/other row crops	Economics Government financial support	Loss of production land Lack of yield increases Lack of market/economic risk	Increased public awareness Less is now the standard	Neighbors led by example Increase awareness of new practices	Cash flow	As restrictions on Ag economy tightens, increased emphasis on insuring and profit
CRP/RIM Conservation tillage	Lacking field wind breaks Not enough care to protect pollinators	Policies are easy to understand and work well	More policies on field boundaries, townships, and right aways	Discussion with family members and work	Personell at county offices Better salesmen of their programs	RIM planting gave a return per acre Increased wildlife and wildflowers for pollinators	More field wind breaks
Cover crops Adoption of buffer strips Pattern tiling	Implementing more fall cover crops Filter strips near ditches	Policies that work are ones beneficial to all	The public should be aware of doing the rightthing environmnetally even if not receiving a financial incentive	Sugar coop does well promoting cover crop program Social pressures to keep up with modern practices	Citizens with septic systems need to know where their effluent is going	Must be beneficial to all Pattern tiling and cover crops good but not enough incentive	More work on conservation tillage Establishing fall cover crops
Buffer law HEL back to CRP Cover crop programs catching on RIM Conservation tillage	Not holding back water Lack of funding for willing land owners Soil health--> prevention of wind erosion	Policies are volunteer Targeting habitat corridors--> mostly along MN river watershed	RIM/CRP only land owner choice More money --> incentives	SWCD does a good job of getting word out Communicating with the right people	More attendance at CC tours and other meetings Need more land owner buy-in Lack of success stories	Applicator and Mapping technology capable of better fertilizer placement	More education on adoption of better and newer practices
Conservation tillage HEL land being cropped smarter More subsurface drainage	Buffering direct surfaces Maintaining established	Policies are not mandatory (besides buffer)	RIM/CRP is land owner willing More compensation for programs	SWCD's / Waterhsed project education Agencies/Universities do a good job with education	More land owner success stories More attendance of education meetings	Technology allows for less and more accurate fertilizer use Yield monitors allow for alternative practices in lower production areas	Need more education and word of mouth
Fertilizer management Pattern tiling Min tillage Cover crops	Not enough funding for research (State/Private)	More conservation getting done in the last few years	Education on rules More funding	Flyers, bulletins one-on-one	Information overlaod --> need better communication	Technology, buffers, nutrient management and more pattern tiling	NA
Education Conservation Storm water management fwertilizer Management	More buffers More setbacks	NA	NA	Net working	Information overlaod --> need better communication	More green space	More green space

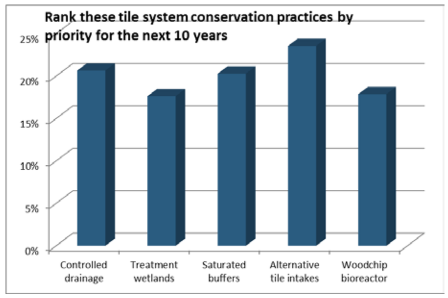
Using less water on lawns Hazardous waster being dealth with better More retention ponds	Recycling is treding backwards	Water retension, storm sewers, and silt fences	County board approval through resolution	Permits Phosphorus free fertilizer Funding	More education	Through stormwater implementation and education	Alternative ways of recycling More urban education
Soil Sampling Less fertilizer applicationPlaces to dispose of used oil properly	Maintaining CRP Tillage could be reduced	Using University of MN reccomendations	NA	Permits Testing Remain consistent with clean-up opportunites	More clean up days Ditch redetermination	Technology has grown	Make CRP more worth while Wetland restoration more worth while
Buffer stips Waterways No moldboared plows	Recycling water	More water retention ponds Greater conservation awareness	Urban stormwater management	Zoning office SWCD Wetland protection	Progress takes time	Fertilizer according to soil test Conservation tillage	NA
Less tillage cover crops Filter strips Patterned tilling	Tillage reduction Less CRP acreage due to Federal overspending	Seeing financial benefits from conservation practices	Not enouhg scientific data to support change Less targeting of Ag in Federal budget	See it being done successfully Willingness to adopt	Break away from old habits	Has to fit finacially and philosophically	Outside sources that don't share philosophical opinions Hurts the bottom line
Easements Wetlands Buffers	Not enough Taking land out of production	State funding for implementation	More input from land owners More financial support for conservation	Family tradition Field days	More opportunities shared through social networks Time	Has to fit the plan	More say in conservation regulation
No till Wasterwater treatment	Stormwater Rain gardens Lake management	Public awareness Farm group involvement Financial support	To much red tape	Local watershed groups Education awareness	More support and recognition	Less lawn fertilizer More stormwater ponds	Education for stormwater controll Public not aware of storm water impact
Rain gardens Stormwater retention Limitation on fertilizer application	Treatment of street flow drainage Not enough rain gardens	Mandates/Laws Economics	Mandates	Conservation is more in the public eye More of an expectation to conserve	Increased awareness	NA	NA
Buffer strips Minumum tillage Cover crops with beets in spring	More effective cover crops Appropriate width buffer strips	Cover crops stongly supported by beet Coop Soil testing froom fertilizer Coops Better tillage	More cover crop education on the value Water quality education	If negative imapcts are not observed there is more support for conservation practices Farm journals	Concerns with profitability	Rediced tillage is cutting back on wind erosion	Policies for conservation are thought of with everyone in mind
Fertilizer effeciency Cover crops Pattern tiling	Farm recycling	Cover crop credits	More incentive for better drainage practices	Public opinion Social networks promote conservation	Get more public opinions together	Profits Tillage packages	Less enforcement and more conservation practices
Buffer strips Minumum tillage Cover crops with beets in spring	Water retention	Buffer strips	NA	Current social environment	More use of public meetings	Changes in cost structures are already influencing increased conservation	More incentives
Grass cover/Cover crops Fertlizer management on garden	To much urban cover on land need more rain gardens	Following county laws and regulations Applying unneeded fertilizer	Allowing to much buildings for the acreage	NA	Don't bend the rules Follow laws Work together	NA	Cost
Soil erosion programs Conservation tillage	NA	Coop farming not being regulated	Get more livestock spread across watershed	Being green--> composting and famers markets	Advertising Less rules	Profit is priority	Make easier to pattern tile
Shorline protection Increased discussion about water protection Rural septic improvements	Shorline protection	Consistent funding	Streamline policies	Neighbor converstion	Citizens not in leadership roles Resistance to change	Feeling and personal responsibility	Expecting others to take action
Buffer Strips CRP/RIM Laws for wetland protection	Water retention Erosion control Nutrient management	Institutional funding	NA	Buffer legislation supported by sportsmen gropus	Farming not welcoming due to less income	NA	NA
Stormwater treatment plants Precision fertilization Conservation tillage Riparian buffers	Water retention ponds	When funding is availbale landowners willing to selling environmentally sensitive land	Policy currently impacting down stream people Policy currently not fair to all	Installation of new conservation practices	Natural shorlines Watering and fertilizing lawns Taking land out of production	Top soil conservation practices Wind erosion controls Precision fertilizer	Fund above expense projection to manke new technologies worthwhile Not enough funding
Cover crops Conservation tillage Redidue management Buffer strips Grass waterways	NA	Phosphorus credits	Fully fund environmental practices Method for funding set aside programs	Ag community is concerned about environment	Lack of communication to the general public on practices implemented	Environmental sound soil management techniques	Flexability on moving wetlands to improve farming practices
Nutrient mangagement Cover crops Residue management Buffer stips	Wind erosion	What is being done is strait forward Involves a fair amount of red tape	Make it feasible to increase wind breaks	Common goal for doing Increasing more conservation	Working together	It's working because it is economically, feasible, and affordable	Currently the cost is prohibitive--> cost benefit not there
Conservation tillage Buffer strips Some cover crops Nutrient management	More cover crops Less intakes/pattern tiling	Don't think conservation is being supported very well	With enough money conservation will be more supported	Friends/neighbors presure	Media pressure Through copperative help	Farm field conditions	Profitablilty Technology--> Nitrogen that does not leech
Pattern tile in fields Not plowing or less tillage Wind breaks Soil test	Open to new ideas	SWCD Beet Coop promotes soil testing	Promotion of wind breaks Promote flood lands into CRP	Pattern tiling Good sound science instead of personal agenda	Support voluntary improvement	Cover crops Pattern tiling	Better understanding of Ag needs
Conservation tillage Buffering to stop erosion	Old tiling systems More effieient fall tiling	SWCD Supports promoting cover crops	Promotion of wind breaks State landscape diverse, Rules cannot be statewide	Rain gardens Support for buffer strips	More positive media Coverage of what good things have been done	People being civil and willing to communicate	Better understanding of Ag needs
Cover crops Shelter belts	Controlling wind erosion	FSA--> cover crop assistance	Information needed on cover crops	NRCS support Local agronomist info	Newspaper articles University involvement Media	Hay for hobby or sale	Not much economic incentive--> more funding is needed
Reduced tillage	Dust control--> wind breaks	CSP program	Have policies simplified	It's not	working together	Not sure	Don't know
Cover crops	slowing ater/water retention	State programs/funding	Better communication of programs	It's being talked about but not reinfroced	More discussion about the practices that have have worked	Projects are better with newer technology	More information
Conservation tillage Some buffer strips	Need more buffer strips Less intakes More diversified crop rotation	Don't think conservation is being supported very well	Make CSP manditory for farm program payments	Word or mouth Economic benefit	Environmental benefit	NA	Education and economic help

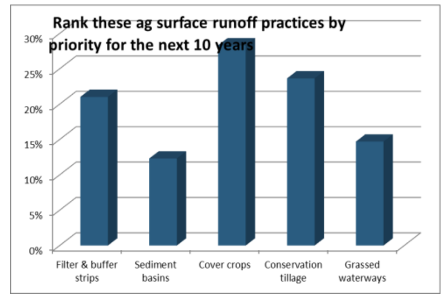

Rank these soil health practices by priority for the next 10years.
25%
20%
15%
10%
5%
0%
Cover crops
No tillage
Reduced tillage
Nutrient management
Crop rotation
Livestock integration

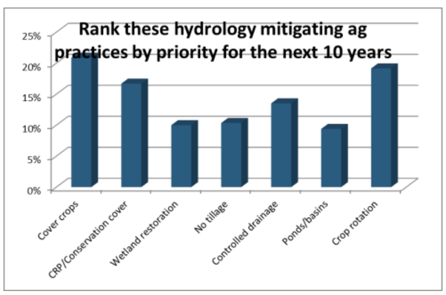

Are you familiar with Gabe Brown?
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Familiar
Somewhat familiar
Not familiar

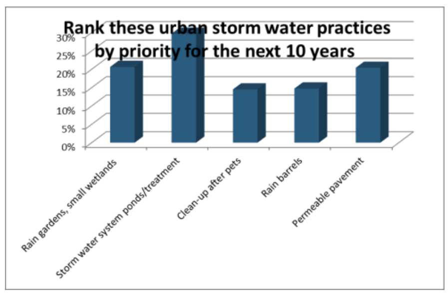

After Watching the video, How would you describe Gabe Brown's Farming?
50%
40%
30%
20%
10%
0%
Smart
Crazy
Inspiring
Wrong
Leader
Not feasible
Profitable


Rank these soil health practices by priority for the next 10years.
25%
20%
15%
10%
5%
0%
Cover crops
No tillage
Reduced tillage
Nutrient management
Crop rotation
Livestock integration

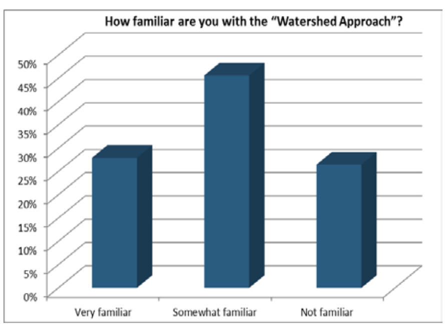

Rank these tile system conservation practices by priority for the next 10 years
25%
20%
15%
10%
5%
0%
Controlled drainage
Treatment wetlands
Saturated buffers
Alternative tile intakes
Woodchip bioreactor

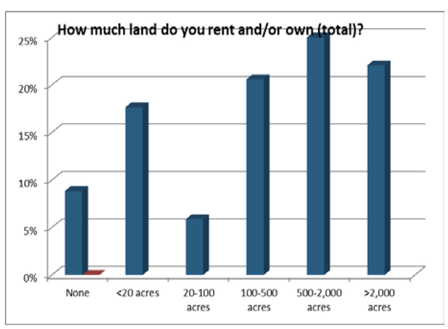

Rank these ag surface runoff practices by priority for the next 10 years
30%
25%
20%
15%
10%
5%
0%
Filter & buffer strips
Sediment basins
Cover crops
Conservation tillage
Grassed waterways


Rank these hydrology mitigating ag practices by priority for the next 10 years
25%
20%
15%
10%
5%
0%
Cover crops
CRP/Conservation cover
Wetland restoration
No tillage
Controlled drainage
Ponds/basins
Crop rotation


Rank these urban storm water practices by priority for the next 10 years
30%
25%
20%
15%
10%
5%
0%
Rain gardens, small wetlands
Storm water system ponds/treatment
Clean-up after pets
Rain barrels
Permeable pavement


Rank these animal waste management practices by priority for the next 10 years
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Feedlot manure management
Manure application management
Restricting animals from streams
Improved pasture grazing


How familiar are you with the "Watershed Approach"?
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Very familiar
Somewhat familiar
Not familiar


How much land do you rent and/or own (total)?
25%
20%
15%
10%
5%
0%
None
<20 acres
20-100 acres
100-500 acres
500-2,000 acres
>2,000 acres

5.23 Conservation Priorities by County selected by Local Work Group

Chippewa County

Viewed Chippewa County portion of the Hawk Creek Watershed as two distinct areas: 1) agricultural lands and 2) Minnesota River Valley

Issues identified

- Need for buffers
- Sloughing streambanks
- Lack of wetlands, opportunities to restore wetlands
- Steep slopes – gullies
- Lack of water retention, need for wetlands and sediment and water retention basins
- CRP acres and contracts expiring

Protection

- Current buffers
- Streambanks in good condition
- Current wetlands
- Steep slopes in good condition
- Current CRP acres

Restoration

- Areas in need of buffers
- Streambanks in poor condition
- Potential restorable wetlands
- Steep slopes in poor condition
- Water retention locations

Kandiyohi County

Viewed Kandiyohi County portion of the Hawk Creek Watershed as two distinct areas: 1) agricultural lands and 2) lakes region

Issues identified

- Lack of buffers
- Need to replace open intakes with alternative intakes
- Need for nutrient management plans and more efficient fertilizer application on cropland
- Over fertilization on lakeshore properties
- Overland and wind erosion
- Residue management and need for grassed waterways
- Lack of water retention, need for wetlands and sediment and water retention basins
- City stormwater and industrial wastewater retention and treatment
- Need for more perennial vegetation

Protection

- Current buffers
- Lakeshores
- Current wetlands

Restoration

- Areas in need of buffers
- Alternative intakes
- More efficient fertilizer application
- Change in cropping practices to reduce compaction, overland and wind erosion (i.e. less moldboard plowing, field rolling, more cover crops, crop residue)
- Potential restorable wetlands
- Water retention locations

Renville County

Viewed Renville County portion of the Hawk Creek Watershed as two distinct areas:

1) Agricultural lands and 2) Minnesota River Valley

Issues identified

- Need for buffers
- Sloughing streambanks
- Lack of wetlands, opportunities to restore wetlands
- Steep slopes - gullies
- Lack of water retention, need for wetlands and sediment and water retention basins
- Need to replace open intakes with alternative intakes
- Need for nutrient management plans and more efficient fertilizer application on cropland
- Overland and wind erosion
- City stormwater and industrial wastewater retention and treatment
- Need for more perennial vegetation and residue management
- Need to reduce ditch bank erosion, install side inlets
- Septic system compliance
- Restore floodplains, particularly along Minnesota River

Protection

- Current buffers
- Streambanks in good condition
- Current wetlands
- Steep slopes in good condition
- Current CRP acres
- Floodplains

Restoration

- Areas in need of buffers
- Streambanks in poor condition
- Potential restorable wetlands
- Steep slopes in poor condition
- Water retention locations
- Alternative intakes
- More efficient fertilizer application
- Change in cropping practices to reduce compaction, overland and wind erosion (i.e. less moldboard plowing, field rolling, more cover crops, crop residue)
- Floodplain

5.24 Minnesota Department of Health Summary for Hawk Creek Watershed

The MDH works with public water suppliers to develop Wellhead Protection Plans and determine Drinking Water Supply Management Areas (DWSMAs). Within the Hawk Creek Watershed, the cities of Danube, Raymond, Renville, and Willmar are all community public water suppliers that have moderate to highly vulnerable areas to potential contamination.

Wellhead protection plans have been completed for the following communities:

Non-Vulnerable/Protected aquifer:

Blomkest

Granite Falls

Olivia

Pennock

Prinsburg

Sacred Heart

Vulnerable/Susceptible to Contamination:

Danube

Raymond

Renville

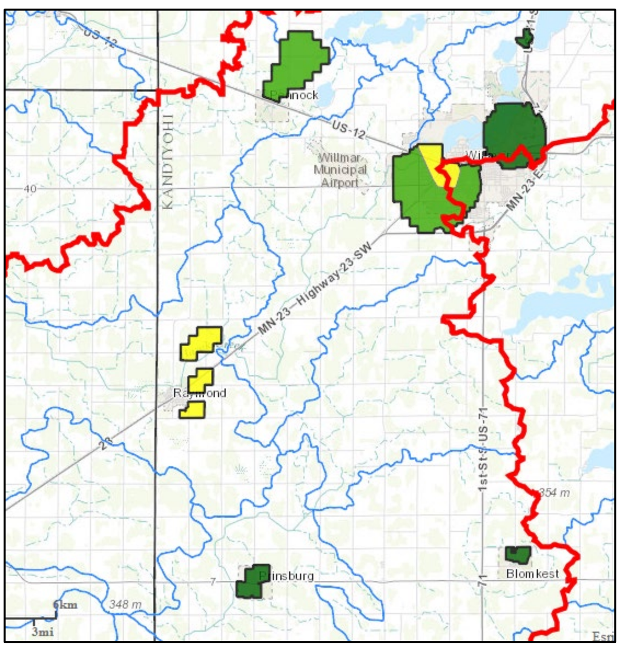
Willmar

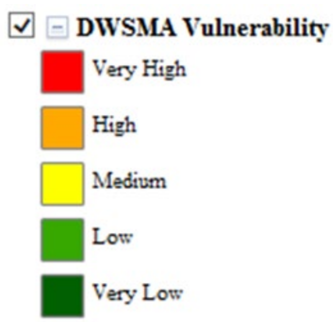
Wellhead Protection Plans Not Completed:

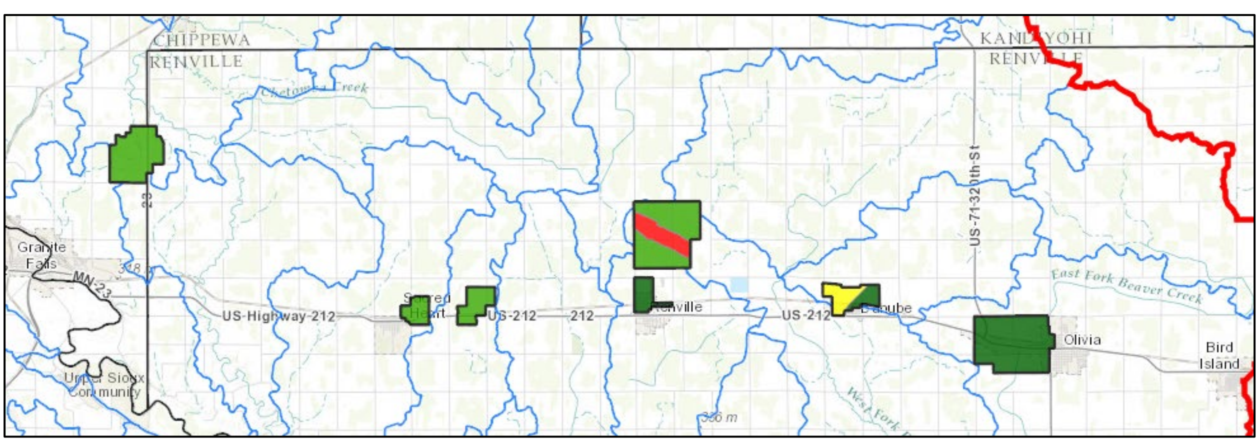
Bird Island

Clara City

Maynard







5.25 Inventory of Tools for Prioritizing and Targeting

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
National Hydrography Dataset (NHD) & Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. A specific application of the data set is to identify buffers around riparian areas.	GIS layers are available on the USGS website.	http://nhd.usgs.gov/
Impaired Waterbodies	Data indicates which stream reaches, lakes, and wetlands have been identified as impaired, or not meeting water quality standards. Attribute table includes information on the impairment parameters.	Examples of region/subwatershed prioritization includes: the number of impairments, specific impairment parameter, % of stream miles/lakes that are impaired, immediate subwatersheds of impaired rivers/lakes, identifying reaches with specific impairment parameters, etc. Field-scale targeting examples include: buffering impaired waters.	GIS layers are available on the PCA website.	http://www.pca.state.mn.us/index.php/data/spatial-data.html?show_descr=1
Hydrological Simulation Program – FORTRAN (HSPF)	Simulation of watershed hydrology and water quality. Incorporates point and non-point sources including pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches. The model is typically calibrated with monitoring data to ensure accurate results.	Since the model produces data on a subwatershed scale, the model output can be particularly useful for identifying "priority" subwatersheds. The modeled pollutant or concentrations or total loads include TSS, TP, and TN. Point and non-point contributions can be extracted separately. Can be used to analyze different BMP "scenarios".	PCA models many major watersheds with HSPF. If completed, model data can be obtained from PCA and imported into GIS.	http://water.usgs.gov/software/HSPF/
HSPF - Scenario Application Manager (SAM)	Designed for those without HSPF training to visualize HSPF data and develop non-point and point source BMP scenarios "on the fly" without having to manually manipulate HSPF code	A local county government could develop HSPF scenarios in SAM that would demonstrate BMPs that would reach local WQ goals; this demonstration could then be used to secure funding for BMP placement. This would be done without having to contract out the scenarios with an engineering firm	Can export data from SAM as shapefile for use in GIS	http://www.respec.com/portfolio_project_view.php?project_id=15
1855 Land Survey Data	Data originally created by land surveyors in the mid-to-late 1800s. Surveys were conducted in one-mile grid and indicated the land cover at the time of the survey. This data has been georeferenced and is available for most of the state. This information has been digitized by PCA staff for the GRBERB.	This information could be used to prioritize areas based on changes in the landscape. This information is also helpful to understand landscape limitations (e.g. former lake beds may not be drain well).	Image data is available from MN Geo. Digitized rivers, lakes, and wetlands (in the GBERB only) are available from PCA staff.	http://www.mngeo.state.mn.us/glo/
Historical Wetlands (PCA Analysis)	Data was created for the GBERB by PCA staff. Created using a combination of techniques including using the 1855 digitized features and a terrain and soils-based analysis.	This data can be used to identify locations to target wetland restorations. Areas with high % of lost wetlands may be prioritized.	Data available from PCA staff (in the GBERB only).	
Restorable Depressional Wetland Inventory	A GIS layer representing drained, potentially restorable wetlands in agricultural landscapes. Created primarily through photo-interpretation of 1:40,000 scale color infrared photographs acquired in April and May, 1991 and 1992.	Identify restorable wetland areas with an emphasis on: wildlife habitat, surface and ground water quality, reducing flood damage risk. To see a comprehensive map of restorable wetlands, must display this dataset in conjunction with the USGS National Wetlands Inventory (NWI) polygons that have a 'd' modifier in their NWI classification code	GIS layer is available on the DNR Data Deli website also available from Ducks Unlimited.	http://deli.dnr.state.mn.us/metadata.html?id=L390002730201 ; http://prairie.ducks.org/index.cfm?&page=minnesota/restorablewetlands/home.htm#downfile
"Altered Hydrology" (PCA Analysis)	GIS layers (results of GIS analysis) of hydrology-influencing parameters indicating the amount of change (since European settlement) including: % tiled, % wetland loss, % stream channelized, % increase in waterway length, % not perennial vegetation, % impervious. Analysis done at the same subwatershed scale as the HSPF modeling was completed to facilitate subwatershed prioritization. Analysis was completed using available GIS data layers.	These 6 layers could be used individually or in combination (using raster calculator) to prioritize subwatersheds to target conservation practices intended to mitigate altered hydrology.	GIS layers (in the Le Sueur Watershed only) are available from PCA staff.	
Altered Watercourse Dataset (Channelized Streams)	Statewide data layer that identifies portions of the National Hydrography Dataset (NHD) that have been visually determined to be hydrologically modified (i.e., ditches, channelized streams and impoundments).	Identifies streams with highly modified stream channels for conservation prioritization. Subwatersheds with high levels of channelized streams may be prioritized for specific conservation practices.	GIS layers are available on the MN Geo website.	http://www.mngeo.state.mn.us/ProjectServices/awat/
Tile Inventory	Data exists in a very limited extent at the County level. The data layer can be created by digitizing visible tile lines from imagery.	Knowing the location, extent, and spacing of tile can help define priority areas or target fields to implement practices that address altered hydrology.	Contact your County to see if any data exists.	
Tile Drainage (PCA Analysis)	Data created as an estimate of whether a pixel is tiled or not. Assumes tiled if: row crop, <3% slope, poorly drained soil type	Can be useful for prioritizing highly drained areas to implement BMPs that address altered hydrology.	Data can be obtained from PCA staff	
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for: erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the MN Geospatial Information website for most counties.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
Stream Power Index (SPI)	SPI, a calculation based on a LiDAR file, describes potential flow erosion at the given point of the topographic surface. As catchment area and slope gradient increase, the amount of water contributed by upslope areas and the velocity of water flow increase. Varying SPI analyses have been done with different resulting qualities depending on the amount of hydrologic conditioning that has been done.	Useful for identifying areas of concentrated flows which can be helpful for targeting practices such as grassed waterways or WASCOBs. Again, the usefulness may depend on the level of hydrologic conditioning that has been done.	This layer has been created by PCA staff with little hydroconditioning for the GBERB and can be obtained from PCA staff.	http://iflorinsky.narod.ru/si.htm
Compound Topographic Index (CTI)	CTI, a calculation based on a LiDAR file, is a steady state wetness index. The CTI is a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction. CTI was designed for hillslope catenas. Accumulation numbers in flat areas will be very large and CTI will not be a relevant variable.	Identifies likely locations of soil saturation which can be useful for targeting certain practices.	Can be downloaded from ESRI	http://arcscripts.esri.com/details.asp?dbid=11863
NRCS Engineering Toolbox	The free, python based toolsets for ArcGIS 9.3 and 10.0 allow for user friendly use of Lidar Data for field office applications, Hydro-Conditioning, Watershed Delineation, conservation planning and more.	Many uses including siting and preliminary design of BMPs.	Toolbox and training materials available on the MnGeo site.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
RUSLE2	RUSLE2 estimates rates of rill and interrill soil erosion caused by rainfall and its associated overland flow. Several data layers and mathematical calculations are used to estimate this erosion.	Estimating erosion to target field sediment controlling practices.		http://www.ars.usda.gov/Research/docs.htm?docid=6016
Crop Land - National Agricultural Statistics Service (NASS)	Data on the crop type for a specific year. Multiple years data sets available.	Identify crop types, including perennial or annual crops and look at crop rotations/changes from year to year. A specific example of a use is to identify locations with a short season crop to target cover crops practice.	Data available for download from the USDA or use the online mapping tool.	http://www.nass.usda.gov/research/Cropland/SARS1a.htm
National Land Cover Database (NLCD) from the MRLC	Data on land use and characteristics of the land surface such as thematic class (urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover.	Identify land uses and target practices based on land use. One example may be to target a residential rain garden/barrel program to an areas with high levels of impervious surfaces.	Data available for download from the MRLC website	http://www.mrlc.gov/
CRP land (2008)	Data on which areas were enrolled in the USDA Conservation Reserve Program. This data is no longer available but may exist at the county level.	Potential uses include targeting areas to create habitat corridors or targeting areas coming out of CRP to implement specific BMPs.		http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
Soils Data (SSURGO)	Data indicates soil type and properties.	Soil types can be used to determine the acceptableness of a practice based on properties such as permeability or erosvity.	Data can be downloaded or online viewers are available on the NRCS website.	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

Manure-applied Fields	Data on which fields received manure (and possible the rate in which manure is applied). This data exists in a spatial format in a very limited extent based on the County Feedlot record keeping. This information could be created from manure management plans and/or annual reports. Martin County has created this layer.	Identifying areas of heavy manure usage. This can be helpful when prioritizing or targeting areas to address E. coli.	Contact County feedlot staff to inquire	
Feedlot Locations	Data indicates the location of existing feedlots. Some data in this data layer is not accurate and feedlot locations could be mapped at the owner's address or in the center of the quarter quarter.	May be helpful prioritizing areas to implement strategies that address E. coli or nutrients.	Data available on PCA website	ftp://files.pca.state.mn.us/pub/spatialdata/ see "mpca_feedlots_ac.zip"
Marginal (Farmed) Lands	Data exists in a limited extent and perhaps not at all in the watershed. This data can be made using other data layers. There are several ways to define marginal (farmed) lands, but criteria usually include either high levels of environmental sensitivity or areas that make little net profit when farmed.	Useful for identify areas that would be most beneficial to take out of crop production to place a BMPs that cannot occur on an actively farmed footprint. Commonly used to identify locations targeted for perennial (biofuel) crops.	Can be created using one of many established definitions or marginal land (see link).	http://kellylab.berkeley.edu/storage/papers/2014-LewisKelly-IJGI.pdf
Tillage Transect Survey	Data regarding the observed tillage or residue cover. Data exists in a very limited extent. MSU WRC will be doing a survey in the Le Sueur River watershed.	Prioritizing areas or targeting specific fields based on the type of tillage used.	Contact Rick Moore at WRC	: http://mrbdc.mnsu.edu/minnesota-tillage-transect-survey-data-center
Land Ownership/ Property Boundaries	Data indicates the owner and property boundary. This data is kept at the county level.	May be helpful for targeting efforts, particularly when a proactive approach is taken (e.g. if areas are targeted for specific practices and land owners are contacted to gauge their interest in a specific practice).	Some data available on the MN Geo website. Not all areas may have data in GIS format. Contact specific counties for more details/information.	http://www.mngeo.state.mn.us/chouse/land_own_property.html
Landowner Interest	Data exists in only a very limited extent at this time. The data exists in areas (e.g. County SWCDs) that have tracked this information themselves. Other entities may consider tracking this information.	Having information on interested landowners (including interest in specific projects) increases chances of being funded. An area with many interested landowners could be high priority.		
Installed Practices	Data exists in a limited extent at this time. Agencies like BWSR, the NRCS, or County SWCDs may be able to provide some information.	Knowing which areas have had multiple practices installed could indicate more interested landowners or help identify areas to anticipate water quality improvements.	Contact listed agencies to inquire if any data is available.	
Watershed Health Assessment Framework (WHAF)	An online spatial program that displays information at the major and subwatershed scaled. Information includes: hydrology, biology, and water quality.	The online program is helpful for quick viewing and could be used to prioritize subwatersheds based on parameters or criteria in the WHAF.	Online only	http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/
Agricultural Conservation Planning Framework (ACPF; Tomer et al.)	An outlined methodology uses several data layers and established analyses to identify specific locations to target several different BMPs. A "toolbox" is being created to facilitate the use of this methodology in MN.	Targeting specific BMPs (see link).	see demo: https://usdanrcs.adobeconnect.com/p6v40eme1cz/	http://northcentralwater.org/acpf/
Ecological Ranking Tool (Environmental Benefit Index - EBI)	Three GIS layers containing: soil erosion risk, water quality risk, and habitat quality. Locations on each layer are assigned a score from 0-100. The sum of all three layer scores (max of 300) is the EBI score; the higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities. Raster calculator allows a user to make their own sum of the layers to better reflect local values or to target specific conservation practices.	GIS layers are available on the BWSR website.	http://www.bwsr.state.mn.us/ecological_ranking/
Lakes of Phosphorus Sensitivity Significance	A ranked priority list for Minnesota's unimpaired lakes based on sensitivity to additional phosphorus loading. The most sensitive lakes will likely see substantial declines in water clarity with increased nutrient pollution loading.	Dataset valuable to local governments and state agencies tasked with prioritizing unimpaired lakes for protection efforts.	GIS layer available from Minnesota Geospatial Information Office.	https://gisdata.mn.gov/dataset/env-lakes-phosphorus-sensitivity
Zonation	A values-based framework and software for large-scale spatial conservation prioritization. Allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses. 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.	Surveys are created and given to targeted audiences to identity their priorities. These survey priorities are then used by the program. The output of Zonation can be used to identify areas that align with the conservation values of the survey respondents.	Zonation results can be exported to GIS. Paul Radomski (DNR) and colleagues have expertise with Zonation.	http://cbig.it.helsinki.fi/software/zonation/
Restorable Wetland Prioritization Tool	The base layer is a restorable wetlands inventory that predicts restorable wetland locations across the landscape. There are also three decision layers including a stress, viability, and benefits layer. The stress and viability decision layers can be weighted differently depending on the users interest in nitrogen and phosphorus reductions and habitat improvement. Lastly, there is a modifying layer with aerial imagery and other supplemental environmental data.	This tool enables one to prioritize wetland restoration by nitrogen or phosphorus removal and/or by habitat. Additional uses include: locating areas most in need of water quality or habitat improvement; prioritizing areas that already are or are most likely to result in high functioning sustainable wetlands; refining prioritizations with aerial imagery and available environmental data.		https://beaver.nrri.umn.edu/MPCAWLPri/
National Fish Habitat Partnership Data System	Supports coordinated efforts of scientific assessment and data exchange among the partners and stakeholders of the aquatic habitat community. The system provides data access and visualization tools for authoritative NFHP data products and contributed data from partners. Data sets available include: anthropogenic barrier dataset,			http://ecosystems.usgs.gov/fishhabitat/
Indicators of Hydrologic Alteration (IHA)	The Indicators of Hydrologic Alteration (IHA) is a software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios. Assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.	The software program assesses 67 ecologically-relevant statistics derived from daily hydrologic data. For instance, the IHA software can calculate the timing and maximum flow of each year's largest flood or lowest flows, then calculates the mean and variance of these values over some period of time. Comparative analysis can then help statistically describe how these patterns have changed for a particular river or lake, due to abrupt impacts such as dam construction or more gradual trends associated with land- and water-use changes.		https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/indicators-hydrologic-alt.aspx
InVEST	InVEST is a suite of software models used to map and value the goods and services from nature that sustain and fulfill human life. InVEST enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.	InVEST models can be run independently, or as script tools in the ArcGIS Arc Toolbox environment. You will need a mapping software such as QGIS or ArcGIS to view your results. Running InVEST effectively does not require knowledge of Python programming, but it does require basic to intermediate skills in ArcGIS.		http://www.naturalcapitalproject.org/InVEST.html
RIOS	RIOS provides a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities in order to maximize the ecological return on investment, within the bounds of what is socially and politically feasible.			http://www.naturalcapitalproject.org/RIOS.html
The Missouri Clipper	This tool will generate a ZIP file containing support files needed for SNMP, MMP and RUSLE2. These support files include aerial photo and topographic map images, soil and watershed shape files, a digital elevation model raster file, and a RUSLE2 GDB file. Soil data is obtained from the NRCS Web Soil Survey and may be limited by availability (see Status Map). To get your data, locate your farm on a map using Google			http://clipper.missouri.edu/index.asp?t=county&state=Minnesota
Map Window GIS + MMP Tools	Map Window GIS + MMP Tools is a free GIS that can be used for the following: 1.As a front-end to MMP when creating nutrient management plans. 2.As a front-end to Irris Scheduler when doing irrigation and nitrogen scheduling. 3.For designing research plots (randomized complete block field experiments).			http://www.purdue.edu/agsoftware/mapwindow/
Objective Model Custom Weight Tool	A decision support tool designed for USFWS resource managers the ability to make thoughtful and strategic choices about where to spend its limited management resources. This tool makes the processes used to prioritize these management units more transparent, improving the defensibility of management decisions. Originally created for the Morris Wetland Management District (WMD)			http://www.umesc.usgs.gov/management/dss/morris_wmd.html
WARPT: Wetlands-At-Risk Protection Tool	The Wetlands-At-Risk Protection Tool, or WARPT, is a process for local governments and watershed groups that acknowledges the role of wetlands as an important part of their community infrastructure, and is used to develop a plan for protecting at-risk wetlands and their			http://www.wetlandprotection.org/

excel table with active links available by request

5.26 Usefulness of GIS Data Layers/Tools

Usefulness of GIS Data Layers/Tools for Prioritizing and Targeting Strategies/BMPs

as determined by participants on Day 1 of the Spatial Targeting Workshop on 4/30/14 at the Mankato PCA. See "Tools Inventory" and "Ideas to Prioritize and Target Strategies/BMPs" for more information. This is not an exhaustive list of all data layers/tools that are available or useful. Targeting efforts should select data layers/tools (included here or additionally) based on individual project needs and local priorities.*Note: Some data sets exist in only a very limited extent and may require substantial work before having a usable, spatially referenced data layer.

- Blue = very/usually useful
- Green = somewhat/sometimes useful
- Yellow = unsure/need more information
- Red = probably not useful/not applicable

GIS Data Layers / Tools*	Strategies/BMPs																				
	Conservation Cover (easements/buffers)	Filter strips and buffers	Lake shoreland buffers	Water and sediment basins, terraces	Restored wetlands	Improved field manure management	Cover crops	Ravine (grade) stabilization	Treatment wetlands	Conservation tillage (no-till, strip till)	Adhere/ increase manure application setbacks	Streambank stabilization	Saturated buffers	Grassed waterways	Nutrient management	Controlled drainage, drainage design	50' buffer on protected of waterways	Side inlet control, extended retention	One rod ditch buffers	Woodchip bioreactors	Livestock exclusion (from rivers)
Landowner interest	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Green	Blue	Blue	Green	Blue	Blue	Blue	Blue	Yellow	Blue	Blue	Blue	Blue
Streams, lakes, wetlands, ditches (NHD & WBD)	Blue	Blue	Blue	Green	Blue	Blue	Green	Green	Blue	Blue	Blue	Blue	Blue	Yellow	Blue	Blue	Blue	Yellow	Blue	Green	Blue
Ownership layer	Blue	Blue	Blue	Green	Blue	Green	Green	Blue	Green	Green	Blue	Green	Blue	Blue	Blue	Blue	Yellow	Blue	Blue	Green	Blue
EBI – Water quality risk	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Green	Blue	Blue	Blue	Green	Green	Blue	Yellow	Red	Yellow	Green	Blue	Green
Crop or vegetation type/land use (NASS & NLCD)	Blue	Blue	Blue	Blue	Green	Blue	Blue	Green	Yellow	Blue	Blue	Green	Green	Green	Blue	Blue	Yellow	Green	Yellow	Green	Yellow
Existing installed practices	Yellow	Blue	Blue	Green	Green	Blue	Blue	Blue	Green	Blue	Blue	Green	Blue	Green	Green	Green	Yellow	Green	Green	Green	Green
Impaired waters/associated subwatersheds, specific impairments	Blue	Green	Blue	Blue	Green	Blue	Green	Green	Green	Green	Blue	Green	Blue	Green	Green	Green	Green	Yellow	Yellow	Green	Blue
HSPF subwatershed pollutant loads and/or concentrations	Blue	Green	Yellow	Blue	Green	Blue	Green	Green	Blue	Green	Yellow	Green	Green	Green	Blue	Green	Green	Red	Green	Blue	Green
Soil type/characteristics (including HEL) (SSURGO)	Yellow	Blue	Green	Green	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue	Green	Blue	Green	Yellow	Yellow	Red	Yellow	Red
LiDAR/derived-data - Elevation, slope, and differences	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Yellow	Blue	Green	Blue	Green	Blue	Red	Blue	Red	Blue	Red	Red	Red
EBI – Soil erosion potential	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Red	Blue	Blue	Green	Yellow	Green	Green	Yellow	Yellow	Yellow	Green	Red	Yellow
NRCS engineering tools	Green	Green	Green	Blue	Yellow	Blue	Green	Blue	Blue	Green	Green	Blue	Green	Blue	Yellow	Yellow	Green	Yellow	Red	Green	Yellow
Le Sueur hydrology analysis	Green	Green	Green	Green	Blue	Green	Green	Yellow	Blue	Green	Red	Blue	Green	Blue	Yellow	Blue	Green	Blue	Red	Red	Yellow
Stream power index	Blue	Blue	Green	Blue	Yellow	Blue	Blue	Blue	Red	Blue	Green	Blue	Green	Blue	Red	Red	Yellow	Green	Green	Red	Red
Tile inventory	Yellow	Green	Green	Blue	Green	Blue	Yellow	Blue	Blue	Yellow	Yellow	Blue	Blue	Red	Green	Green	Green	Green	Red	Green	Red
Marginal farmed lands	Blue	Green	Green	Green	Yellow	Blue	Green	Green	Blue	Blue	Green	Green	Green	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Red	Yellow
Compound topographic index	Blue	Green	Yellow	Blue	Blue	Green	Green	Green	Blue	Yellow	Green	Blue	Yellow	Yellow	Red	Blue	Green	Green	Yellow	Red	Red
RUSLE	Blue	Blue	Blue	Green	Yellow	Green	Blue	Blue	Red	Green	Yellow	Red	Red	Blue	Yellow	Yellow	Red	Yellow	Green	Red	Red
Watershed Health Assessment Framework	Green	Yellow	Yellow	Green	Yellow	Blue	Yellow	Yellow	Blue	Yellow	Yellow	Blue	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Blue	Yellow
Tillage Transects	Yellow	Green	Green	Blue	Yellow	Green	Green	Green	Red	Blue	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Red	Yellow
Zonation	Blue	Green	Green	Green	Yellow	Red	Yellow	Yellow	Blue	Red	Green	Blue	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow
Manure-applied fields	Green	Blue	Green	Red	Red	Blue	Blue	Yellow	Green	Blue	Blue	Red	Green	Red	Green	Red	Yellow	Red	Red	Red	Red
Flexible framework to facilitate ag watershed planning	Green	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Blue	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Blue	Yellow
Feedlots	Red	Green	Green	Red	Red	Blue	Blue	Yellow	Green	Green	Blue	Red	Yellow	Red	Green	Red	Yellow	Red	Yellow	Red	Green
EBI – Habitat quality	Blue	Blue	Blue	Red	Blue	Red	Yellow	Yellow	Green	Yellow	Yellow	Red	Green	Red	Yellow	Yellow	Red	Yellow	Yellow	Red	Yellow
Channelized streams	Red	Blue	Green	Red	Green	Red	Yellow	Red	Red	Red	Green	Yellow	Yellow	Red	Red	Yellow	Green	Yellow	Blue	Red	Green
Restorable Wetland Prioritization Tool	Blue	Yellow	Blue	Red	Blue	Red	Red	Yellow	Blue	Yellow	Green	Red	Green	Red	Red	Red	Red	Red	Red	Red	Red
2008 CRP	Blue	Yellow	Green	Red	Yellow	Red	Green	Green	Red	Red	Red	Green	Green	Green	Red	Red	Yellow	Red	Red	Red	Red
Historical wetlands (1855 high probability wetland/marshes)	Green	Red	Yellow	Green	Blue	Red	Red	Yellow	Blue	Red	Red	Red	Red	Green	Green	Yellow	Red	Red	Red	Red	Red
Restorable Depression Wetland Inventory	Blue	Red	Yellow	Green	Blue	Red	Red	Green	Blue	Red	Yellow	Yellow	Red	Red	Yellow	Red	Red	Red	Red	Red	Red
1855 survey of land features	Yellow	Red	Yellow	Green	Blue	Red	Red	Green	Green	Red	Red	Red	Red	Red	Red	Red	Yellow	Red	Red	Red	Red

5.27 NPDES Permit Holders in the Hawk Creek Watershed

Type	Name	County
Industrial Stormwater Permit	Southern MN Beet Sugar - Clara Ct E - SW	Chippewa
Industrial Stormwater Permit	Southern MN Beet Sugar - Clara Ct W - SW	Chippewa
Industrial Stormwater Permit	Southern MN Beet Sugar - Maynard - SW	Chippewa
Industrial Stormwater Permit	Clara City Ready Mix Plant 2 - Mobile - SW	Chippewa
Industrial Stormwater Permit	Henrich & Sons Inc - SW	Chippewa
Industrial Stormwater Permit	Ervin Construction - SW	Chippewa
Industrial Stormwater Permit	Clara City Ready Mix - SW	Chippewa
Industrial Stormwater Permit	Maynard city of Garage and Shop - SW	Chippewa
Industrial Stormwater Permit	WIC Inc - SW	Chippewa
Industrial Stormwater Permit	Schoep & Sons Contracting - SW	Chippewa
Industrial Stormwater Permit	Truwe Precision Machining Inc - ISW	Chippewa
Industrial Stormwater Permit	Clara City Herald - ISW	Chippewa
Industrial Stormwater Permit	Clara City West Concrete Plant Site - ISW	Chippewa
Industrial Stormwater Permit	NSP/Xcel Energy MN Valley Plant - SW	Chippewa
Industrial Stormwater Permit	Chippewa Cty Hwy Dept Shop 1 & 2 - SW	Chippewa
Industrial Stormwater Permit	Chippewa County Highway Dept Shop 5 - SW	Chippewa
Industrial Stormwater Permit	Clara city of WWTP - SW	Chippewa
Industrial Stormwater Permit	Montevideo city of Municipal Garage - SW	Chippewa
Industrial Stormwater Permit	Consolidated Ready Mix Inc - Montevideo - ISW	Chippewa
Industrial Stormwater Permit	Granite Falls Redi-Mix - ISW	Chippewa
Industrial Stormwater Permit	Marr Valve Co	Chippewa
Industrial Stormwater Permit	Flykt Demolition Landfill - SW	Kandiyohi
Industrial Stormwater Permit	Southern MN Beet Sugar - Raymond - SW	Kandiyohi
Industrial Stormwater Permit	AGCO Manufacturing - SW	Kandiyohi
Industrial Stormwater Permit	Willmar Poultry Co Inc - SW	Kandiyohi
Industrial Stormwater Permit	Prinsburg City Garage - SW	Kandiyohi
Industrial Stormwater Permit	Willmar Air Service - SW	Kandiyohi
Industrial Stormwater Permit	US Army Reserve Willmar Memorial Ctr - SW	Kandiyohi
Industrial Stormwater Permit	Raymond city of - SW	Kandiyohi
Industrial Stormwater Permit	Pennock city of WWTP - SW	Kandiyohi
Industrial Stormwater Permit	Willmar Municipal Airport - SW	Kandiyohi
Industrial Stormwater Permit	West Central Printing - ISW	Kandiyohi
Industrial Stormwater Permit	Uncommon USA Inc - ISW	Kandiyohi
Industrial Stormwater Permit	Schiller Cabinetry Inc - SW	Kandiyohi
Industrial Stormwater Permit	Central Minnesota Fabricating Inc - SW	Kandiyohi
Industrial Stormwater Permit	Prinsco - Prinsburg Plant ISW	Kandiyohi
Industrial Stormwater Permit	Epitopix - ISW	Kandiyohi
Industrial Stormwater Permit	Dooley's Amoco - SW	Kandiyohi
Industrial Stormwater Permit	Willmar city of WWTP - SW	Kandiyohi
Industrial Stormwater Permit	Rohner's Auto Parts Inc - SW	Kandiyohi
Industrial Stormwater Permit	Willmar city of Brush & Compost Site - SW	Kandiyohi
Industrial Stormwater Permit	Willmar city of Public Works Fac - SW	Kandiyohi
Industrial Stormwater Permit	Bergh's Fabricating Inc - SW	Kandiyohi
Industrial Stormwater Permit	Relco LLC - ISW	Kandiyohi
Industrial Stormwater Permit	BNSF RR - Willmar - SW	Kandiyohi
Industrial Stormwater Permit	Willmar Wastewater Treatment Facility ISW	Kandiyohi
Industrial Stormwater Permit	Willmar Ready Mix ISW	Kandiyohi
Industrial Stormwater Permit	Serbus Gravel - SW	Renville
Industrial Stormwater Permit	Olivia Canning Co - SW	Renville
Industrial Stormwater Permit	Southern MN Beet Sugar - Renville - SW	Renville
Industrial Stormwater Permit	Sacred Heart city of WTP - SW	Renville
Industrial Stormwater Permit	Olivia city of Vehicle Maint Garage - SW	Renville
Industrial Stormwater Permit	Sacred Heart city of Community Ctr - SW	Renville
Industrial Stormwater Permit	Danube city of WWTP - SW	Renville
Industrial Stormwater Permit	Cretex Concrete Products North - Olivia - SW	Renville
Industrial Stormwater Permit	Sacred Heart WWTP - SW	Renville
Industrial Stormwater Permit	Loyal Transport Co - ISW	Renville
Industrial Stormwater Permit	Renville Sanitary & Demolition Ldfl - SW	Renville
Industrial Stormwater Permit	H&L Printing - Olivia - ISW	Renville
Industrial Stormwater Permit	Bird Island city of Maintenance Shop-SW	Renville
Industrial Stormwater Permit	Sacred Heart city of City Shop - SW	Renville
Industrial Stormwater Permit	Renville city of City Garage - SW	Renville
Industrial Stormwater Permit	Renville Cty Highway Garage - SW	Renville
Industrial Stormwater Permit	Renville Cty Highway Garage No. 5 - SW	Renville
Industrial Stormwater Permit	Renville Cty Highway Garage No. 3 - SW	Renville
Industrial Stormwater Permit	Renco Publishing Inc - ISW	Renville
Industrial Stormwater Permit	Danube Ready Mix ISW	Renville

Feedlot	Justin Ulferts Farm	Chippewa
Feedlot	Kevin Rosendahl Farm	Chippewa
Feedlot	Kleene Farms Inc	Chippewa
Feedlot	Lone Tree Farm LLC - Site 1	Chippewa
Feedlot	Lone Tree Farm LLC - Site 2	Chippewa
Feedlot	Rosendahl Feedlots	Chippewa
Feedlot	Ruschen Turkey Inc	Chippewa
Feedlot	Riverview LLP - Hawk Creek Calves	Chippewa
Feedlot	Scott Roelofs Farm	Chippewa
Feedlot	Christensen Farms Site C074	Chippewa
Feedlot	Lone Tree Farms LLC	Chippewa
Feedlot	Willmar Poultry Co Inc - Burlington	Kandiyohi
Feedlot	Willmar Poultry Co Inc - Soloman Lake	Kandiyohi
Feedlot	Willmar Poultry Co Inc - Highland	Kandiyohi
Feedlot	Willmar Poultry Co Inc - Millcreek	Kandiyohi
Feedlot	Country Pork LLP - Farm 1	Kandiyohi
Feedlot	Country Pork LLP - Farm 2	Kandiyohi
Feedlot	Country Pork LLP - Farm 3	Kandiyohi
Feedlot	Gorans Bros Inc - Crown Farm	Kandiyohi
Feedlot	Huisinga Farms Inc 8	Kandiyohi
Feedlot	Meadow Star Dairy LLP	Kandiyohi
Feedlot	Prinsburg Farmers Co-op Brooder Site	Kandiyohi
Feedlot	Prinsburg Farmers Co-op East Site	Kandiyohi
Feedlot	Prinsburg Farmers Co-op West Site	Kandiyohi
Feedlot	Taatjes Farms Inc	Kandiyohi
Feedlot	Willmar Poultry Farms Inc - Fransen	Kandiyohi
Feedlot	Willmar Poultry Farms Inc - Prinsburg	Kandiyohi
Feedlot	Willmar Poultry Farms Inc - Svea	Kandiyohi
Feedlot	Willmar Poultry Farms Inc - Hilltop	Kandiyohi
Feedlot	Sunnyside Turkeys Inc - Bartel	Kandiyohi
Feedlot	Gorans Bros Inc H1-2 & HBr1-3 Farm	Kandiyohi
Feedlot	Gorans Bros Inc H3-4 & HBr4 Farm	Kandiyohi
Feedlot	Gorans Bros Inc HBr5 Farm	Kandiyohi
Feedlot	JAM Farms Inc - Sec 7	Kandiyohi
Feedlot	Jennie-O Turkey Store - Morning Star	Kandiyohi
Feedlot	Gorans Bros Inc H5-8 Farm	Kandiyohi
Feedlot	Voelz Brothers	Renville
Feedlot	RANCO LLC	Renville
Feedlot	Christensen Farms Site M002	Renville
Feedlot	Upper Midwest Swine Management	Renville
Feedlot	Christensen Farms Site C043	Renville
Feedlot	Christensen Farms Site C044	Renville
Feedlot	Christensen Farms Site F075	Renville
Feedlot	Christensen Farms Site N013	Renville
Feedlot	Christensen Farms Site NF001	Renville
Feedlot	Clay & Lisa Bryan Farm - Site 1	Renville
Feedlot	Clay & Lisa Bryan Farm - Site 2	Renville
Feedlot	Huisinga Farms Inc	Renville
Feedlot	Randall Dolezal Farm	Renville
Feedlot	Rembrandt Enterprises Inc (Feedlot)	Renville
Feedlot	Roger D Kingstrom Farm	Renville
Feedlot	Roger R Mulder Farm	Renville
Feedlot	Steven M Peterson Farm	Renville
Feedlot	Teri Kubesh	Renville
Feedlot	The Pullet Connection Inc	Renville
Feedlot	Willmar Poultry Farms - Tersteeg	Renville
Feedlot	Kevin & Sandra Malecek Farm - Kevin's Site	Renville
Feedlot	Kevin & Sandra Malecek Farm - Sandra's Site	Renville
Feedlot	J&C Swine - Jeremy Site	Renville
Feedlot	James Hebrink Farm - Home Site	Renville
Construction Stormwater Permit	SAP 12-605-15 CSW	Chippewa
Construction Stormwater Permit	Construct 3 Grain Storage Bins - CSW	Chippewa
Construction Stormwater Permit	Montevideo 94-1 Utility Improv CSW	Chippewa
Construction Stormwater Permit	Maynard Water Distribution System Imp - CSW	Chippewa
Construction Stormwater Permit	CP 05-03A - CSW	Chippewa
Construction Stormwater Permit	SP 1202-47 CSW	Chippewa
Construction Stormwater Permit	Grain Storage Bunker - CSW	Chippewa
Construction Stormwater Permit	SP 1205-25 (TH 23) - CSW	Chippewa
Construction Stormwater Permit	2005 Hawk Creek Acres Imp - CSW	Chippewa
Construction Stormwater Permit	SAP 12-604-07, 08, SAP 12-618-02, CP 03 - CSW	Chippewa

Construction Stormwater Permit	Donner Bros Conv Store/ Restaurant CSW	Chippewa
Construction Stormwater Permit	SP 12-602-18 - CSW	Chippewa
Construction Stormwater Permit	Cargill Railtrack Upgrade CSW	Chippewa
Construction Stormwater Permit	Granite Falls Community Ethanol CW - CSW	Chippewa
Construction Stormwater Permit	Impact Innovations Addition - Clara City - CSW	Chippewa
Construction Stormwater Permit	SAP 34-601-29 CSW	Kandiyohi
Construction Stormwater Permit	Dorothy A Olson Aquatic Center - CSW	Kandiyohi
Construction Stormwater Permit	Willmar Municipal Airport CSW	Kandiyohi
Construction Stormwater Permit	Arnold's Implement CSW	Kandiyohi
Construction Stormwater Permit	SP 34-601-25 CSW	Kandiyohi
Construction Stormwater Permit	Norling Turkeys South Farm CSW	Kandiyohi
Construction Stormwater Permit	West Central Steel Office - CSW	Kandiyohi
Construction Stormwater Permit	Hennen's Furniture Store - CSW	Kandiyohi
Construction Stormwater Permit	Prinsburg WW Treatment/Disposal System - CSW	Kandiyohi
Construction Stormwater Permit	Prinsburg WW Treatment/Disposal - CSW	Kandiyohi
Construction Stormwater Permit	Raymond Receiving Station CSW	Kandiyohi
Construction Stormwater Permit	Pine Bend Exp Phase 1A & 1B - CSW	Kandiyohi
Construction Stormwater Permit	Koosman Twin Home Development CSW	Kandiyohi
Construction Stormwater Permit	Holland Pork Co CSW	Kandiyohi
Construction Stormwater Permit	SP 6509-23 CSW	Renville
Construction Stormwater Permit	SP 6511-26 CSW	Renville
Construction Stormwater Permit	Wastewater Treatment Facility - Renvill - CSW	Renville
Construction Stormwater Permit	1999 Bayberry 2nd Addition Improv - CSW	Renville
Construction Stormwater Permit	2001 Baumgartner 1st Add. Street & Util - CSW	Renville
Construction Stormwater Permit	CSAH 3 & County Road 65, Sunrise Dr CSW	Renville
Construction Stormwater Permit	Olivia 2003 Street Imp CSW	Renville
Construction Stormwater Permit	Olivia Airport Pavement Rehab - CSW	Renville
Construction Stormwater Permit	Renville Co San Landfill Cell 1 Closure - CSW	Renville
Construction Stormwater Permit	SAP 65-601-12 -CSW	Renville
Construction Stormwater Permit	SAP 65-606-11 & SAP 34-607-12 - CSW	Renville
Construction Stormwater Permit	SAP 65-616-23 (CSAH 16) CSW	Renville
Construction Stormwater Permit	SAP 65-638-01 CSW	Renville
Construction Stormwater Permit	SP 65-599-31, 65-599-32 CSW	Renville
Construction Stormwater Permit	Judicial Ditch #15 Clean & Repair CSW	Renville
Construction Stormwater Permit	1998 NE Side Utility Improvements - CSW	Renville
Construction Stormwater Permit	SAP 65-601-11 CSAH 1 CSW	Renville
Construction Stormwater Permit	SAP 65-599-53 Bridge L8619 - CSW	Renville
Construction Stormwater Permit	1996 Infrastructure Improv - CSW	Renville
Construction Stormwater Permit	SAP 65-605-24 CSW	Renville
Construction Stormwater Permit	TH 212 Frontage Rd - CSW	Renville
Construction Stormwater Permit	SAP 65-609-07 (CSAH 9) - CSW	Renville
Construction Stormwater Permit	SP 6510-62 2006 TH 212 Imp - CSW	Renville
Construction Stormwater Permit	SP 6511-30 CSW	Renville
Construction Stormwater Permit	Beet Sugar Coop WWTP - CSW	Renville
Construction Stormwater Permit	Renville Co Sanitary Landfill Cell 3 - CSW	Renville
Construction Stormwater Permit	2006 Renville St/Utility Imp - CSW	Renville
Construction Stormwater Permit	Lime Storage Unit Construction -CSW	Renville
Construction Stormwater Permit	County Ditch #66 Improvements CSW	Renville
Construction Stormwater Permit	SAP 65-609-08 - CSW	Renville
Construction Stormwater Permit	SAP 65-604-16 - CSW	Renville
Construction Stormwater Permit	Einerson Field Grading CSW	Renville
Construction Stormwater Permit	Midwest Investors Inc Poultry Cmplx CSW	Renville
Construction Stormwater Permit	Grain Storage, Loading/Unloading Facilit - CSW	Renville
Construction Stormwater Permit	Coal Road Resurface & Scale House - CSW	Renville
Construction Stormwater Permit	2007 Mill and Overlay Project - CSW	Renville
Construction Stormwater Permit	2008 TH 71 Utility Improvement - Olivia - CSW	Renville
Construction Stormwater Permit	Soil Test Plot for Hay and Grass - CSW	Renville