Cannon River Watershed Restoration and Protection Strategies Report

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Cannon River Watershed Partnership

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

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Limestone outcrop in Lower Cannon Watershed, Justin Watkins, MPCA

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Key Terms

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

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

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

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Mississippi River Basin is assigned a HUC-4 of 0704 and the Cannon River Watershed is assigned a HUC-8 of 07040002

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

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

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

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

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

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

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

Summary

The Cannon River Watershed (CRW) encompasses a diverse landscape that supports productive farms and growing urban centers. It includes lakes and rivers of varying water quality and groundwater that is sensitive to pollution. Land use is a variable mix of agriculture, forest, and developed land. Agricultural cropland, pasture and forage acreage account for approximately 75% of the watershed. Cropland is used predominantly for growing corn and soybeans.

The condition monitoring, trend analysis and field investigations that comprise a foundation of this document are detailed in subsequent Chapters 1 and 2. The general summary of this work is that some waters are of good quality and need protection, and many rivers and lakes are impaired and need restoration:

- Approximately 80% of the sites sampled for fish showed good populations.
- Trends at long-term monitoring sites indicate decreases in phosphorus concentrations over time. This comports generally with Minnesota's Nutrient Reduction Strategy (NRS) that estimates a 33% improvement in the phosphorus load leaving the state since the mid-1990s.
- Monitoring data have documented significant decreases in point source loads of phosphorus from the wastewater treatment facilities (WWTFs) in the watershed, in particular those at Northfield, Faribault, and Owatonna (the most populous cities).
- In spite of the general trend of decreasing phosphorus loads, 80% of the watershed's lakes are excessively enriched with this nutrient, resulting in frequent algae blooms and impacts to recreation potential.
- Stream habitat has been degraded at most of the sites sampled for aquatic macroinvertebrates such that the populations have been negatively impacted.
- Minnesota's NRS estimates little, if any, reduction in the nitrogen load to streams in the state since the mid-1990s, and the data in the CRW show many instances of high nitrogen loading and some increasing concentration trends in streams and springs.

The purpose of the Watershed Restoration and Protection Strategy (WRAPS) is to use this foundation of technical information as a starting point from which to develop tools that will help local governments, land owners, and special interest groups determine (1) the best strategies for making improvements and protecting resources that are already in good condition, and (2) focus those strategies in the best places to do work (see Figure 1).

Chapter 3 is the primary section of this report for local partner use in planning or project conception. It includes details and products that came of a year-long engagement with watershed stakeholders and local government units aimed at prioritizing and implementing restoration and protection strategies. A general summary is as follows:

- Cultivated land is the source for the vast majority of the nitrogen load in the CRW. Less than 10% of the nitrogen load leaving those land areas is via runoff; the dominant transport mechanism is leaching loss to tiles or groundwater and management should be applied accordingly. The nitrogen load can be reduced by improving nutrient use efficiency and control, and treatment of excess nitrogen via drainage management and adding living cover such as perennials and cover crops.

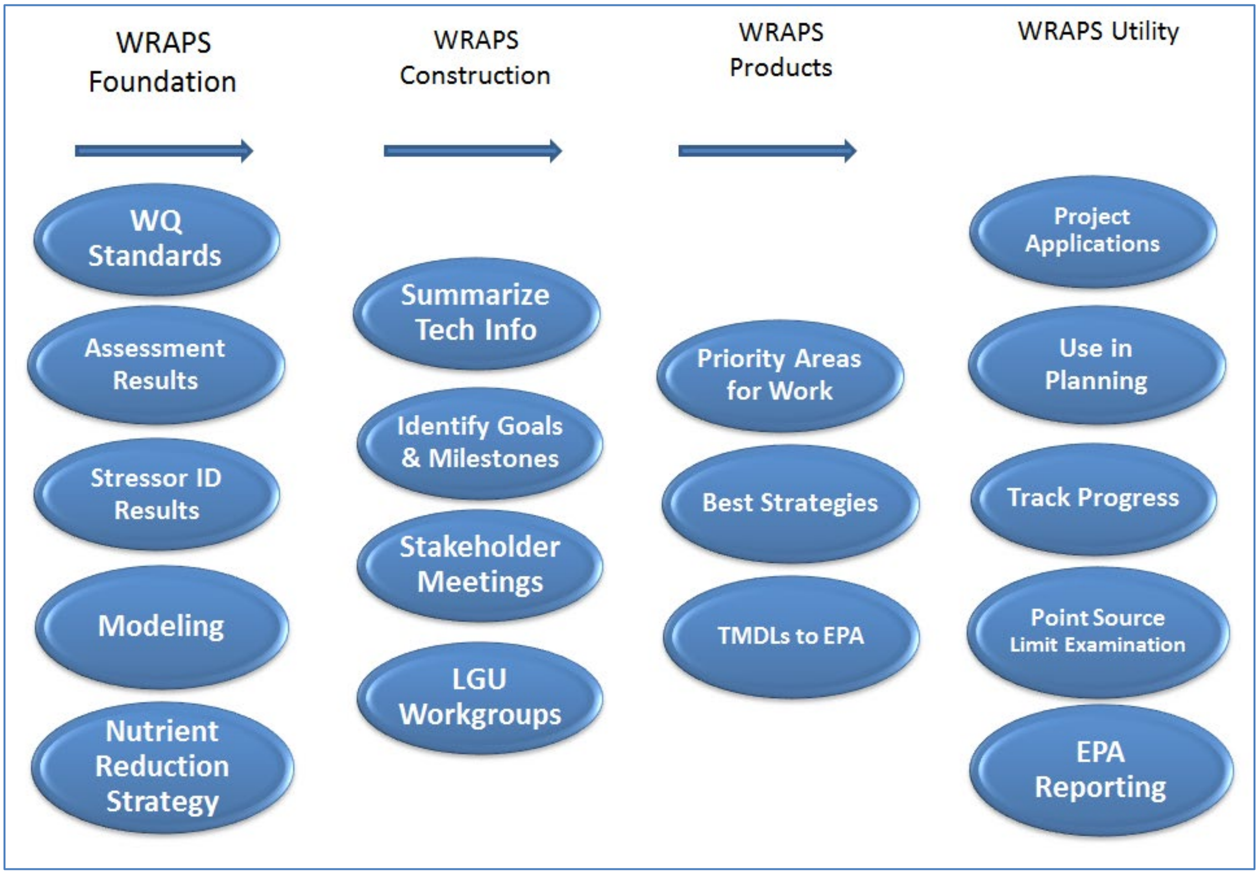
- A long-term effort to reduce phosphorus loading in the Upper Cannon Watershed is needed to make improvements in the region's lake water quality. Stakeholders identified the lakes in this subwatershed as a priority.
- More study of the sources of low flow phosphorus concentrations in the Straight River upstream of Owatonna is needed in order to work to reduce the load and meet the water quality goal for the Byllesby Reservoir.
- Point source phosphorus loads are important during low flow years and point source permits should reflect the wasteload allocations in the CRW Total Maximum Daily Loads (TMDL) Report.

Chapter 3 concludes with a summary of restoration and protection strategies for the CRW. Regarding phosphorus and sediment, the strategies are focused on proven agricultural conservation practices that are the hallmark of soil and water conservation districts (SWCDs). For nitrogen, they center on source control and vegetation changes.

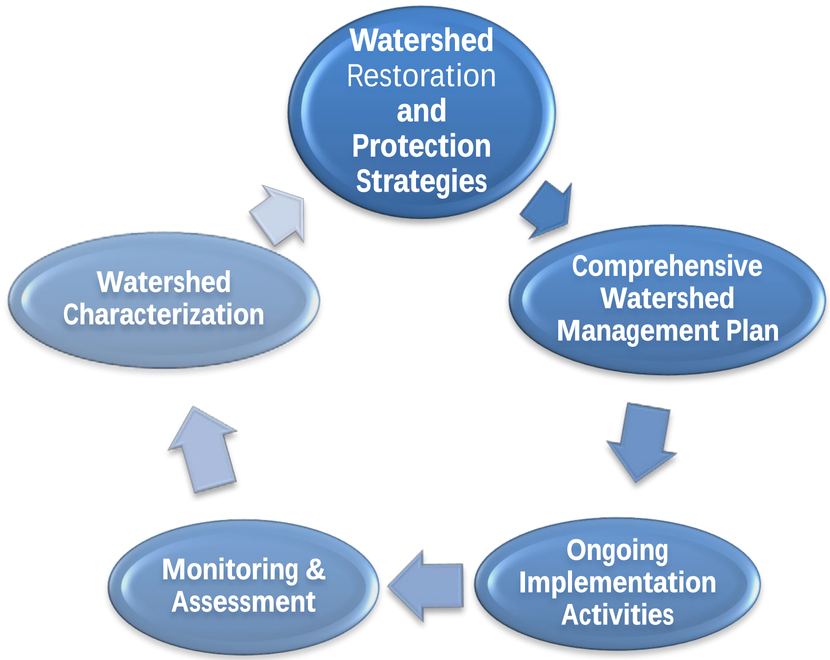
Taken as a whole, the strategies state that to meet the nutrient reduction goals in the CRW, partners should work to *fully implement the buffer rule, change marginal cropland (not suited to annual crops) to perennial cover, expand application of cover crops in particular on short season annual cropland, and improve source control of nitrogen fertilizer*. Chapter 3 provides more discussion and detail, including stakeholder-derived examples of estimated scales of adoption of these best management practices (BMPs) that will result in goal attainment. It also tabulates a number of watershed diagnostic tool outputs that can be used to focus these strategies.

Progress and improvement in the CRW will be marked by implementation of these strategies. On-going measurement and condition monitoring will examine the fish and macroinvertebrate populations in streams, algae blooms in lakes, and the pollutant loads leaving the watershed.

Figure 1. WRAPS concept.



What is the WRAPS Report?



The state of Minnesota has adopted a “watershed approach” to address the state’s 80 “major” watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, waters not meeting state standards are still listed as impaired and TMDL studies are completed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies and actions for point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as a watershed plan addressing the U. S.

Purpose

- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
    - *Cannon River Watershed Management Strategy 2011-2015 (2011)*
    - *North Cannon River WMO Plan (2013)*
    - *Cannon River Watershed Monitoring and Assessment (2014)*
    - *Cannon River Watershed Biotic Stressor Identification (2015)*
    - *Cannon River Watershed Total Maximum Daily Loads, LimnoTech, Inc. (2016)*
    - *Cannon River Watershed HSPF Modeling documents (2014-2016)*

Scope

- Impacts to aquatic recreation in lakes and streams.
- Impacts to aquatic life in streams and drinking water as assessed in cold water streams.
- Development of tools and strategies for use in restoration and protection of water resources.

Audience

- Local working groups: local governments, SWCDs, watershed groups, etc.
- State and Federal agencies: MPCA, DNR, BWSR, MDA, MDH, NRCS, etc.

Environmental Protection Agency's (EPA's) nine minimum elements to qualify applicants for eligibility for Clean Water Act Section 319 (Section 319) implementation funds.

1. Watershed Background & Description

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

The CRW spans a portion of nine counties (Figure 2). The six counties with the largest land area in the watershed include Steele, Rice, Goodhue, Dakota, LeSueur, and Waseca while small portions of Scott, Blue Earth, and Freeborn dot the periphery of the watershed.

Figure 2. CRW lobes, counties and major cities.

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

The CRW is comprised of three Level III ecoregions (Figure 3): North Central Hardwoods (NCH), Western Cornbelt Plains (WCBP) and Driftless Area (Omernik and Gallant 1988). The ecosystem framework attempts to characterize broad regional differences in geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Omernik 1995) and consequent ecosystem responses to disturbance (Bryce et al. 1999) in order to assist agencies and organizations in design and implementation of effective management strategies (Omernik et al. 2000).

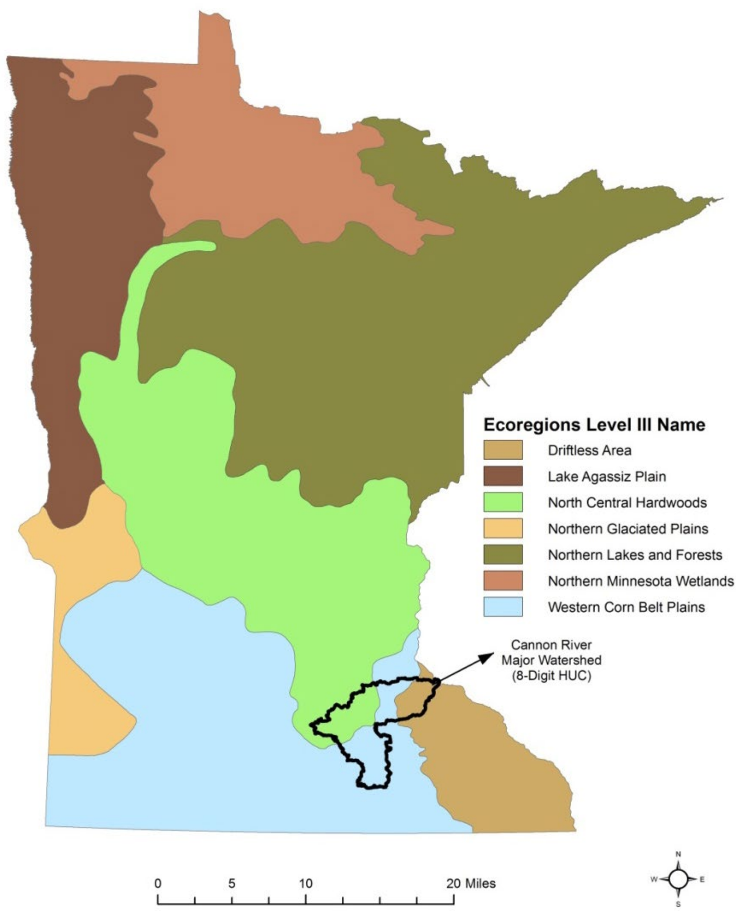


Figure 3. The CRW within the Level III ecoregions of Minnesota.

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

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

Geology/soils

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

The CRW has three major land resource areas (Figure 4). The *Central Iowa and Minnesota Till Prairies* cover the largest portion of the western and southern extent of the watershed. Part of the Des Moines Lobe of the Wisconsin ice sheet, the land is mostly a rolling glaciated plain of sand and gravel with higher hills formed by glacial meltwaters with lake plains in some areas. Consequently, the geology is predominantly glacial till, outwash and glacial lake deposits with clay, silt, sand, and gravel fill the bottoms of most of the major river valleys (NRCS 2006). Soils are generally very deep, loamy, and range from well drained to very poorly drained. The *Eastern Iowa and Minnesota Till Prairies* encompass land near Northfield and Cannon Falls. The geology is a mix of glacial till and outwash deposits with clay, silt, sand, and gravel fills the major river valleys. Karst features exist in this area with shallow depth of soils and glacial material covering limestone. Soils are classified as well drained to very poorly drained. Subsurface drain tile is commonly used to lower water tables and increase crop production (NRCS 2006). The *Northern Mississippi Valley Loess Hills* lies on the far eastern extent of the watershed. This region is part of what is known as the "Driftless Area" because it underwent limited landscape formation by glacial ice. The resulting landscape is mostly gently sloping to rolling summits that create scenic landscapes of deep valleys, abundant rock outcrops, high bluffs, caves, crevices, and sinkholes (NRCS 2006). Limestone and sandstone outcrops are observed along some streams and rivers in the area. Loess deposits cover bedrock in many areas. Some karst areas exist where carbonate rocks are near the surface. Soils are generally moderately deep to very deep, loamy, and well drained to moderately well drained.

Karst landscapes are challenging to protect because limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution release points to drinking water wells or surface water. These pathways can be widened, interconnected fractures or caves in the subsurface. Sometimes the process of dissolving limestone forms distinctive landforms on the ground surface, and in other places there is no distinctive landform at all. Together, the processes that dissolve limestone bedrock and the landforms that result are called karst. The MPCA karst web page (https://www.pca.state.mn.us/water/karst-minnesota, MPCA 2015) discusses the process leading to the formation of Minnesota's karst, karst landforms and environmental problems that occur in karst landscapes.

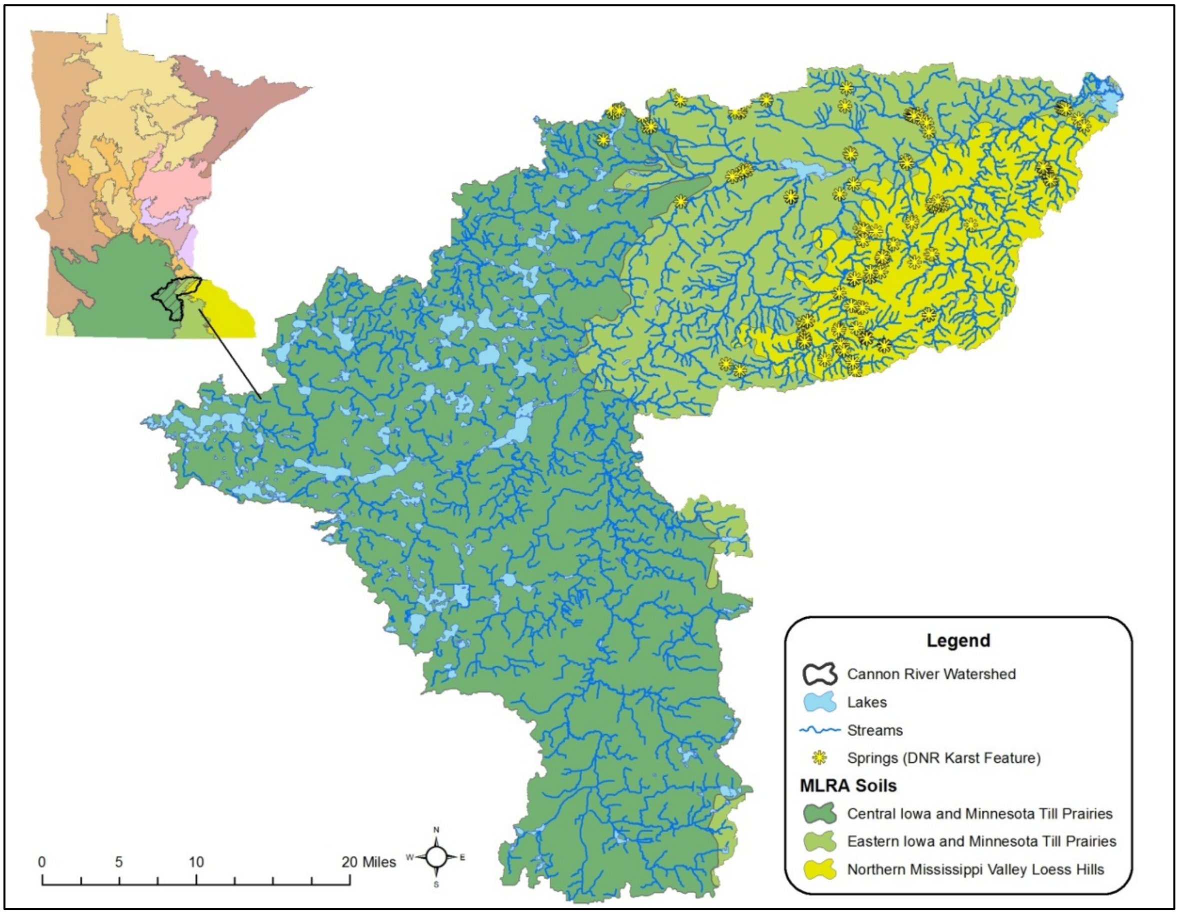


Figure 4. Major land resource areas and springs in the Cannon River Watershed.
*Springs depicted in this figure are those that have been identified to date; the karst features database is a product of the combined efforts of the University of Minnesota, DNR, and Minnesota Geological Survey (MGS) and is now managed by the MGS.

Land use summary

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

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

Today, the CRW is comprised of a variable mix of agriculture, forest, and developed land (Figure 5). Agricultural cropland, pasture and forage acreage account for approximately 75% of the watershed. Cropland is used predominantly for growing corn and soybeans. Forest (approximately 10%) and wetland together comprise 12.5%. Developed land (e.g. industrial land use, urban and rural housing, and roads) is approximately 8%.

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

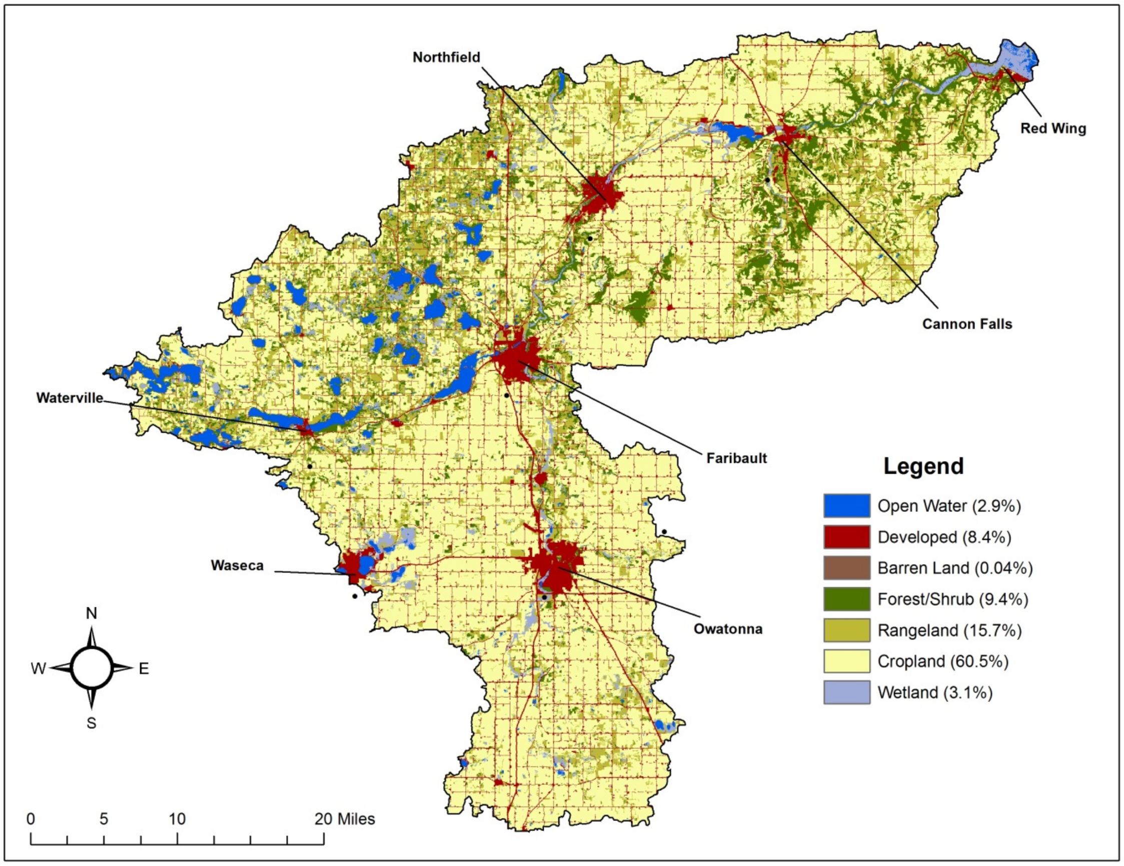


Figure 5. Land use in the CRW.

Wetlands

Historically, 294,000 acres of wetlands (~31% of watershed area) covered the CRW prior to European settlement (soil survey staff, NRCS 2013), including a greater than 10,000-acre wetland complex in the headwaters of the Straight River. This estimation of historical wetland acres is based on the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, and is a summation of “all hydric” map units. In contrast, according the National Wetlands Inventory (NWI) identification of wetland acreage, the CRW presently has only a fraction of its original wetland acreage (~56,000 acres of wetlands, or ~6% of the watershed area). Therefore, a comparison of these two time periods (i.e. pre-settlement versus early 1980s) yields an estimate of 81% wetland loss for the CRW.

Wetlands with herbaceous emergent (i.e. marsh) vegetation are the most predominant wetland type in the watershed (Figure 6). The distribution of wetlands across the watershed is not uniform with the majority of wetland area occurring in the west-central region, corresponding to the Upper Cannon River, Wolf Creek, Heath Creek, Chub Creek, and Crane Creek Subwatersheds. In addition, an extensive corridor of floodplain wetlands (forested, emergent, and shallow open) occurs along the lower reaches of the Cannon River as it empties into the Mississippi River. It should be noted that these estimates represent a snapshot of the location, type, and extent of wetlands occurring in the early 1980s, which is the time period that aerial imagery was acquired to develop NWI maps in this part of the state. Updated NWI maps are currently available for select counties in the watershed (Dakota, Scott, Rice, and Goodhue) that were included in a recent update of wetland spatial data for the east-central region of

Minnesota based on 2010 and 2011 aerial imagery. Soil data can be used to estimate the extent of historic or pre-settlement wetlands that can serve as a baseline against which current wetland acreage can be compared. Historic wetland loss is discussed in greater detail in the CRW Monitoring and Assessment Report https://www.pca.state.mn.us/sites/default/files/wq-ws3-0704002b.pdf.

Some efforts to restore wetland acreage in the CRW have occurred over the last few decades (See information on the Straight River Marsh Project at http://www.steeleswcd.org/ProSerRIM.htm). Approximately, 2,300 acres of a 10,000-acre wetland have been set-aside as wetland acres through conservation easements and acquisition of public lands.

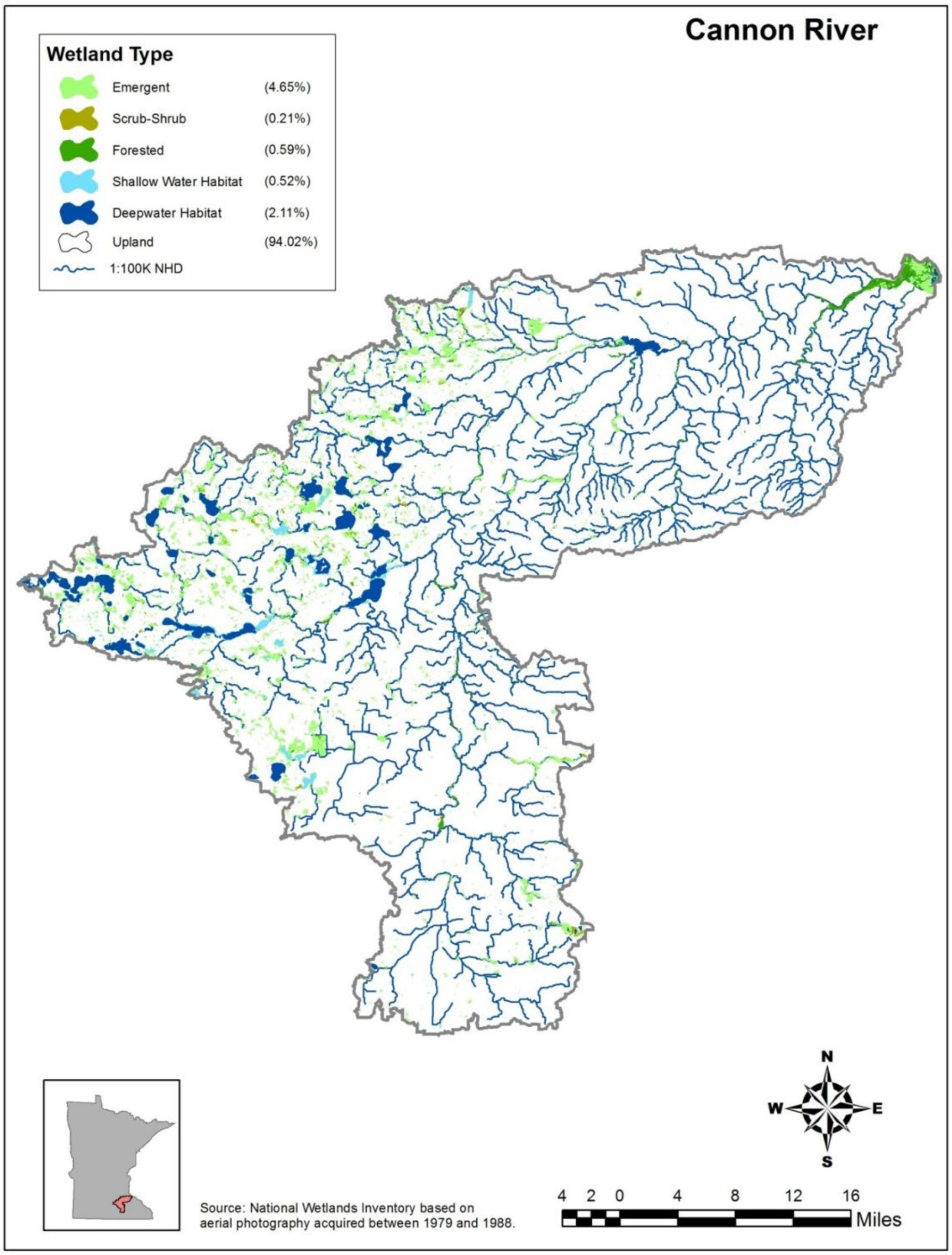


Figure 6. Wetland types and their distribution across the CRW.

Surface water hydrology

The CRW consists of two river systems: the Cannon River and the Straight River (Figure 7). From the south, the Straight River headwaters begin as a fan of smaller stream and ditches stretching from Ellendale to north of Blooming Prairie. Along its way, it connects with Turtle Creek, Maple Creek, and Crane Creek before flowing into the Cannon River in Faribault. The headwaters of the Cannon River begin as the outflow of Shields Lake on the western side of the watershed. The mainstem of the Cannon River then curves west and south through an alternating chain of streams and lakes north of Waterville before heading east through lakes Tetonka and Sakata. The Cannon River then flows east until it enters the Cannon Lake Reservoir in Faribault. From there the combined stream flow of the Straight and Cannon River travels east and picks up outflow from Wolf Creek, Heath Creek, Chub Creek, and Prairie Creek before passing through Dundas and Northfield and entering the Byllesby Reservoir west of Cannon Falls. From the Byllesby Reservoir, the Cannon River flows east past scenic limestone bluffs in the Driftless Area near Welch. The Driftless Area has many coldwater springs that feed tributary streams to the Cannon River such as Trout Brook, Pine Creek, Spring Creek, Belle Creek, and the Little Cannon River. Finally, the Cannon River empties into the Mississippi River north of Red Wing.

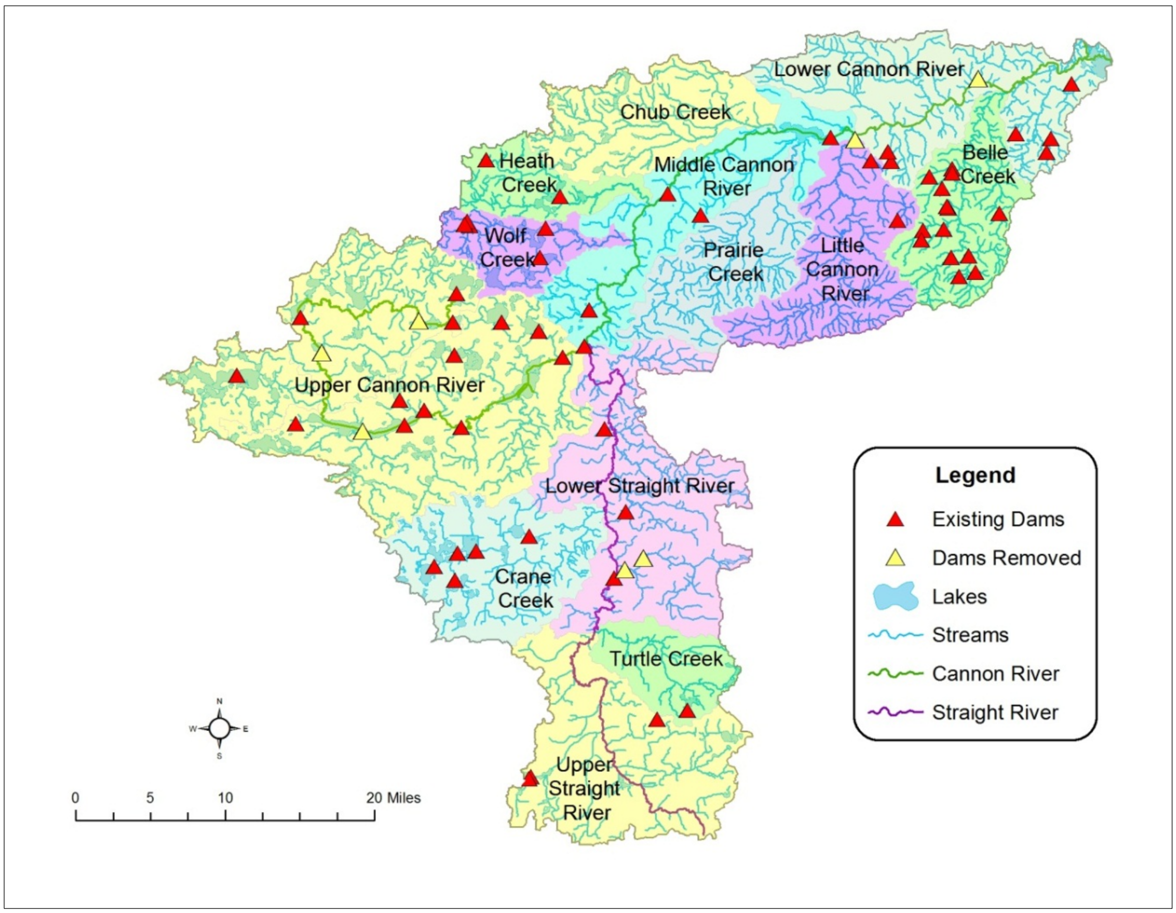


Figure 7. Subwatersheds of the Straight and Cannon Rivers with locations of dams (existing and removed).

Historically, a number of dams were built along the Straight and Cannon Rivers and tributary streams in order to harness the energy of flowing water for operating mills, control flooding, and manage water levels of recreational lakes and reservoirs. Figure 7 includes dams of various types on different stream orders, ranging from big rivers (e.g. Northfield dam on the Cannon) to small sedimentation basins or flood control projects (e.g. Belle Creek PL-566 project). Many of these dams act as fish barriers, preventing fish migration between spring spawning areas and refugia during winter months and large flooding events. In addition, many species of mussels have disappeared or have had numbers greatly reduced in association with land use changes, over extraction, and dams that limit mussel dispersal since certain species of migratory fish are hosts for mussel larvae. During the last 30 years, three larger dams have been removed—on the Cannon River at Welch in 1994, at Cannon Falls in 2001 and the Morehouse dam on the Straight River in Owatonna in 2006. According to the DNR, many species of fish that previously were only collected downstream of the dam in Welch are now found along the Cannon River further upstream. The Byllesby Reservoir dam, which was recently renovated, impounds the Cannon River for hydroelectric power generation.

Hydrogeology

Geology in southeast Minnesota and the CRW is characterized by karst features (Figure 8). These geologic features occur where limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution sources to drinking water wells or surface water.

Surface water and groundwater are so closely connected in karst areas that the distinction between the two is sometimes difficult to determine. Groundwater may emerge as a spring, flow a short distance above ground, only to vanish in a disappearing stream, returning to groundwater conduits and perhaps re-emerge farther downstream again as surface water.

Karst aquifers, like those commonly used in the CRW, are very difficult to protect from activities at the ground surface because pollutants can be quickly transported to drinking water wells or surface water. Because of this, the best strategy to protect groundwater in this watershed is pollution prevention from common sources like row-crop agriculture, septic systems, abandoned wells, and animal feedlot operations.

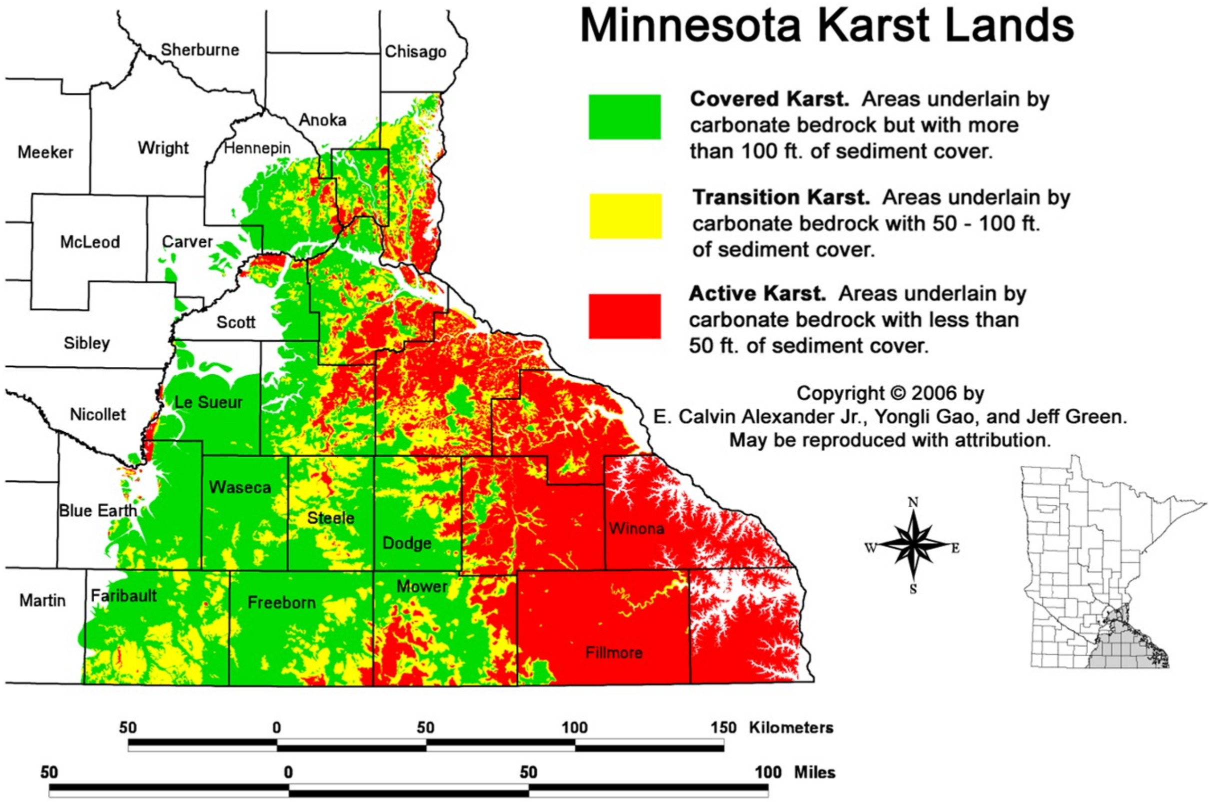


Figure 8. Locations of karst features in southeast Minnesota (E. Calvin Alexander, University of Minnesota).

2. Watershed Conditions

In 2011, the Minnesota Pollution Control Agency (MPCA) undertook an intensive watershed monitoring (IMW) effort of the CRW's surface waters. There were 102 sites sampled for biology at the outlets of watersheds of varying size (site locations can be reviewed in detail in the Monitoring and Assessment Report https://www.pca.state.mn.us/sites/default/files/wq-ws3-0704002b.pdf). As part of this effort, the MPCA also contracted with the Cannon River Watershed Partnership (CRWP) who completed stream water chemistry sampling at 13 locations in the watershed (sites placed according to hydrology). Over the course of the 10-year assessment window (2002 through 2012), 125 biological stations were sampled for fish and 116 stations were sampled for macroinvertebrates, while water chemistry data was collected on numerous lakes and stream stations by agencies, local watershed groups, and volunteer citizen monitors. In 2013, a holistic approach was taken to assess all of the watershed's surface water bodies for support of drinking water, aquatic life, aquatic recreation, and fish consumption uses where sufficient data were available. During this process, 45 lakes and 72 stream reaches were assessed for aquatic recreation and/or aquatic life. (Not all lake and stream reaches were assessed; insufficient data and/or modified channel condition excluded some.)

Across the watershed, four coldwater streams (protected as drinking water given association with local aquifers) have high concentrations (exceeding the drinking water standard of 10 mg/l) of nitrates in baseflow: Pine Creek and Little Cannon River in Goodhue County, Rice Creek (a.k.a. Spring Brook) in Rice County, and Trout Brook in Dakota County. The only assessed coldwater stream not impaired due to elevated levels of nitrates is Spring Creek in Goodhue County.

For aquatic consumption, only 5 lakes are fully supporting while 18 lakes and the Cannon River between Faribault and Lake Byllesby are impaired due to high levels of mercury in fish, while the Cannon River below the Byllesby Reservoir to the Mississippi River has high levels of polychlorinated biphenyls (PCBs). Fish consumption advisories have been recommended for lakes across the watershed. Many additional lakes have not yet been assessed. The five lakes that are fully supporting aquatic consumption are Beaver, Dora, German, Jefferson, and Roberds.

Thirty-six lakes do not support aquatic recreation use due to elevated nutrients that may cause unsightly algae blooms that could make swimming in them undesirable or unsafe. Most of the impaired lakes are located west of Faribault where agricultural land use dominates lake watersheds. While many of the lakes in the CRW are highly eutrophic (nutrient rich), five lakes stand out as high quality resources for recreation: Roemhildts, Fish, Dudley, Kelly, and Beaver. These lakes generally benefit from being in relatively intact, small watersheds and from their depth. Protection efforts should be put in place to keep the quality of these lakes high. Due to a number of projects aimed at managing nutrients, Lake Volney has declining nutrient levels and is showing an improving trend in water clarity.

Excessive bacteria that may make activities in or on the water unsafe were found in rivers and streams across the watershed including the Straight River, Cannon River, and many smaller streams for a total of 41 impairments. Bacteria issues are widespread not only in the CRW, but much of the Lower Mississippi River Basin. A regional TMDL and implementation plan has been developed and projects are underway to better manage bacteria sources.

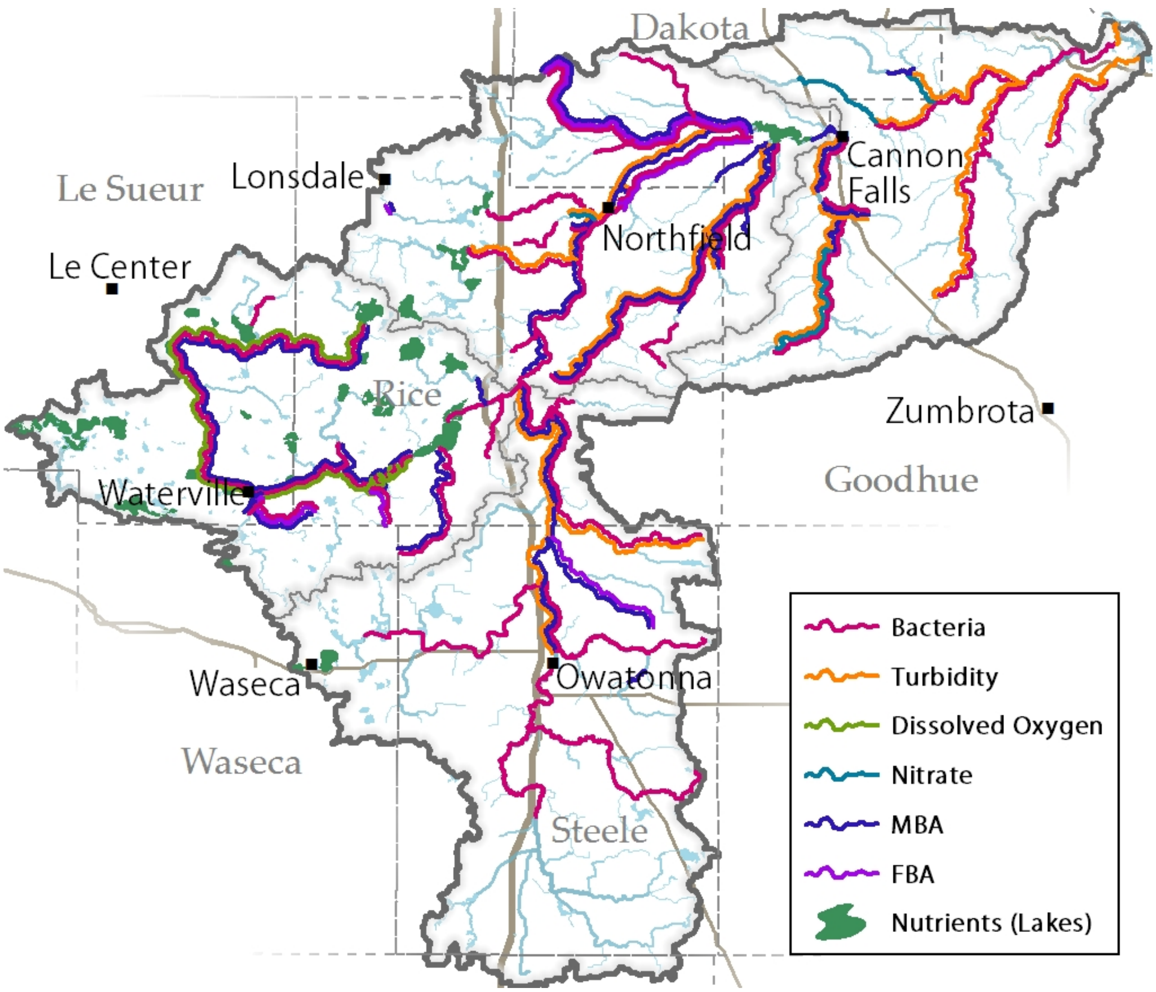
Fish and macroinvertebrate communities across the watershed are showing a loss of sensitive species due to water pollution and habitat issues. Biological indices (fish IBI (F-IBI) and macroinvertebrate-IBI (M-IBI)) were compared between pre and post flooding (2004 and 2011) and no significant difference in scores was observed indicating that the 2010 flood was not a driver in the fish and macroinvertebrate impairments found. Currently, there are 36 stream reaches that are not supporting aquatic life with one or more impairments, while only 14 stream reaches are supporting. In addition, 12 stream segments were not assessed for aquatic biology because the stream at the biological station is greater than 50% channelized. (Channelized reaches are currently not being assessed until new biological standards can be applied.) A preliminary examination of channelized streams indicates quality ranging from good to poor across the watershed based on their fish and macroinvertebrate assemblages.

While many streams have impaired aquatic life use, there are other streams that were assessed as fully supporting or have special concern species with specific habitat requirements. For example, the Little Cannon River Subwatershed was the only location where the Redside Dace (*Clionostomus elongates)* was collected. The Middle and Lower Cannon River Subwatersheds also have a number of high quality coldwater streams that support brook and brown trout communities, including Trout Brook, Pine Creek, Rice Creek (a.k.a. Spring Brook), Belle Creek, Spring Creek and the Little Cannon River. However, many of these coldwater streams have macroinvertebrate impairments. For warmwater streams, Maple Creek, Falls Creek, Turtle Creek, Mud Creek, and the Lower Cannon River were supporting aquatic life of both fish and macroinvertebrates with many pollution sensitive species collected. These streams and others should be considered for additional protection to prevent additional aquatic life impairments in the future.

Land use changes in vegetation, loss of wetlands, ditching, urban development, failing septic systems and over application of fertilizers have all likely contributed to algal blooms, potentially unsafe swimming conditions, fishing advisories, drinking water impairments, and loss of sensitive aquatic species. This watershed is a diverse landscape and the main sources and drivers of water quality issues may vary between regions. The technical information and tools developed in the CRW and summarized in the WRAPS report provide a foundation for planning and supporting local partner work to improve the condition of the watershed and its surface and groundwater.

Figure 9 depicts impaired waters in the CRW. Note that aquatic life use impairments are indicated by indirect measures (turbidity) and direct integrative measures (macroinvertebrate bioassessments (MBA) and fish bioassessments (FBA)). The streams impaired based solely or in part on MBA and/or FBA were the focus of stressor identification (described in subsequent chapters).

Figure 9. Impaired waters map.



***MBA: macroinvertebrate bioassessment; FBA: fish bioassessment.**

2.1 Condition Status

Use support status is meaningful in prioritizing and planning in the CRW. The CRW Monitoring and Assessment Report include maps and tables that comprehensively summarize use support status for most streams, river reaches and lakes in the watershed. Due to size and number of pages, these tables and figures are not included in this document. Rather, a summary table is provided below. Please refer to the Monitoring and Assessment Report (https://www.pca.state.mn.us/sites/default/files/wq-ws3-0704002b.pdf) for more information.

Table 1. Assessments summary.

Beneficial Use	Number of Supporting	Number of Not Supporting
Lakes – recreation, swimming	5 (Roemhildts, Fish, Dudley, Kelly, and Beaver)	36
Streams and Rivers – fish and aquatic invertebrates	14 stream reaches for which both are supporting	36 reaches for which at least one of the two is not supporting or water clarity data indicate impairment
Streams and Rivers – pathogens as indicated be *E. coli*	2 (Lyman Lakes outflow and Byllesby outflow)	41
Trout Streams protected as drinking water (baseflow is groundwater)	1 (Spring Creek)	5 (Pine Cr, Trout Br (two reaches), Little Cannon, Rice Cr)

Some of the waterbodies in the CRW are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments see the statewide mercury TMDL at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Regional Context for Aquatic Life Use Support

In the CRW and in southeast Minnesota regionally, IMW has documented many F-IBI (index of biological integrity (IBI), which uses various metrics to "score" biotic communities) values that are high relative to their corresponding M-IBI values. The following figures describe this phenomenon. Note that greater than 80% of the F-IBI values in the Cannon are good or fair/good, while only ~45% of the invertebrate IBI values are good or fair/good. This may be due to general robustness of fish (relative to macroinvertebrates) and/or greater sensitivity to habitat quality or water chemistry in the case of macroinvertebrates. Both IBI values (when available) were used as lines of evidence in aquatic life use support decisions. In general, if one of the values is below the threshold or "goal" the stream is categorized as not supporting.

Figure 10. Lower Mississippi F-IBI values.

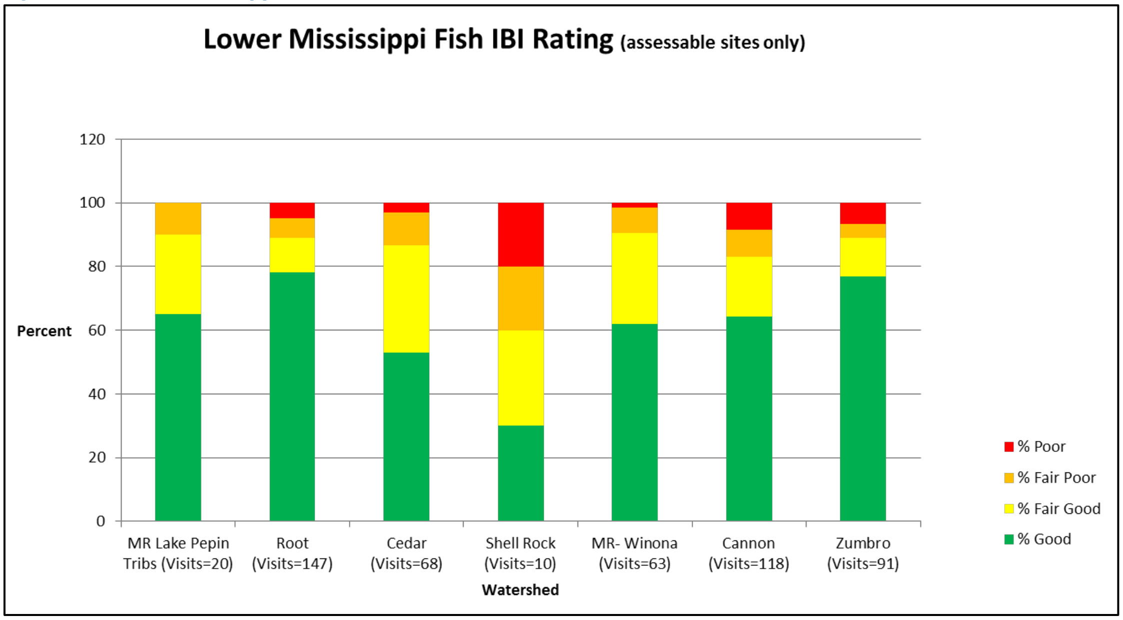
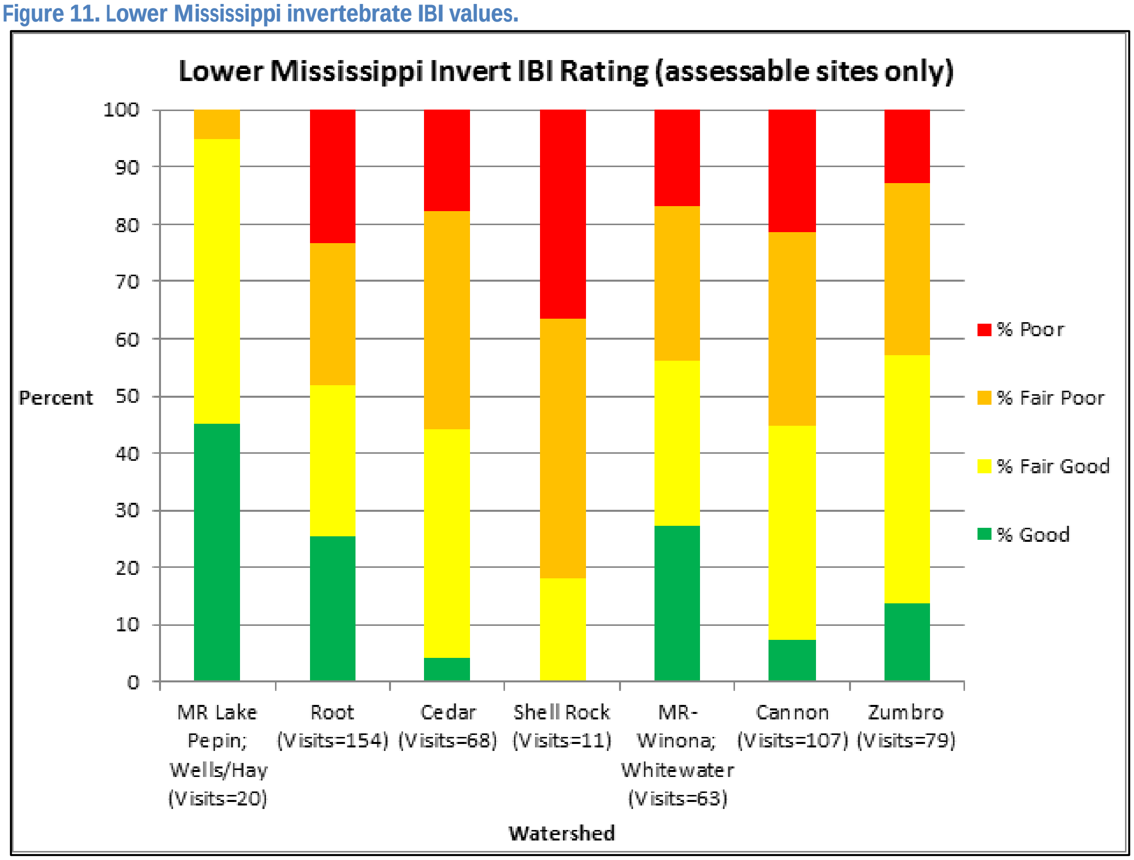


Figure 11. Lower Mississippi invertebrate IBI values.



2.2 Water Quality Trends

2.2.1 River and Stream Data

Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites notes that sites across Minnesota, including those on the Cannon River and Straight River, show significant reductions over the period of record for total suspended solids (TSS), phosphorus, ammonia and biochemical oxygen demand (MPCA 2014). NRS documented a 33% reduction of the phosphorus load leaving the state via the Mississippi River from the pre-2000 baseline to current. These reports and others listed below generally agree that while further reductions are needed (e.g. for lake goals and for Byllesby Reservoir), municipal and industrial phosphorus loads as well as loads of runoff-driven pollutants (i.e. TSS and total phosphorus (TP)) are decreasing; a conclusion that lends assurance that the CRW WRAPS phosphorus goals and strategies are reasonable.

Regarding nitrite/nitrate nitrogen, the longest period of record (Milestone data in Table 2 below) suggests an increasing trend at the Cannon River (site at Welch). The difference between the two Milestone sites (Cannon and Straight Rivers) included in Table 2 lies in statistical significance. Using the *Seasonal Kendall Test for Trends*, the Cannon was shown to have a statistically significant trend at the 90% confidence level, though the Straight was not (although it was very close).

A more detailed examination of nitrogen trends in the watershed show different trends over specific periods of time likely related to climate and precipitation variability; these can be examined via the links provided in this chapter. *The Minnesota NRS* indicates little if any progress regarding reductions of the nitrogen load leaving our state: approximately 0% change since the pre-2000 baseline.

Table 2: Water quality trends summary from *Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites* (MPCA 2014).

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Straight River near CSAH-1, 1 Mi SE of Clinton Falls (S000-047)(ST-18) (period of record 1955 - 2009)						
overall trend	decrease	decrease	no trend	decrease	decrease	increase
average annual change	-1.9%	-1.0%		-7.4%	-3.5%	1.4%
total change	-64%	-43%		-98%	-85%	114%
1995 - 2009 trend	no trend	no trend	no trend	no trend	no trend	little data
average annual change						
total change						
median concentrations first 10 years	38	0.7	1	0.44	7	17
median concentrations most recent 10 years	23	0.3	4	<0.05	1	30
Cannon River at Bridge on CSAH-7 at Welch (S000-003)(CA-13) (period of record 1953 - 2008)						
overall trend	decrease	decrease	increase	decrease	decrease	increase
average annual change	-2.6%	-2.3%	1.4%	-7.0%	-0.8%	1.8%
total change	-77%	-69%	105%	-97%	-37%	178%
1995 - 2008 trend	no trend	no trend	increase	no trend	no trend	little data
average annual change			1.9%			
total change			31%			
median concentrations first 10 years	26	0.3	1	0.20	4	11
median concentrations most recent 10 years	14	0.2	4	<0.05	2	28

2.2.2 Citizen Monitoring Data

Citizen Monitoring Programs for both lakes and streams provide long-term records of water clarity for many of the waters in the CRW. The statistical analyses included in the CRW Strategy suggest trends of both increasing and decreasing clarity (data through 2008). A more recent examination of Citizen Lake Monitoring Program data (through 2014) found evidence of only three trends, included in the table below. Fox Lake had the strongest trend of the three lakes (Table 3). Fox has a continuous Secchi database since 1974. Periodic TP measurements between 1979 and 2008 indicate an increase in TP, with measurements from 1979 through 1981 averaging 41 µg/L as compared to 2003 through 2008, which averaged 85 µg/L. The Secchi and TP data from 1979 through 1981 indicate the lake once met the NCHF ecoregion WQS for deep lakes.

The Secchi trend for Volney is more subtle than that for Fox, but it is significant (Figure 13). Reduction in TP over time is evident, with summer-mean TP averaging about 100 µg/L in 1986 through1991, as compared to 60 µg/L in 2005 through 2010.

See Appendix D for the full output of the analysis.

Table 3. Citizen Lake Monitoring Program data trends.

Lake	DNR ID	Trend
Upper Sakatah	40-0002-00	Evidence for possible decreasing trend in water clarity
Volney	40-0033-00	Evidence for increasing trend in water clarity
Fox	66-0029-00	Strong evidence for decreasing trend in water clarity

Figure 12. Fox Lake water clarity trend.

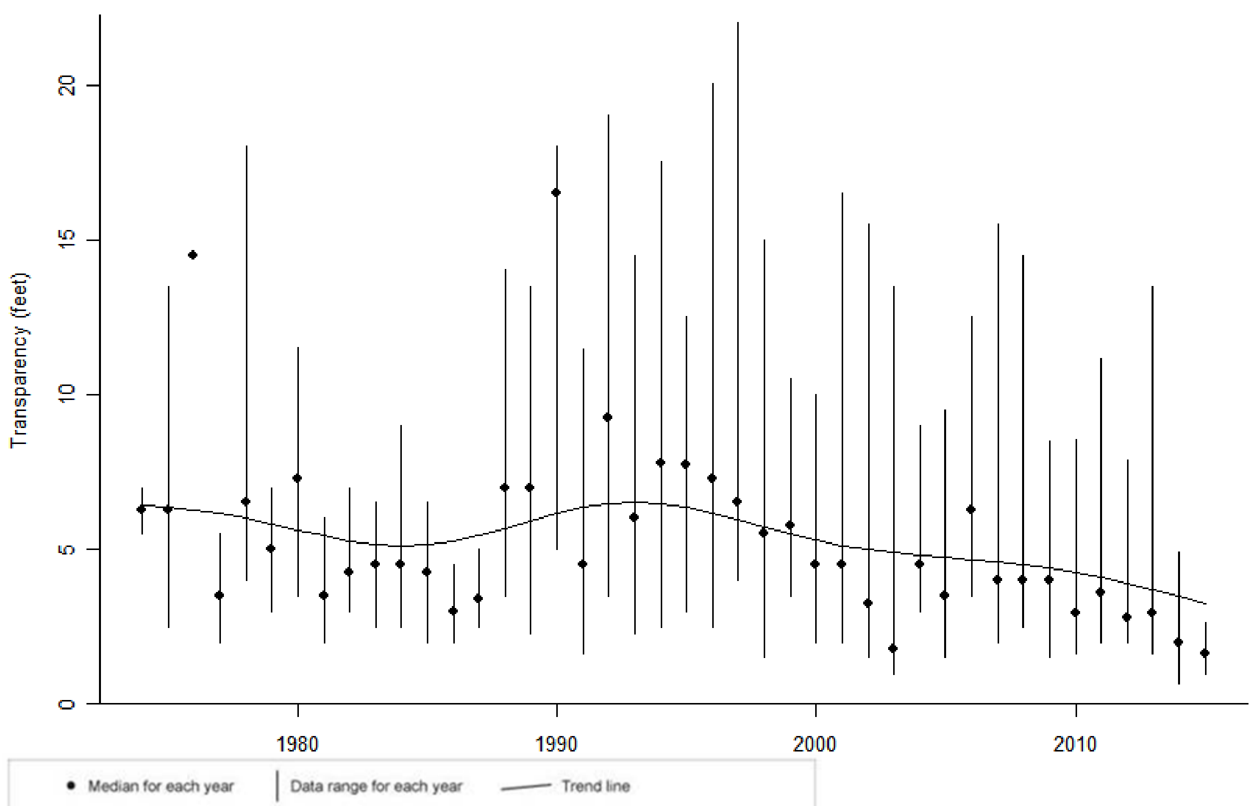
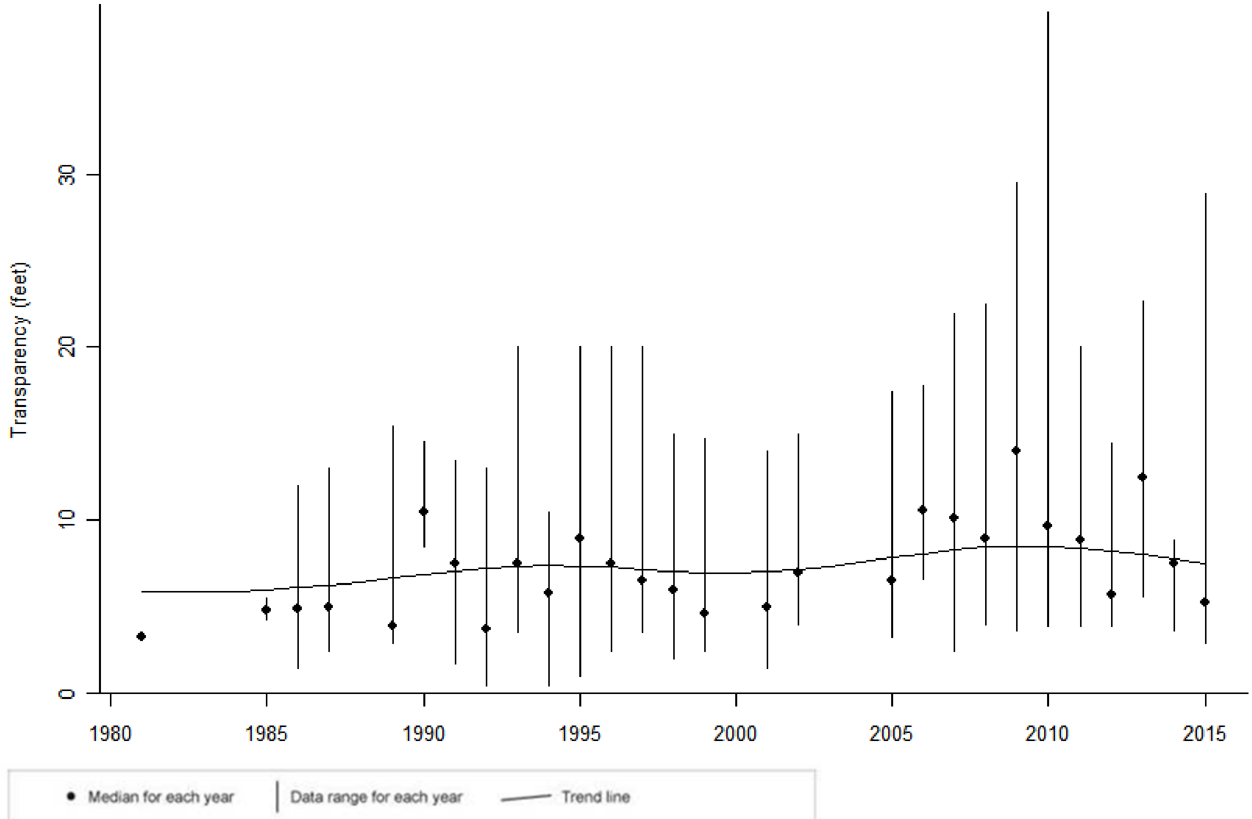


Figure 13. Lake Volney water clarity trend.

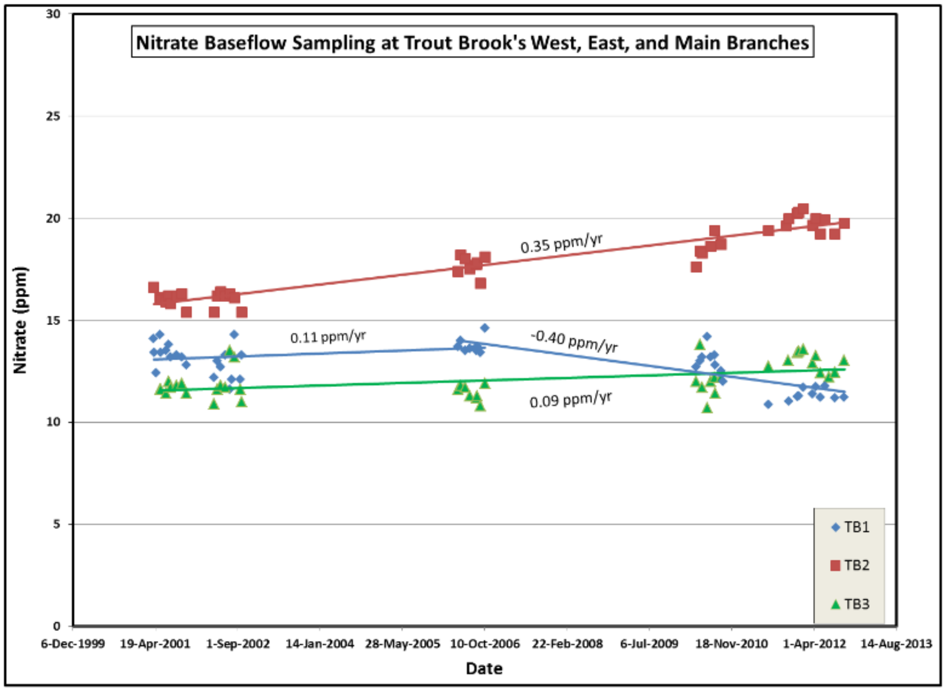


2.2.3 Nitrates in trout stream baseflow and springs

The Dakota County SWCD has collected baseflow and stormflow samples at three sites in the Trout Brook Watershed since 2001. The east tributary site (Trout Brook in Figure 14) is just downstream of LeDuc Spring; the west tributary site (Trout Brook2 in Figure 14) is just downstream of Fox Spring (see Groten & Alexander 2013 that joined recent Trout Brook spring samples with historical data collected by Ron Spong).

Given their vicinity to the respective headwater springs the baseflow (not influenced by runoff) samples at TB1 and TB2 approximate the nitrate concentrations in the upstream spring discharges. TB1 depicts an apparent (but not statistically verified) decreasing trend from 2006 to 2012 while the nitrate concentration at TB2 continued to rise; Groten & Alexander note that the scope of their study did not include further analysis of this phenomenon.

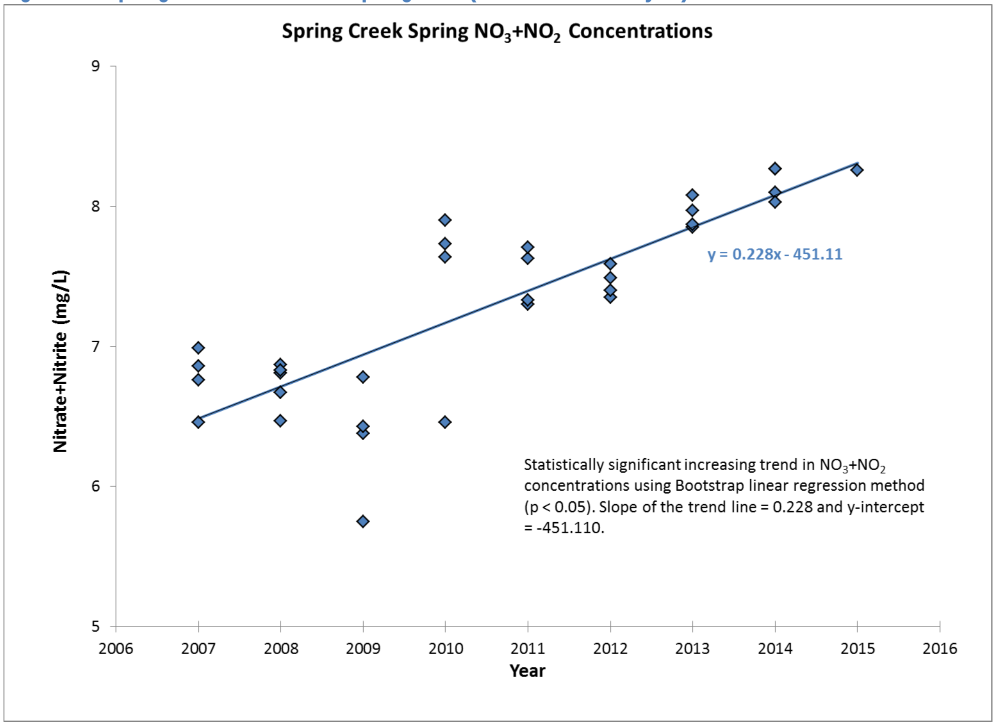
Figure 14. Trout Brook baseflow nitrate data over time.



*TB: Trout Brook

The Minnesota Department of Agriculture (MDA) collects pesticide and nitrate/nitrogen water quality samples from approximately 13 springs in southeast Minnesota. Samples are collected twice per year, and are intended to target baseflow (groundwater) periods instead of stormflow (rain event) periods. In addition, the MDA monitors approximately 12 domestic wells in the fall to supplement regional spring monitoring. The MDA publishes an annual work plan that provides specific information for the upcoming year and an annual report with monitoring results available at www.mda.state.mn.us/monitoring. Nitrate samples collected from a headwater spring of Spring Creek (Goodhue County) are included in Figure 15 below; they depict a statistically significant increasing trend over time.

Figure 15. Spring Creek headwater spring data (MPCA trend analysis).



Cannon River Watershed Trend Analysis

Signs of Progress: The State of the Cannon and Straight Rivers (CRWP)
http://crwp.dreamhosters.com/wp-content/uploads/2013/01/Appendix-A-Signs-of-Progress.pdf

Cannon River Watershed Management Strategy 2011-2015 (CRWP)
http://crwp.dreamhosters.com/wp-content/uploads/2013/01/Appendix-C-Cannon-River-Watershed-Statistical-Water-Quality-Trend-Analysis.pdf

Nitrogen in Minnesota Surface Waters (MPCA)
https://www.pca.state.mn.us/sites/default/files/wq-s6-26c1.pdf

Comprehensive Water Quality Assessment of Select Metropolitan Area Streams (METC)
http://www.metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management/Stream-Monitoring-Analysis/Mississippi-River-Tributary-Streams-Assessment.aspx

Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites (MPCA)
https://www.pca.state.mn.us/sites/default/files/wq-s1-71.pdf

2.3 Stressors and Sources

2.3.1 Stressors of Aquatic Life

The MPCA has increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This approach centers on examination of fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an IBI score can be developed, which provides a measure of overall community health. In cases of aquatic life use impairment, stressors to the aquatic community must be identified in order to translate the problem from an integrative measure(s) to causal factors. This is accomplished by further examining streams (via both field work and desktop work) that show low IBI values for fish and bugs, with a focus on linking the biotic communities to probable stressors. For example, if a macroinvertebrate community sampled in a given stream reach is composed primarily of nitrate-tolerant species and the stream shows high nitrate values in baseflow a likely conclusion is that nitrate is a stressor to the invertebrate biota.

In the CRW, 34 of the 36 Assessment Unit ID (AUIDs) impaired for aquatic life use support made use of biota data (i.e. "fish and bug data") in the assessment process and therefore required further examination via stressor identification report (SID). During the original assessment in 2013, three AUIDs were deferred due to uncertain flow and wetland conditions; a follow-up assessment was completed in 2015, which documented impairments for two of these AUIDs. Table 4 summarizes stressors.

Table 4. Stressors of aquatic life.

Pollutant Stressors	Non-pollutant Stressors	Stressors with Potential Links to Pollutants
Phosphorus (5 instances), Nitrate (22), TSS (10), Chloride (1), Temperature (1)	Fish Passage (2), Flow Alteration (1)	Degraded Habitat (22), Low Dissolved Oxygen (5)

Pollutant stressors are addressed via TMDLs (see Chapter 2.4). Non-pollutant stressors are not subject to load quantification and therefore do not require TMDLs. If a non-pollutant stressor is linked to a pollutant (e.g. habitat issues driven by TSS or low DO caused by excess phosphorus) a TMDL is required. However, in many cases habitat stressors are not linked to pollutants. With respect to the few DO stressors in the Cannon Watershed, there are insufficient means for conclusively linking the condition to a pollutant cause. See Table 8 for a summary of TMDL computations in the watershed, including those that were computed according to SID results. See Appendix I for a tabular summary of stressors for each Assessment Unit Identification (AUID).

Brief summaries for each HUC-10 follow; for details regarding stream reach locations, monitoring sites and SID data see the Cannon River Watershed Stressor Identification Report.

Lower Cannon River

Little Cannon River 10-Digit HUC Summary

Nitrate, TSS, and habitat were the dominant stressors in the Little Cannon River 10-digit HUC (Figure 48 and Figure 53). Temperature and fish passage were also stressors in the upper end of the Little Cannon River. Elevated phosphorus has been measured throughout the 10-digit HUC, but in no case could a conclusive link to biota impairment be confirmed. In summary, nitrate was identified as a stressor in four AUIDs, TSS, and habitat were identified as stressors in three AUIDs, and temperature and fish passage were identified as stressors in one AUID.

Lower Cannon River 10-Digit HUC Summary

Within the Lower Cannon River 10 digit HUC common stressors are nitrate and lack of habitat. Phosphorus and the response variables (e.g. DO) and TSS are not conclusive stressors but merit further monitoring. The periphyton in this system should be monitored and further quantitative information may be beneficial to understanding the stream dynamics. Although fish passage is not a key stressor, the perched culvert in Trout Brook should be replaced to prevent loss of hydrologic connectivity and fish passage.

Middle Cannon River Lobe SID Summary

Prairie Creek 10-Digit HUC Summary

Nitrate, TSS, and habitat are identified stressors in the Prairie Creek 10-digit HUC (Figure 48 and Figure 52). Elevated phosphorus has been measured throughout the 10-digit HUC, but in no case could a conclusive link to biota impairment be confirmed. Nitrate and habitat are stressors in all four AUIDs, and TSS was a stressor in two AUIDs.

Chub Creek 10-Digit HUC Summary

Elevated phosphorus, localized low DO (middle to upper portion), TSS (middle to lower portion), and habitat (upper portion) are stressors in Chub Creek. Phosphorus levels are extremely high (even during baseflows), and likely contributing to the low DO; local wetlands and Chub Lake are also likely contributing to the low DO conditions, in that organic matter leaves these wetland and shallow lake systems and impacts DO dynamics downstream. It is inconclusive if nitrate is a stressor, and temperature and fish passage are not currently stressing the biota. Further examination of the linkages between stressors and pollutants would help confirm causal factors for low DO conditions. Reducing nutrient and sediment loading in Chub Creek and improving in-stream habitat will benefit and improve the fish and macroinvertebrate communities.

Middle Cannon River 10-Digit HUC Summary

Within the Middle Cannon River 10 digit HUC common stressors are lack of habitat and nitrate. Other stressors in this watershed include elevated TP with response variables, low DO, TSS, fish passage, and chloride. Primary productivity in lakes can lead to seasonal export of algae to downstream waters (see Figure 16). Further examination of the linkages between stressors and pollutants would help confirm causal factors for low DO conditions. Three reaches on the Cannon River have insufficient information for conclusive identification of stressors. Additional sampling would help further examine stressors and potential additive effects on biota. The second cycle of IWM and SID in the Cannon should allocate time and resources be focused on examining linkages between stressors and pollutants.

Figure 16. Wolf Creek outflow from Circle Lake.

Upper Cannon River Lobe SID Summary (only one 10-digit HUC)

Within the Upper Cannon River 10 digit HUC identified stressors are lack of habitat, low DO and nitrate (Figure 48 and Figure 50). Elevated phosphorus concentrations are common in the Upper Cannon and its tributaries, a system that is largely driven by primary productivity in the numerous lakes both on-channel and in smaller subwatersheds. Significant masses of algae are exported from many of these lakes during summer months; this can lead to elevated DO flux and at times of algal die-off, low DO. Given this hydrology, and that the Upper Cannon AUID is exceptionally long, the lakes are used in the WRAPS to provide phosphorus reduction goals. Dissolved oxygen is a stressor in Devil's Creek but the available information does not sufficiently link phosphorus and low DO.

Straight River Lobe SID Summary

Straight River 10-Digit HUC Summary

Nitrate, TSS, and habitat were identified stressors in the Straight River 10-digit HUC (Figure 48 and Figure 51). Nitrate is a stressor in all of the AUIDs examined via SID. Elevated phosphorus has been measured throughout the 10-digit HUC, but it is not a conclusive stressor. In summary, nitrate was identified as a stressor in six AUIDs, TSS was identified as a stressor in three AUIDs, and habitat was identified as a stressor in two AUIDs. There were several inconclusive determinations due to limited data and/or mixed biological response.

For more information on the stressors in the CRW, see the Cannon River Watershed Stressor Identification Report.

Pollutant sources

The following chapter provides an overview of point and nonpoint sources of pollution in the CRW (Chapter 4 of CRW Management Strategy provides additional discussion of this topic: http://crwp.dreamhosters.com/wp-content/uploads/2013/01/Chapter-4-Pollutants-of-Concern-and-Stressors.pdf). Further, the impairments in the CRW that are linked to a conventional pollutant are addressed in the Cannon River TMDLs (see Chapter 2.4 and full document). A good resource for examining nonpoint source pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions (statute language) is the Hydrological Simulation Program –FORTAN (HSPF) model output maps (some of which are included in Chapter 3).

Point Sources

Permitted point sources are included in Table 5 below. Given that the CRW is a predominately rural landscape, point sources account for a relatively small component of pollutant loads. However, at lower flows, point sources can play a significant role in pollutant loading and water quality conditions. Figure 17 is a comparison of the total annual modeled phosphorus load at the outflow of the Straight River (Reach 800, see CRW HSPF documentation and Appendix F) and the total annual phosphorus load from the point sources in the Straight River. The figure also depicts the variability in the overall (nonpoint source dominated) loads and the decreasing point source loads.

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

Figure 17. Straight River point and nonpoint source phosphorus comparison.

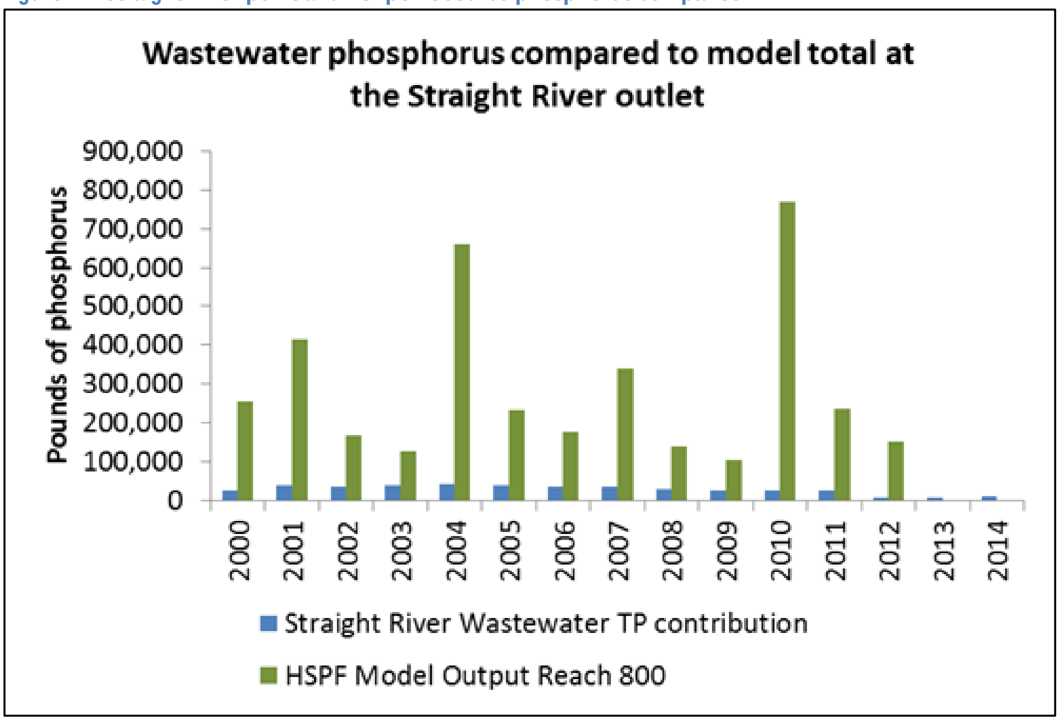


Figure 18. Point sources in context (from Metropolitan Council 2014).

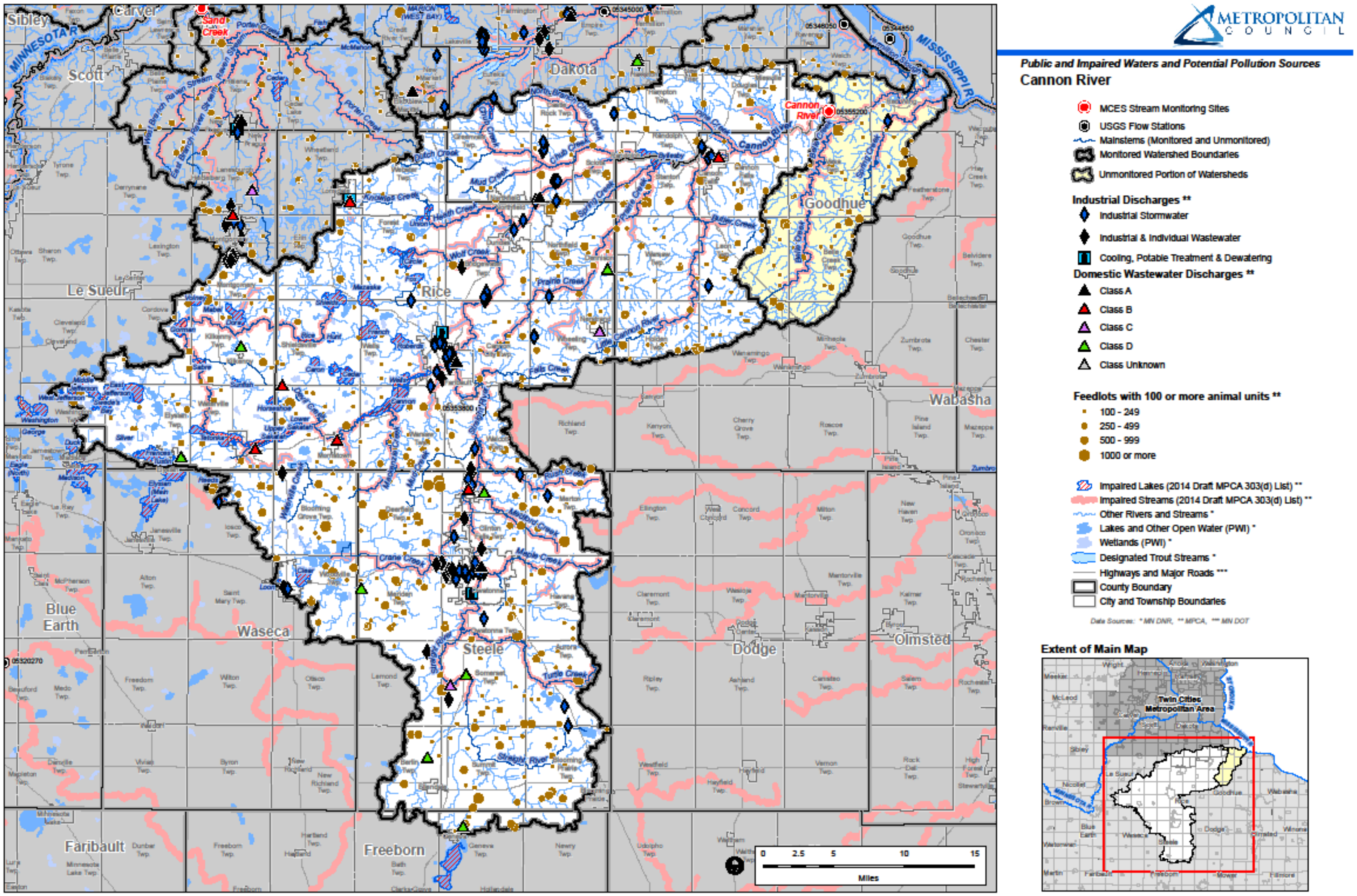


Table 5: Point Sources in the CRW. (Point sources with consistent flows.)

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

Nonpoint Sources

The state of Minnesota has invested significant time and resources into major investigations of key pollutants of concern (e.g. sediment, phosphorus, nitrogen). Conclusions regarding nonpoint sources apply to the CRW in sum or in part and are thus summarized below (via major study conclusions and tables). For further information and detail refer to the respective source documents. The Cannon River HSPF modeling documentation addresses nonpoint pollutant sources, including apportionment of sediment loads.

Overview of Sediment & Phosphorus Sources

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

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

A summary of general findings of the literature review:

- Overall sediment delivery from tributaries to the Upper Mississippi River in southeast Minnesota has increased substantially since European settlement and the onset of agricultural activities in the tributary watersheds; and
- The relative contributions of "non-field" sources of sediment to the overall watershed sediment yield appears to be increasing over time, with a likely link to the "flashier" hydrology (i.e. rapidly increasing and decreasing flow volumes) resulting from agricultural land use and associated drainage and urban development (LimnoTech 2013).

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

- The primary sources of phosphorus transported to surface waters are cropland runoff, atmospheric deposition, permitted wastewater, and streambank erosion. These four sources combined are 71%, 76%, and 83% of the statewide phosphorus load under dry, average, and wet years, respectively.
- During dry conditions, National Pollutant Discharge Elimination System (NPDES) permitted wastewater discharges and atmospheric deposition becomes more prominent sources of phosphorus.

- The most significant phosphorus sources by major basin during an average precipitation year include cropland runoff, wastewater point sources, and streambank erosion in the Mississippi River Major Basin (MPCA 2014).

Other resources useful in examining sediment and phosphorus sources in the CRW include:

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

Sediment Source Apportionment from CRW HSPF Model Development

The calibrated CRW HSPF model simulates that upland sources contribute 41% of the sediment load for the entire watershed. This is consistent with the observation that a larger upland source percentage may be appropriate for the Cannon River given the predominance of type "C" or highly erodible/unstable soils. The highest simulated sediment source is bed and bank erosion at 48% and the third-largest contributor is gully and ravine erosion at 10%. Point sources, tile drainage, and groundwater outflow pathways each contribute less than 1% to the overall sediment delivery. A breakdown of the sediment sources is shown in Table 1 and Figure 19 (LimnoTech 2015).

Table 6. Breakdown of Sediment Sources by Major Drainage Area and for the Entire CRW HSPF Model (1996-2012).

Drainage Area	Gully/Ravine	Upland	Tile Drains	Groundwater	Point Sources	Bed/Bank Erosion
Straight River[1]	9%	50%	3%	<1%	<1%	38%
Lakes[2]	10%	86%	1%	2%	<1%	0%
Upper Cannon[3]	9%	62%	1%	1%	<1%	26%
Middle Cannon[4]	4%	35%	<1%	<1%	<1%	59%
Lower Cannon[5]	12%	33%	<1%	<1%	<1%	54%
Entire Watershed	**10%**	**41%**	**<1%**	**<1%**	**<1%**	**48%**

Notes:
[1] Results tallied for free-flowing reaches in the Straight River and includes Maple Creek, Turtle Creek and Crane Creek Watersheds.
[2] Results tallied for all lakes, including Byllesby, in the watershed.
[3] Results tallied for free-flowing reaches in portion of CRW from the river headwaters to the confluence with the Straight River.
[4] Results tallied for the free-flowing reaches in the portion of the CRW from the confluence with the Straight River downstream to the Lake Byllesby outlet and includes the Prairie Creek Watershed.
[5] Results tallied for the portion of the CRW from the Lake Byllesby outlet to the confluence with the Mississippi River and includes the Lower Cannon River and Belle Creek Watersheds.

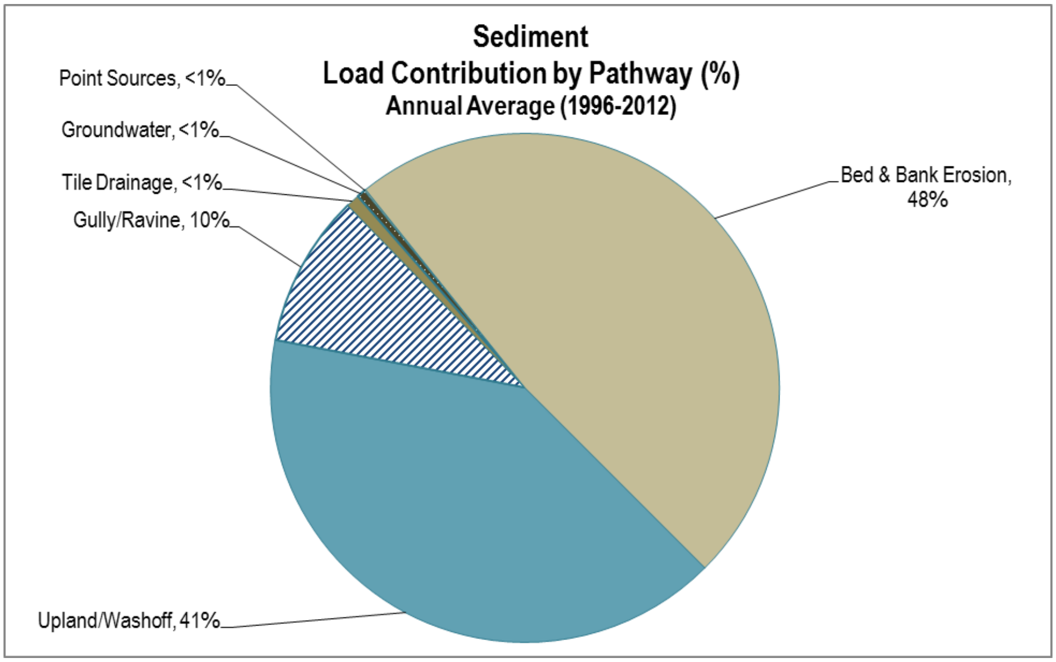


Figure 19. Breakdown of Sediment Sources for the CRW HSPF Model (1996-2012)

The HSPF model also summarizes Unit Area Loading (UAL) values for a number of pollutants in the CRW. A summary of the phosphorus UALs is included in the following figure.

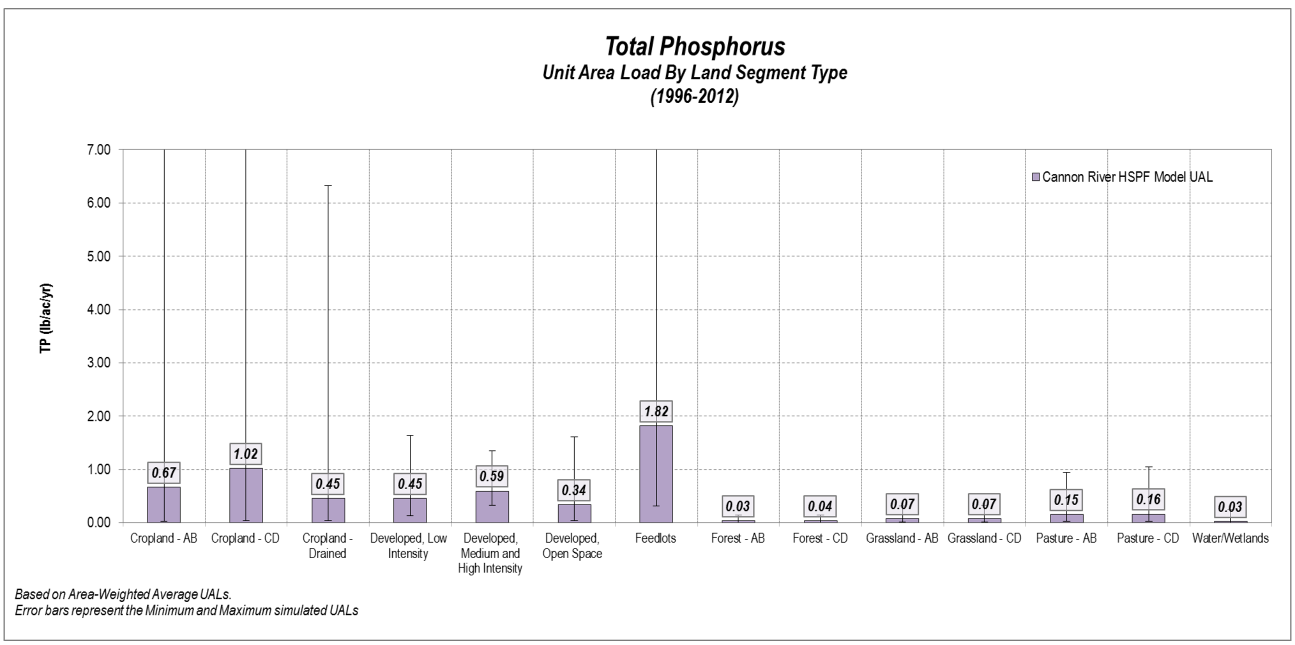


Figure 20.TP Unit Area Loads by Land Segment Type for the 1996-2012 Simulation Period.

*The suffixes AB and CD describe low and high runoff potential respectively for each model land cover category.

Of the approximately of 2,150 feedlots in the CRW, there are 46 active NPDES permitted operations, 38 of which are Concentrated Animal Feeding Operations (CAFOs) (Figure 18). The MPCA currently uses the federal definition of a CAFO in its regulation of animal feedlots. In Minnesota, the following types of livestock facilities are issued, and must operate under, a NPDES Permit: a) all federally defined CAFOs, some of which are under 1000 animal units (AUs) in size; and b) all CAFOs and non-CAFOs which have 1000 or more AUs. These feedlots must be designed to totally contain runoff, and manure management planning requirements are more stringent than for smaller feedlots. In accordance with the state of Minnesota's agreement with EPA, CAFOs with state-issued General NPDES Permits must be inspected twice during every 5-year permitting cycle and CAFOs with state issued Individual NPDES Permits are inspected annually. The number of AUs by animal type registered with the MPCA feedlot database (November 2014) is summarized in the TMDLs document.

While feedlots are not considered one of the major sources of phosphorus to the Mississippi River (MPCA 2014), local impacts to water resources in the CRW could in some cases be significant (as indicated by the relatively high UAL in Figure 20). Heiskary and Martin (2015) used feedlot inventories in the context of BATHTUB modeling to examine potential feedlot phosphorus loads to the Upper Cannon Lakes. This analysis can be paired with working knowledge of local government units to identify and address feedlot pollution hazards. Based on the BATHTUB-estimated P budgets for several of the lakes in the Upper Cannon the numerous small feedlots may be a significant source of P to the lakes. Data indicate that there are 166 feedlots located in shoreland (within 1,000 feet of a lake or 300 feet of a river/stream). Of the 166 feedlots 147 have open lots and of those, 56 feedlots have Open Lot Agreements (OLA). Feedlots in shoreland with an OLA should be priority for inspection.

Internal Phosphorus Loads in Lakes and Reservoirs

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

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

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

See Heiskary and Martin (2015) for more details regarding data and inventory (e.g. DNR carp population estimates) available for considering internal phosphorus loads for the various lakes in the CRW.

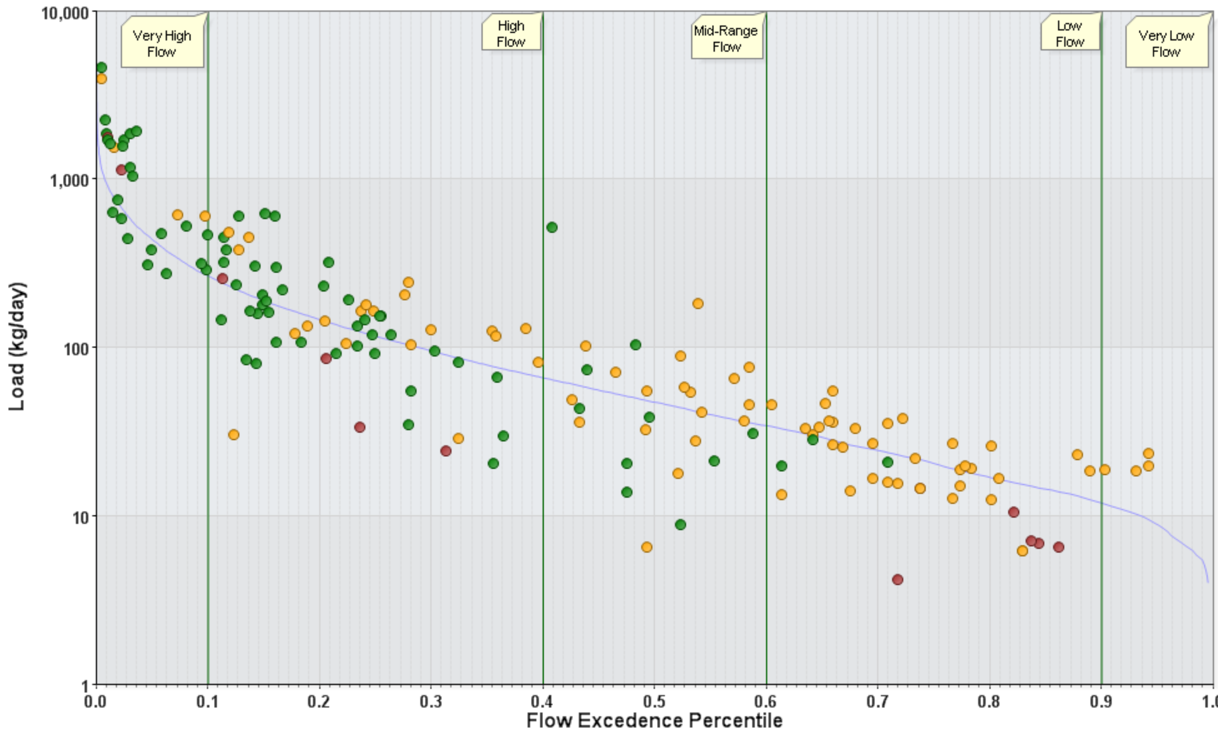
More accurate phosphorus budgeting for the Upper Cannon lakes would benefit from the collection of sediment cores and determination of phosphorus release through laboratory incubation and measurement. Lakes could be grouped according to size, morphometry and residence time and representative members of each group could be subjected to further study of phosphorus budget and cycling.

Low Flow Phosphorus Load in Upper Straight River

High phosphorous concentrations in the Upper Straight River (upstream of Owatonna) have been well documented by Steele County Environmental Services monitoring. The concentration in the river at low flows is often greater than the inflow water quality goal for the Byllesby Reservoir (0.150 mg/l).

Decreasing this low flow load is critical to downstream goal attainment. At this time the geographic confine of the Upper Straight River Watershed is understood to be a "source" of high phosphorus during the critical condition for aquatic recreation (late summer, low flows) but the sources of the pollutant mass and the dynamics that deliver the mass to surface waters must be further studied before specific restoration strategies can be developed. See Chapter 4.1 regarding watershed research needs. The MPCA staff has begun to communicate with local partners in developing further investigative monitoring in the watershed.

Figure 21. Load duration curve for Straight River upstream of Owatonna.



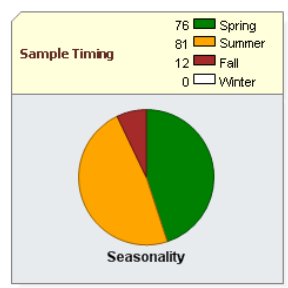


Figure 21 depicts daily loads computed from grab samples collected by Steele County staff at S003-015 (Straight River near intersection of Interstate 35 and Highway 14) and flows recorded at the U.S. Geological Survey (USGS) station upstream of Faribault (Hydstra ID 39101001 and USGS ID 05353800). The curve represents the loads across the flow ranges using the Byllesby Reservoir inflow goal of 0.150 mg/l TP. The key for the figure describes the seasonality of the sample collection and the colors correspond to those in the graph. Note that at low and very low flows in summer and fall approximately half of the samples collected exceed the Byllesby goal and as such the respective computed loads are above the line.

Figure 22 below includes six sample dates in late 2012 (a very dry period) on which TP values from 0.22-0.37 mg/l are paired with tube and TSS results that indicate very clear water at time of collection.

Figure 22. Example data from site S003-815.

Year 2012 Data

Station Data

Sample Date	Type Information	Temp	BOD	Chl-a	Stream Trans	DO	TKN	NO2NO3	pH	Pheo	TP	TSS
09-27-12	Routine	12.2			> 60						0.37	4
09-20-12	Routine	13.1			> 60						0.31	6
09-13-12	Routine	14.9			> 60						0.27	7
09-06-12	Routine	16.1			> 60						0.26	7
08-30-12	Routine	17.9			> 60						0.24	6
08-23-12	Routine	19.7			> 60						0.22	5
08-20-12	Routine	17.74			100	10						

Other sites in the Upper Straight River Watershed (Turtle Creek S003-016, Crane Creek S003-009 and S003-011) show similar high phosphorus concentrations at low flows.

Nitrogen Sources Overview

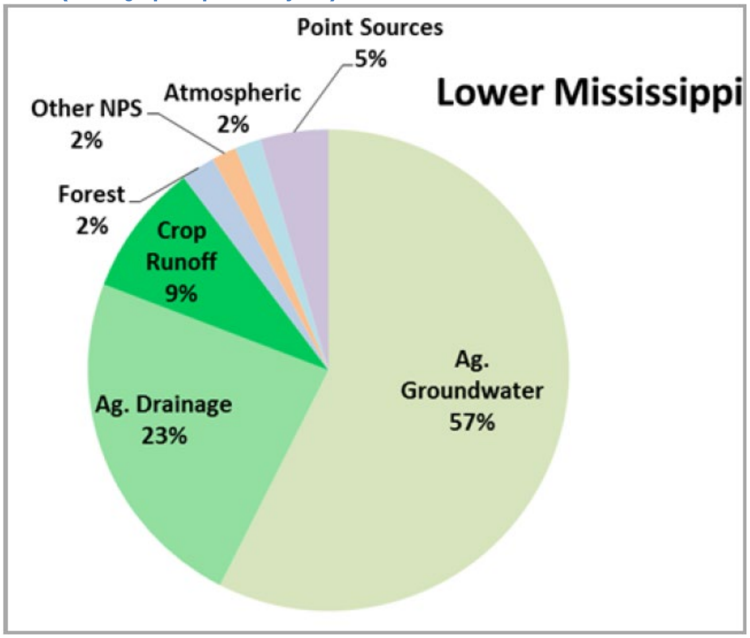
Minnesota recently initiated two state-level efforts related to nitrogen in surface waters. The MPCA is developing water quality standards to protect aquatic life from the toxic effects of high nitrate concentrations. The standards development effort, which is required under a 2010 Legislative directive,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

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

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

The Nitrogen Study and the NRS state that cropland nitrogen losses through agricultural tile drainage and agricultural groundwater (leaching loss from cropland to local groundwater) make up the majority of nitrogen sources in Minnesota, contributing 51%, 68%, and 73% of the nitrogen load under dry, average, and wet years, respectively. In the Lower Mississippi River Basin, agricultural groundwater is the greatest source of nitrogen to surface waters (MPCA 2014). Figure 23 below suggests that less than 10% of the region's nitrogen load is delivered via erosion/runoff transport mechanisms. This finding is important in considering tools for targeting and strategies for addressing nitrogen (in contrast to those applied when addressing phosphorus). The two nutrient pollutants are transported to surface waters via distinctly different pathways.

Figure 23.**Estimated nitrogen sources to surface waters from the Minnesota contributing areas of the Lower Mississippi River Basin (average precipitation year). From MPCA 2013.**



Cropland Nitrogen: Main Source in CRW

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

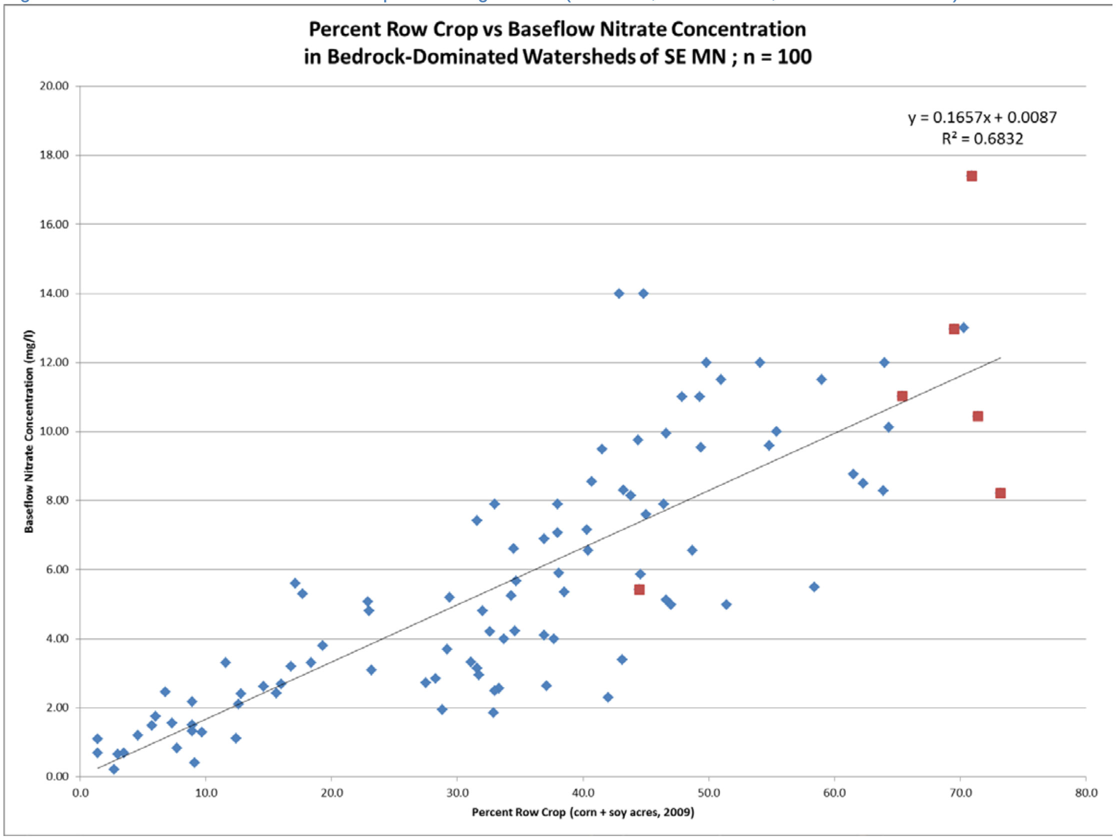
Stream baseflow is the critical condition with respect to nitrate concentration and loading in heavily karsted watersheds (which contain most of southeast Minnesota's trout streams). In such settings, unlike sediment and phosphorus, baseflow conducts the majority of the nitrate load, as nutrients readily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

An analysis of the relationship between base flow nitrate concentrations in southeast Minnesota trout streams and percentage of row crop land in the watersheds of these streams produced a statistically significantly regression. The one hundred trout stream sites examined included six in the CRW (see Figure 24) Specific conclusions of this work include:

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

In Figure 24 below, the six CRW points include three in Trout Brook Watershed, two in Rice Creek Watershed and one in the Spring Creek (Goodhue County) Watershed.

Figure 24.Baseflow nitrate and row crop acres regression (Watkins, Rasmussen, Streitz et al. 2013).



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

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

Figure 25. Effect of cropping system on nitrogen loss (slide from Gyles Randall, U of MN).

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

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

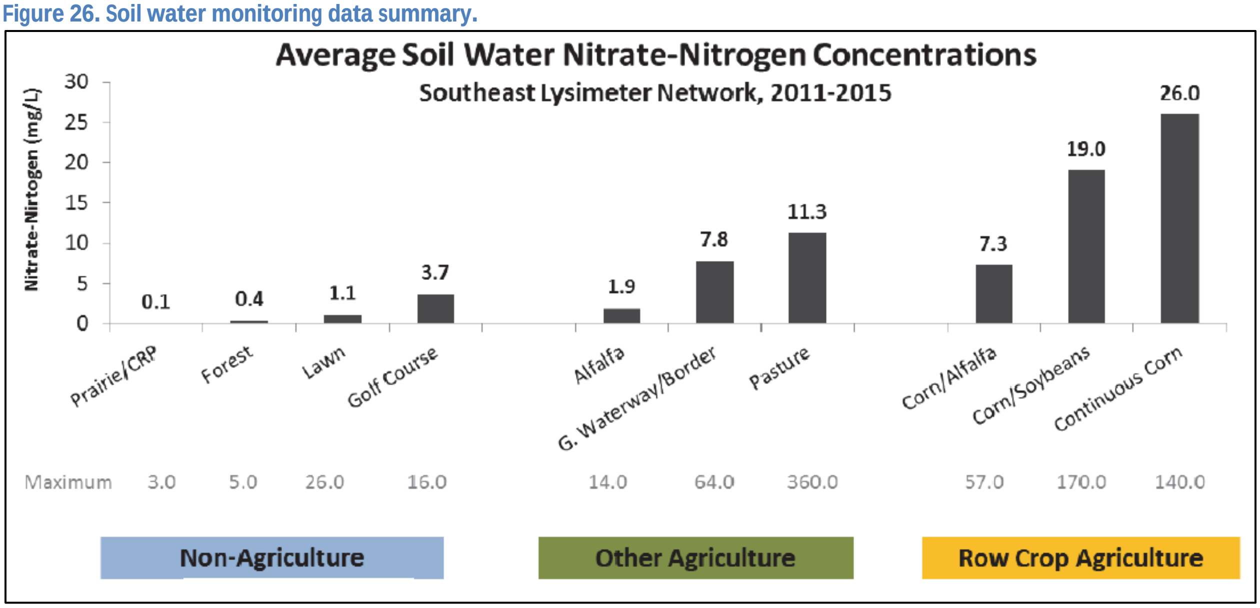
University of Minnesota
Driven to Discover

Regarding nitrogen leaching from cultivated lands, there is no desktop method for discerning relative loss from field to field within the bound of the watershed's row crop acres; the agronomic variables are too many and they are not captured in available geographic data. Rather, areas of greatest leaching loss should be determined by the local government units (mainly the SWCDs and NRCS) and interested landowners, using the best available local nutrient management data and professional judgment.

In 2010, a nitrate consortium that met in Rochester, Minnesota, concluded that monitoring nitrate concentrations in soil water would provide significant support to such efforts to understand and manage nitrogen leaching loss from various land uses and crop management settings in southeast Minnesota. Nitrate-N concentrations in the soil water at 5 feet (below the root zone) provide a good basis upon which to compare the environmental risks associated with various N management systems (Randall).

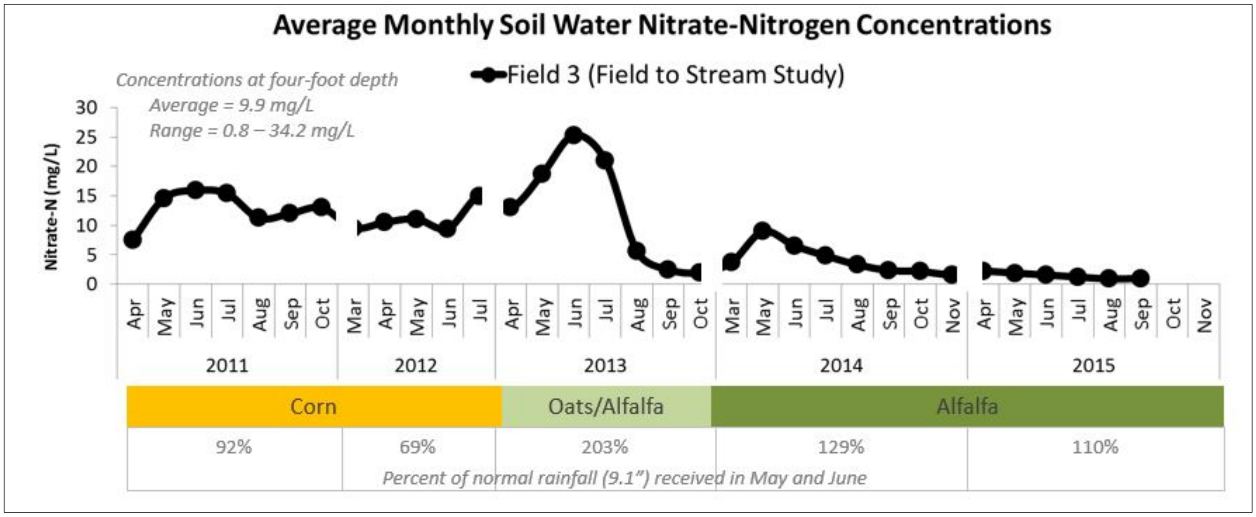
In 2011, a soil water monitoring network was implemented in southeast Minnesota with the main purpose of identifying the range of nitrate-nitrogen concentrations leaching from various land cover and management types under various climatic conditions. From 2011 through 2015, nearly 60 lysimeters on 21 sites covering 10 different types of land use were sampled. Nitrate concentrations were measured using suction-cup lysimeters. In the bar chart below, over 2,500 samples are summarized and average nitrate concentrations are displayed above each land cover type. Row crop averages ranged from 7.3 to 26.0 mg/l while non-row crop averages ranged from less than 1.0 to 11.3 mg/L. Maximum observed values are also displayed below the chart. A special thanks to project farmers and landowners for their cooperation.

Figure 26. Soil water monitoring data summary.



The network monitors different row cropping systems and tracks the management in each. These data can be paired with the soil water nitrate concentrations over time to examine apparent impacts on leaching loss at the local field scale, as in Figure 27 below. This information is useful to the producer (i.e. farm economics) and in aggregate provides guidance in considering the various means of reducing nitrogen loss from the row crop acres in southeast Minnesota, including those in the CRW. These data also lend further assurance that the strategies outlined in the NRS and supported by CRW stakeholders are viable means to reducing nitrogen loads.

Figure 27. Example soil water data at Field 3.



Graphic from Root River Field to Stream Partnership, Minnesota Department of Agriculture.

Note that concentrations are not flow-weighted and measured from a very small area of the field. As such, while the general conclusions regarding land use and management system differences are robust, individual results can vary.

Figure 28. Management information for Field 3.

Row Crop, Corn/Alfalfa

Site Field 3

Nitrogen Management

Year	Crop	Prev. Crop	Main N Source	Timing	Method	Total N Rate[1]	Notes
2011	Corn	Soybeans	urea	spring	broadcast/inc.	117	
2012	Corn	Corn	urea	pre-plant	broadcast/inc.	192	dry
2013	Oats/Alfalfa	Corn				No N applied	very wet
2014	Alfalfa	Oats/Alfalfa				No N applied	
2015	Alfalfa	Alfalfa				No N applied	

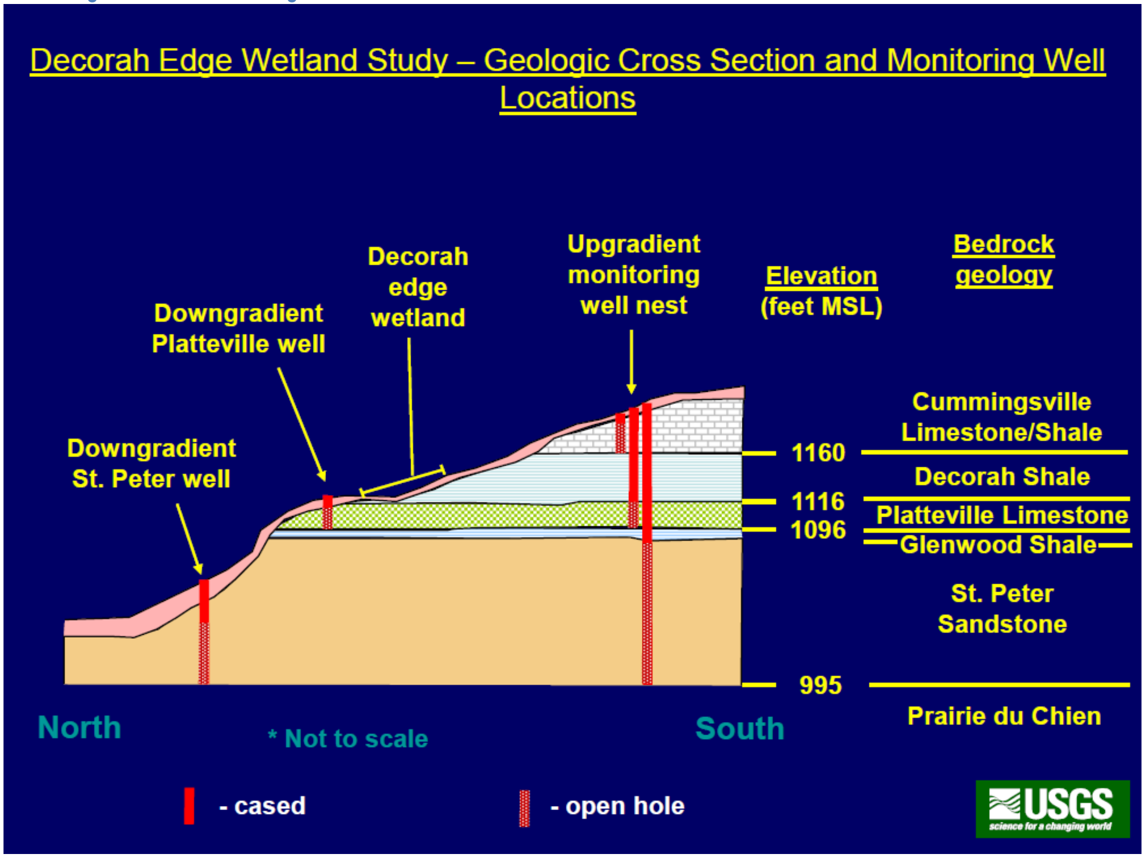
[1]Total N rate includes credits from starter, AMS, MAP/DAP and first or second year manure and/or alfalfa

Graphic from Root River Field to Stream Partnership, Minnesota Department of Agriculture.

Case Study: Elimination of the Primary Nitrogen Source

In a study designed to examine the nitrate-nitrogen reduction in a wetland along the Decorah Edge in Rochester, Minnesota, Jones et al. evaluated the effects of changing land use at a small scale. In the course of developing a land area for residential housing, row cropping ceased thereby marking a point of dramatic change in the local land use and management. The study installed a well nest that allowed for monitoring of nitrates in the groundwater of various stratigraphic units beneath the study area. The work confirmed that the effects of crop fertilization are present in groundwater well after cessation of the practice, but continued monitoring of the well in the uppermost unconfined limestone bedrock has documented a steady decline in nitrate concentration over time. See Figure 29 and Figure 30 below.

Figure 29. Decorah Edge study wells. The data in Figure 30 are from the shallow well with the open-hole interval in the Cummingsville Limestone. Figure from Jones et al.



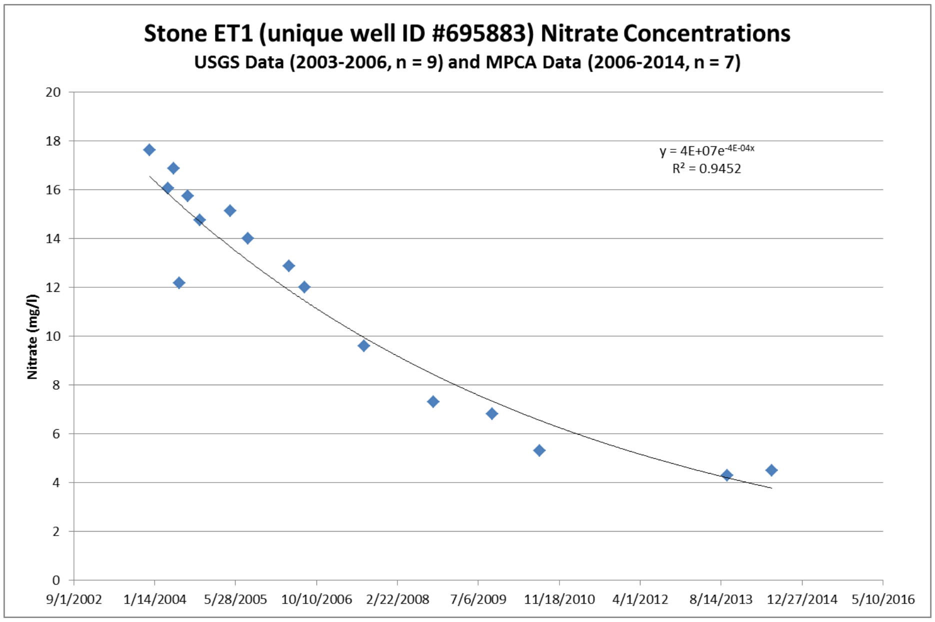


Figure 30. Stone ET1 well nitrate data.

The MPCA Ambient Groundwater Monitoring Program continues to monitor Stone ET1; the dataset stands as unique and valuable in documenting the effects of land use changes on local groundwater quality.

Given that the primary transport mechanisms for loading nitrate to the surface waters of the CRW are via tile drainage and leaching to groundwater from agricultural production areas, it follows that the response time of nitrate concentrations in wells, springs streams and rivers to changes in land use practices will likely vary in different hydrogeological settings (MGS 2013). In the case of the Stone ET1 well, groundwater nitrate concentrations dropped below 10 mg/l after approximately four years of cessation of row cropping. Other settings (e.g. tiled stream systems) may respond more quickly, while others (e.g. trout streams with deeper ("older") source water) may take longer to show water quality changes. As such, water quality changes in receiving waters cannot be the only measure of attainment of nitrogen reduction goals. Interim measures (e.g. successfully implementing the combinations of BMPs described in subsequent chapters of this document) should be considered. Nitrate concentrations of soil water, shallow wells or springs in the upper bedrock units may allow for monitoring of "middle points" between land use practices and surface water monitoring locations. Studies outside of southeastern Minnesota have concluded that some hydrogeological systems function in a manner whereby changes in base flow nitrate concentrations lag changes in land use practices by decades (e.g. Tesoriero et al. 2013). The most significantly lagged response in southeastern Minnesota should be expected in the deep valleys incised into the Prairie du Chien Plateau, where significant baseflow is derived from deep, siliciclastic-dominated bedrock sources with one or more overlying aquitards (MGS 2013).

Other resources useful in examining nitrogen sources in the CRW include:

- Nitrogen in Minnesota Surface Waters (MPCA https://www.pca.state.mn.us/news/report-nitrogen-surface-water),
- Minnesota's NRS (https://www.pca.state.mn.us/water/nutrient-reduction-strategy), and
- Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams (MGS http://conservancy.umn.edu/handle/11299/162612).
- Minnesota's Nitrogen Fertilizer Management Plan (MDA, http://www.mda.state.mn.us/~/media/Files/chemicals/nfmp/nfmp2015.pdf)

Pathogen Sources

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

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

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

Urban and Rural Stormwater

Untreated stormwater from cities, small towns, and rural residential or commercial areas can be a source for many pollutants including fecal coliform bacteria and associated pathogens. Fecal coliform concentrations in urban runoff can be as great as or greater than those found in cropland runoff, and feedlot runoff (EPA 2001). Sources of fecal coliform in urban and residential stormwater include pet and wildlife waste that can be directly conveyed to streams and rivers via impervious surfaces and storm sewer systems. Newer urban development often includes stormwater treatment in the form of such practices as sedimentation basins, infiltration areas, and vegetated filter strips. Smaller communities or even rural residences not covered by MS4 Permits may be sources of stormwater and associated pollutants.

Livestock Facilities and Manure Application

The MPCA currently uses the federal definition of a CAFO in its regulation of animal feedlots. In Minnesota, the following types of livestock facilities are issued, and must operate under, a NPDES Permit: a) all federally defined (CAFOs), some of which are under 1000 AUs in size; and b) all CAFOs and non-CAFOs, which have 1000 or more AUs.

The vast majority of livestock facilities in the Lower Mississippi River Basin in Minnesota are not CAFOs subject to NPDES Permit requirements. Nevertheless, they are subject to state feedlot rules, which include provisions for registration, manure management, inspection, permitting, and upgrading. Much of this work is accomplished through delegation of authority from the state to county government.

The DNR Watershed Health Assessment Framework (WHAF) Tool (http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/#) can be used to interactively examine feedlot locations in the CRW. Summary data regarding AUs are provided in the preceding discussion of phosphorus sources.

Individual Sewage Treatment Systems & Unsewered Communities

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

Table 7. Subsurface sewage treatment system estimates for four watershed counties.

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

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

2.4 TMDL Summary

The CRW TMDLs report addresses 76 water quality impairments on 41 stream AUIDs and 27 lake AUIDs through the CRW (

Figure 9). In the case of the stream impairments, many of the use support decisions drew heavily on biota data, which require further examination (stressor identification, see Chapter 2.3) to determine whether or not pollutants are causing the impairments. Pollutant stressors are addressed via TMDLs. Non-pollutant stressors are not subject to load quantification and therefore do not require TMDLs. If a non-pollutant stressor is linked to a pollutant (e.g. habitat issues driven by TSS or low DO caused by excess phosphorus) a TMDL is required. However, in many cases habitat stressors are not linked to pollutants. With respect to the few identified DO stressors in the Cannon Watershed, there are insufficient means for conclusively linking the condition to a pollutant cause. Note that all aquatic life use impairments – not just those with associated TMDLs - are addressed in the WRAPS Report. For example, many streams that are stressed by degraded habitat do not require TMDLs but may still be a focus in future planning or restoration work in the CRW.

Table 8 summarizes CRW impairment addressed by TMDL:

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

For more information see the CRW TMDLs report: https://www.pca.state.mn.us/water/watersheds/cannon-river

Table 8. Pollutants addressed in the TMDLs report by AUID and use class.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Belle Creek	Unnamed Creek	07040002-699	2B, 3C	ü				
Belle Creek	Belle Creek	07040002-734	2B, 3C	ü				ü
Belle Creek	Belle Creek	07040002-735	2B, 3C	ü				ü
Chub Creek	Chub Lake	19-0020-00	2B, 3C				ü	
Chub Creek	Chub Creek	07040002-528	2B, 3C					ü
Chub Creek	Mud Creek	07040002-558	2B, 3C	ü				
Chub Creek	Chub Creek	07040002-566	2C	ü				
Little Cannon River	Little Cannon River	07040002-526	2B, 3C	ü				ü
Little Cannon River	Little Cannon River	07040002-589	1B, 2A, 3B	ü		ü		ü
Little Cannon River	Butler Creek	07040002-590	2B, 3C	ü				ü
Lower Cannon River	Cannon River	07040002-501	2B, 3C	ü				
Lower Cannon River	Pine Creek	07040002-520	1B, 2A, 3B			ü		
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-567	1B, 2A, 3B			ü		
Lower Cannon River	Spring Creek	07040002-569	1B, 2A, 3B	ü				
Lower Cannon River	Unnamed Creek (Trout Brook)	07040002-573	1B, 2A, 3B			ü		
Middle Cannon River	Circle Lake	66-0027-00	2B, 3C				ü	
Middle Cannon River	Fox Lake	66-0029-00	2B, 3C				ü	
Middle Cannon River	Union Lake	66-0032-00	2B, 3C				ü	
Middle Cannon River	Mazaska Lake	66-0039-00	2B, 3C				ü	
Middle Cannon River	Cannon River	07040002-507	2B, 3C	ü				
Middle Cannon River	Cannon River	07040002-508	2B, 3C	ü				
Middle Cannon River	Cannon River	07040002-509	2B, 3C					ü
Middle Cannon River	Heath Creek	07040002-521	2B, 3C	ü				
Middle Cannon River	Wolf Creek	07040002-522	2B, 3C	ü				ü
Middle Cannon River	Unnamed Ditch	07040002-555	2B, 3C		ü			
Middle Cannon River	Unnamed Creek (Rice Creek)	07040002-557	1B, 2A, 3B	ü		ü		
Middle Cannon River	Unnamed Creek (Rice Creek)	07040002-562	2B, 3C	ü				
Middle Cannon River	Cannon River	07040002-581	2B, 3C	ü				

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Middle Cannon River	Cannon River	07040002-582	2B, 3C	ü				
Middle Cannon River	Unnamed Creek	07040002-703	2B, 3C	ü				
Prairie Creek	Prairie Creek	07040002-504	2C					ü
Prairie Creek	Unnamed Creek	07040002-512	2B, 3C					ü
Straight River	Straight River	07040002-503	2B, 3C					ü
Straight River	Rush Creek	07040002-505	2B, 3C					ü
Straight River	Straight River	07040002-515	2B, 3C					ü
Straight River	Straight River	07040002-536	2B, 3C					ü
Straight River	Falls Creek	07040002-704	2B, 3C	ü				
Upper Cannon River	Horseshoe Lake	40-0001-00	2B, 3C				ü	
Upper Cannon River	Upper Sakatah Lake	40-0002-00	2B, 3C				ü	
Upper Cannon River	Sunfish Lake	40-0009-00	2B, 3C				ü	
Upper Cannon River	Dora Lake	40-0010-00	2B, 3C				ü	
Upper Cannon River	Mabel Lake	40-0011-00	2B, 3C				ü	
Upper Cannon River	Sabre Lake	40-0014-00	2B, 3C				ü	
Upper Cannon River	Tetonka Lake	40-0031-00	2B, 3C				ü	
Upper Cannon River	Gorman Lake	40-0032-00	2B, 3C				ü	
Upper Cannon River	Silver Lake	40-0048-00	2B, 3C				ü	
Upper Cannon River	Frances Lake	40-0057-00	2B, 3C				ü	
Upper Cannon River	Tustin Lake	40-0061-00	2B, 3C				ü	
Upper Cannon River	Cannon Lake	66-0008-00	2B, 3C				ü	
Upper Cannon River	Wells Lake	66-0010-00	2B, 3C				ü	
Upper Cannon River	Roberds Lake	66-0018-00	2B, 3C				ü	
Upper Cannon River	French Lake	66-0038-00	2B, 3C				ü	
Upper Cannon River	Lower Sakatah Lake	66-0044-00	2B, 3C				ü	
Upper Cannon River	Hunt Lake	66-0047-00	2B, 3C				ü	
Upper Cannon River	Rice Lake	66-0048-00	2B, 3C				ü	
Upper Cannon River	Caron Lake	66-0050-00	2B, 3C				ü	
Upper Cannon River	Cedar Lake	66-0052-00	2B, 3C				ü	

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	Designated Use Class	Bacteria	Chloride	Nitrate	Phosphorus	TSS
Upper Cannon River	Shields Lake	66-0055-00	2B, 3C				ü	
Upper Cannon River	Toner's Lake	81-0058-00	2B, 3C				ü	
Upper Cannon River	Cannon River	07040002-540	2B, 3C	ü				
Upper Cannon River	Cannon River	07040002-542	2B, 3C	ü				
Upper Cannon River	Waterville Creek	07040002-560	2B, 3C	ü				
Upper Cannon River	MacKenzie Creek	07040002-576	2C	ü				
Upper Cannon River	Devils Creek	07040002-577	2B, 3C	ü				
Upper Cannon River	County Ditch 63	07040002-621	2B, 3C	ü				
Upper Cannon River	Unnamed Creek	07040002-702	2B, 3C	ü				
Upper Cannon River	Unnamed Creek	07040002-705	2B, 3C	ü				
Upper Cannon River	Whitewater Creek	07040002-706	2B, 3C	ü				

2.5 Protection Considerations & Waters at or Near Thresholds

Protection of Existing Use Support

Use support is one consideration in examining protection needs in the CRW. However, in southeast Minnesota use support should be considered in a greater context because in some cases it alone should not call for prescription of a unique set of strategies that purport to address "protection" but not "restoration." Strategies to reduce pollutant loading, maintain or increase perennial vegetation, improve habitat, etc. apply well to nearly all watersheds in the region. As such, in many instances fully supporting waters may indicate priorities for work while not meriting unique strategies (and therefore not requiring individual rows in Tables 16 to 20).

Despite the many documented impaired uses, the CRW Monitoring and Assessment Report details well the fully supporting waters in the CRW. Two example excerpts are included below. Considerations beyond use support are summarized in subsequent sections of text.

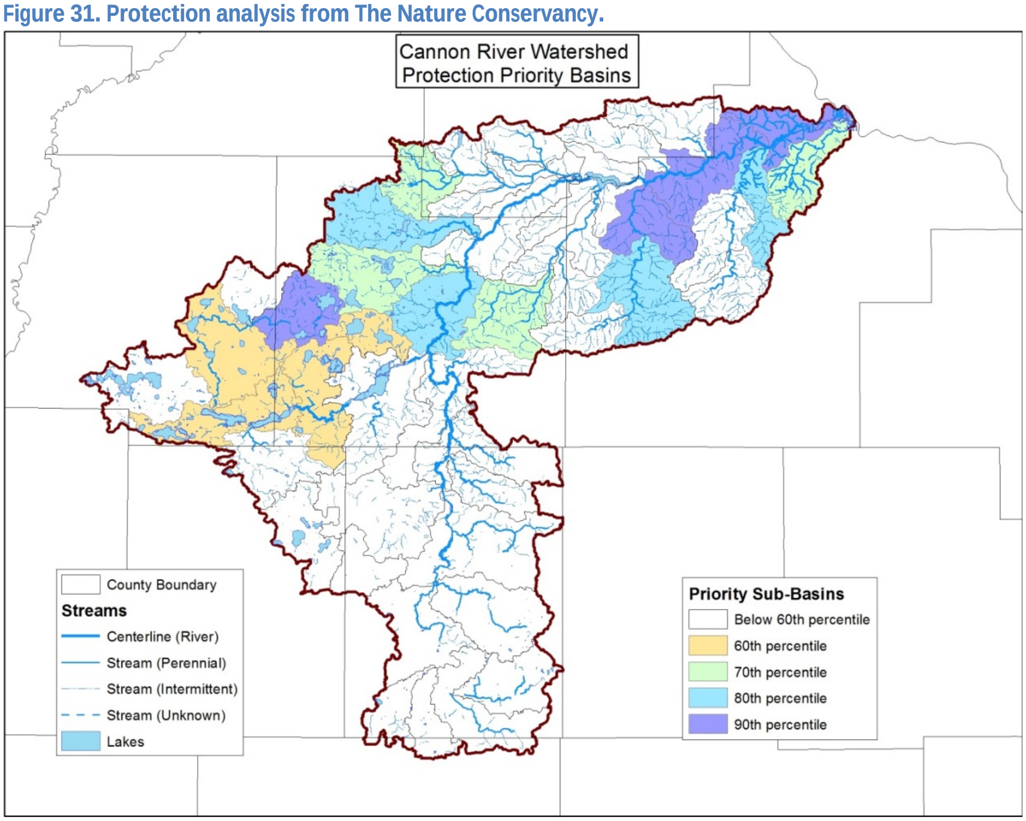
> *While many of the lakes in the CRW are highly eutrophic (nutrient rich), five lakes stand out as high quality resources for recreation: Roemhildts, Fish, Dudley, Kelly, and Beaver. These lakes generally benefit from relatively intact, small watersheds and from their depth. Protection efforts should be put in place to keep the quality of these lakes high.*
>
> *For warm water streams, Maple Creek, Falls Creek, Turtle Creek, Mud Creek, and the Lower Cannon River support aquatic life for both fish and macroinvertebrates with many pollution sensitive species collected. These streams and others should be considered for additional protection to prevent additional aquatic life impairments in the future.*

The waters listed above should be key protection considerations going forward. Increased pollutant loading or habitat degradation could significantly impact these waters. Because there are clear protection goals and strategies for the lakes, there are corresponding rows in Table 1 to Table 18. Regarding the supporting streams listed above, more information (e.g. smaller scale examination and consultation with local stakeholders) is needed to discern any strategy that would constitute protection (such that it would be distinct from a "restoration strategy"). However, their full support status identifies them as priorities for conservation work in general.

Protection of Outstanding Resource Areas

In addition to consideration of existing use support, protection planning is focused on outstanding value natural resources in the CRW. These land and water areas are best examined via tools and plans maintained by The Nature Conservancy (TNC) and DNR, both partners in conservation planning. Figure 31 depicts an example of protection priority watersheds (HUC12 scale) according to analysis by The Nature Conservancy that examined overlap between aquatic and terrestrial protection targets, sub-basin health (based on a subset of the WHAF dataset), and both agricultural land conversion and development risk. See Appendix G for TNC methodology used to derive Figure 31 below.

Figure 31. Protection analysis from The Nature Conservancy.



These land areas can be paired with output from other planning efforts that focus on protection to derive priorities for acquisition, easement and technical assistance that would maintain and manage perennial cover (e.g. forest stewardship planning) on private lands. For example, priorities described in DNR's Wildlife Action Network (WAN) for the Lower Cannon lobe overlap well with those of TNC (e.g. main river corridor and the bottom reaches of Little Cannon and Belle Creeks). Further discussion of WAN and other protection prioritization and strategies follows in Chapter 3.1 and Table 12.

Protection of Baseflow especially in Lower Cannon Trout Streams

The Driftless Area is a geographic region covering parts of southwest Wisconsin, southeast Minnesota, northeast Iowa, and a small part of northwest Illinois. The distinctive landscape of the Driftless Area is characterized by craggy limestone, sandstone valleys, and steep hillsides. This ancient terrain, which was bypassed by the glaciers, is characterized by one of the highest concentrations of limestone spring creeks in the world. The spring water emerging from limestone bedrock provides a near constant flow of cold water. The limestone enriches the water with essential minerals for aquatic insects and other creatures, which contributes to prime conditions for healthy populations of trout and other coldwater dependent species. More than 600 spring creeks (exceeding 4,000 river miles) cross this 24,000 square-mile landscape. Trout anglers produce an economic benefit to the Driftless Area in excess of $1.1 billion every year (Northstar Economics & Trout Unlimited 2008).

All of the designated trout waters in the Lower Cannon Watershed lobe meet the criteria for the southeast Minnesota coldwater F-IBI. While there are restoration considerations in this lobe (e.g. high nitrates in the trout streams and poor M-IBIs in Trout Brook) a focus of protection work should be preserving the baseflow of streams via focused monitoring and application of water appropriation analysis.

Protection of Rice Creek Brook Trout Fishery

Rice Creek (a.k.a. Spring Brook) is the only trout stream in southeast Minnesota outside of the Driftless Area. Its cold, clear baseflow is sustained by local and shallow sources (relative to the Driftless Area trout streams in the lower Cannon). It sustains a population of brook trout that have been used by the DNR as a source of egg stock for other streams further east and south. While condition monitoring confirmed that the trout population is in good condition, signs of stress from unstable banks and high nitrates may be contributing to degraded macroinvertebrate communities. Due to the opportunity for trout fishing and a rare self-sustaining population of brook trout, additional restoration and protection strategies are needed to maintain and improve this valuable resource and prevent further degradation. Examination of the shallow groundwater inflows should continue and efforts should focus on protecting the baseflow of the stream.

3. Prioritizing and Implementing Restoration and Protection

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

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

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts, other tool application (e.g. BMP spreadsheets) and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on developing the stakeholder understanding and motivation needed to implement desired changes. Finally, behavior and land management changes needed to protect and restore waters exceed historical levels and so, program capacity to provide assistance and funding will need to be secured at a time when WRAPs and local water plans are being developed and implemented across the state. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation and course correction.

Element 'd' of EPA's "Nine Minimum Elements to Be Included in a Watershed Plan…" calls for *"An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan."* A local plan or project work plan is a more appropriate document for cost estimates. However, sources and authorities that will likely be relied upon to implement strategies described herein (and those carried forward in plans or projects) are summarized in Table 9 below (although it does not provide a limiting list).

Table 9. Partial list of nonpoint implementation funding sources.

Sponsor or Information Source	Funding Programs Description
MPCA	§ Section 319 Grants: Federal grant funding from the EPA as part of the Clean Water Act, Section 319. Grants awarded by MPCA to LGUs and other groups are to address nonpoint source pollution through implementation projects. § Clean Water Partnership: The state funded Clean Water Partnership Program awards loans to LGUs and other groups for work on projects that address nonpoint source pollution. § Clean Water State Revolving Fund (SRF): The SRF provides loans to for both point source (wastewater and stormwater) and nonpoint source water pollution control projects.
Board of Water and Soil Resources (BWSR)	§ Clean Water Fund Competitive Grants: These grants are to restore, protect, and enhance water quality. Eligible activities must be consistent with a comprehensive watershed management plan, county comprehensive local water management plan, SWCD comprehensive plan, metropolitan local water plan or metropolitan groundwater plan that has been State approved and locally adopted or an approved TMDL, WRAPS document, surface water intake plan, or well head protection plan. § Targeted Watershed Demonstration Program: This program awards grants to LGUs organized for the management of water in a watershed or subwatershed where multiyear plans that will result in a significant reduction in water pollution in a selected subwatershed are in place. § The Erosion Control and Water Management Program, commonly known as the State Cost-Share Program: This program provides funds to SWCD to share the cost of systems or practices for erosion control, sedimentation control, or water quality improvements that are designed to protect and improve soil and water resources. Through this program, land occupiers can request financial and technical assistance from their local District for the implementation of conservation practices. § Other BWSR grant programs are available as well.
MDA	§ AgBMP Loan Program: This program encourages implementation of BMPs that prevent or reduce pollution problems, such as runoff from feedlots, erosion from farm fields and shoreline, and noncompliant septic systems and wells. § MDA provides a wide array of other information from their agency as well as other state and federal agencies on conservation programs addressing agriculture and other land uses. In addition, Clean Water Research Projects are available for funding.
DNR	· DNR grants are available for a variety of programs relating to land preservation, wildlife and habitat, native prairie, forestry and wetlands.
United States Department of Agriculture (USDA)-Natural Resource Conservation Service (NRCS)	§ Conservation Reserve Program – Continuous Signup (CCRP): The CCRP is a USDA Farm Service Agency-funded voluntary program designed to help farmers restore and protect environmentally sensitive land—particularly wetlands, wildlife habitat and water quality buffers. § Environmental Quality Incentives Program (EQIP): EQIP is a voluntary program to implement conservation practices, or activities, such as conservation planning, that address natural resource concerns for agricultural producers § Conservation Stewardship Program (CSP): CSP is a voluntary program to improve resource conditions such as soil quality, water quality, water quantity, air quality, habitat quality, and energy. § Other NRCS funding opportunites are available as well.

3.1 Targeting of Geographic Areas

Critical Areas

The Clean Water Legacy Act states that WRAPS should "*summarize … priority areas for targeting actions to improve water quality" and "identify nonpoint sources of pollution … with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions."* This language comports with the EPA's directive to identify critical areas for pollution reduction for application of Section 319 nonpoint source funds. In the CRW the best tools for identifying these critical areas are the HSPF and SWAT models, both of which operate on subwatersheds that are approximately scaled to typical HUC-12 polygons. Model output allows for ready identification of relatively small areas that according to the best available information load the most nutrients and sediment to surface waters. These models are discussed further in subsequent text, summarized in Appendix F, and example maps of model output can be reviewed in Figures 33 through 36. Critical areas may describe contiguous geography (e.g. a HUC-12 watershed) or a condition or landscape feature present across a broader area (e.g. riparian zones or ephemeral gullies). Within the modeled polygons further delineation of critical areas can be achieved via Geographic Information System (GIS) work where available (e.g. terrain analysis) and professional judgment and experience of local government units and stakeholders.

Beyond critical areas for pollutant reduction, restoration and protection work can be prioritized according to other condition examination (e.g. "layering" multiple impairments and stressors together), high level directives, (e.g. Nonpoint Source Funding Plan), and/or stakeholder input (e.g. Zonation results). The following text overviews a number of directives, works and tools that can be used to prioritize work in the CRW, some of which may be best applied in the segue way from CRW WRAPS to subsequent planning steps or project concepts.

Waters at or Near Thresholds

In 2013, the Minnesota Legislature added accountability language to the Clean Water Legacy Act. This new language aimed to increase accountability for the public funds used to clean up our water. The Act now defines WRAPS and requires the BWSR to prepare a Nonpoint Priority Funding Plan (NPFP).

The NPFP is a criteria-based process to prioritize Clean Water Fund investments. It provides state agencies with a coordinated, transparent and adaptive method to ensure that Clean Water Fund implementation allocations are targeted to cost-effective actions with measurable water quality results. The process may also help agencies identify gaps in programming to accelerate progress toward meeting water management goals. The plan can be reviewed here: http://www.bwsr.state.mn.us/planning/npfp/NPFP%20Final.pdf. The plan excerpt below indicates high-level priorities for spending.

Figure 32. Priority statement from *NPFP for Clean Water Implementation Funding*.

2.6 High-Level State Priorities

State agencies have identified the following three high-level state priorities for investing Clean Water Fund nonpoint implementation money in FY 2016-2017, based on the principles of asset preservation and risk-opportunity assessment:

- **Restore those impaired waters that are closest to meeting state water quality standards.**
- **Protect those high-quality unimpaired waters at greatest risk of becoming impaired.**
- **Restore and protect water resources for public use and public health, including drinking water.**

Four lakes that are currently impaired but are close to meeting water quality standards are included in Table 10 below. Rice County has included these lakes as priorities in the implementation section of their 2015 water plan (http://www.co.rice.mn.us/sites/default/files/pdfs/planning/documents/Rice%20County%20Water%20Plan%202015-2019.pdf).

Table 10. Impaired lakes near thresholds.

Deep Lakes			
Lake ID	**Lake Name**	**TSI Phosphorus**	**TSI Phosphorus Goal**
66-0052-00	Cedar	62	<57
66-0029-00	Fox (strong evidence for decreasing trend in water clarity; see Chapter 2.2 and Table 3)	69	<57
Shallow Lakes			
66-0045-00	Sprague	65	<63
66-0047-00	Hunt	69	<63

Appendix C includes a list of stream reaches that are above or below IBI thresholds but within the respective confidence interval. There are 33 AUIDs highlighted; this delineation helps in examining streams that are currently close to aquatic life use support goals.

Targeting Areas for pollutant load reduction using Hydrologic Simulation Program -FORTRAN

A hydrologic water quality simulation model was developed to support decision-making for sediment and nutrient reduction strategies in the CRW. The MPCA chose the HSPF Model for this purpose and enlisted LimnoTech Inc. consultants for model calibration and application. Full documentation of the HSPF Model calibration can be found reviewed on the CRW website:

https://www.pca.state.mn.us/sites/default/files/wq-ws4-23d.pdf (model construction and calibration)

https://www.pca.state.mn.us/sites/default/files/wq-ws4-23c.pdf (scenarios report)

A modeling summary is provided in Appendix F.

In the HSPF model, the CRW was divided into subbasins (or subwatersheds) that have a single, representative reach. A total of 219 such subbasins made the divisions, ranging in size from 45 acres to 28,588 acres with an average subbasin area equal to 4,172 acres. LimnoTech utilized the water quality data collected between 1995 and 2012 to calibrate and successfully validate the model for hydrology and water quality. Base condition or baseline simulations, constructed on the collected water quality and quantity data, were developed for the major nutrients, phosphorus (P) and nitrogen (N), and sediment. Examples for total nitrogen (TN) and TP base conditions maps are shown in Figure 33 and Figure 34 below.

Figure 33. CRW HSPF Baseline simulation for TN.

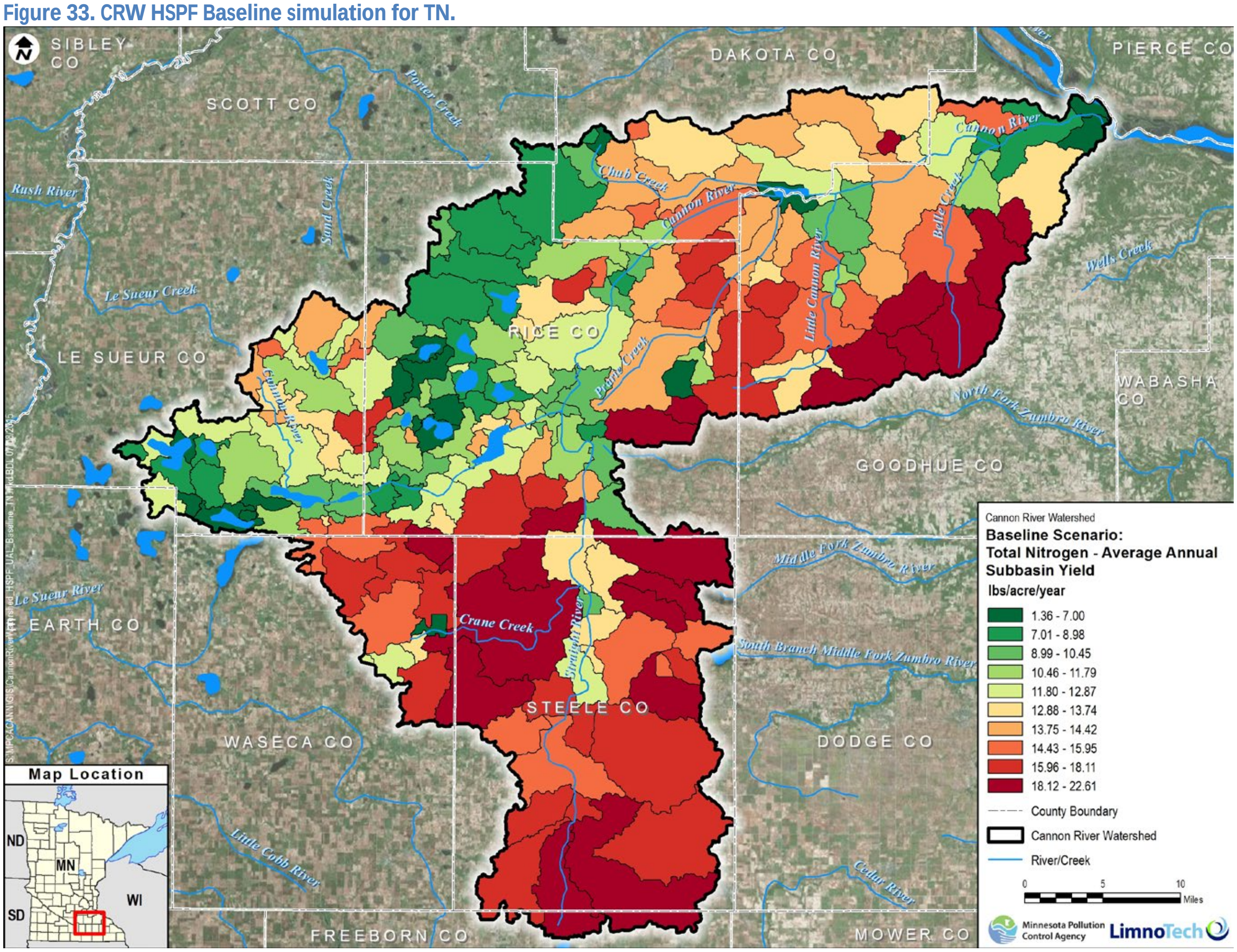
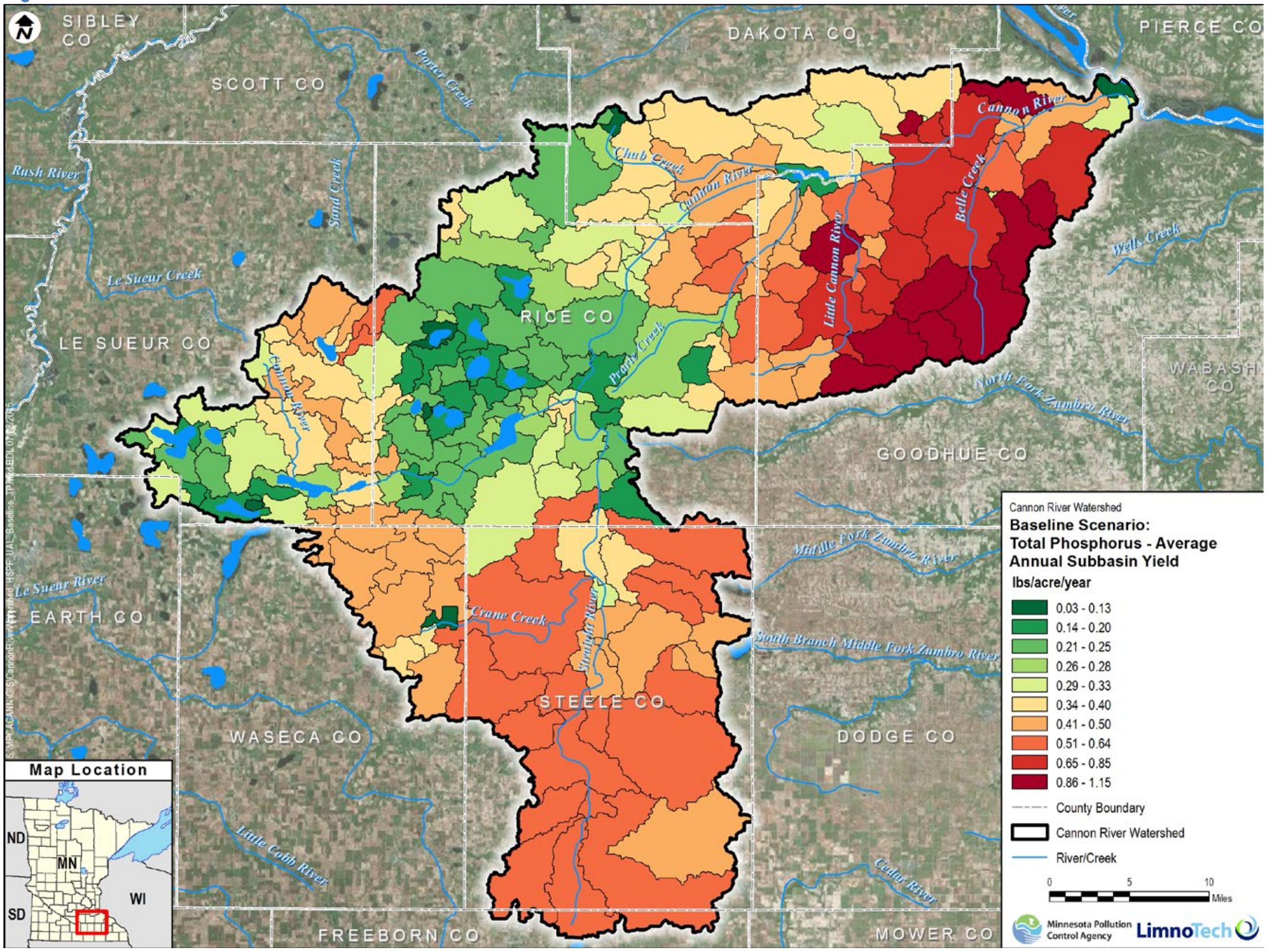


Figure 34. CRW HSPF Baseline simulation for TP.



In addition to modeling baseline conditions, the HSPF model was applied in the CRW to evaluate various management scenarios to help provide information on how effective specific pollutant reduction practices may be for decreasing sediment and nutrient loading and for improving water quality. The HSPF model scenario development was discussed at meetings and marks an important point of civic engagement. Specifically, 10 different management scenarios were developed in consultation with watersheds partners. Stakeholder input helped shape a number of the scenarios such that they would be most useful in examining pollutant loading in the CRW.

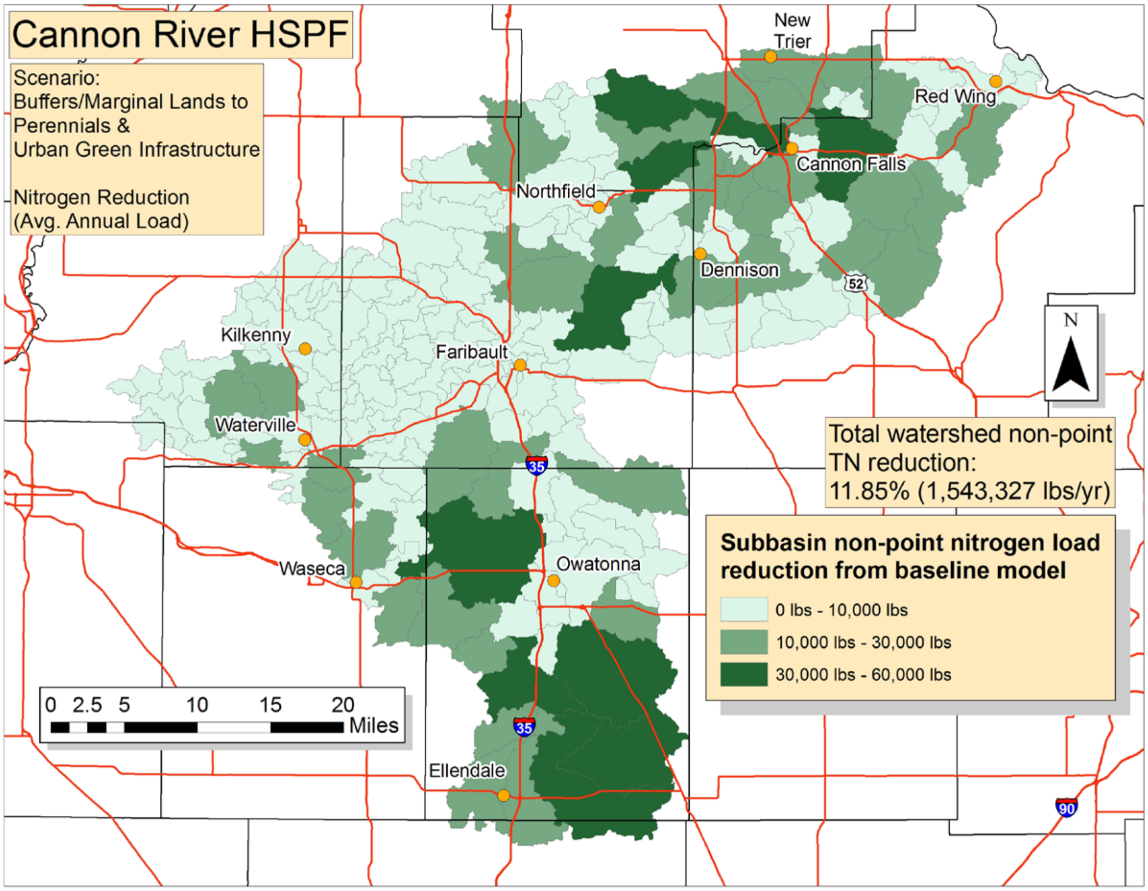
Table 11 tabulates and describes six of these management scenarios for estimated sediment and nutrient pollutant load reductions. The pollutant load reductions are from base line conditions. Note management scenario H (restored wetlands and sedimentation ponds) work equally well for TSS, TP, and TN reductions, while management scenario E (conservation tillage), has much better reductions for TSS and TP, while only marginally effective for reducing TN.

Table 11. Management Scenarios and Percent Load Reductions for TSS, TP, and TN.

Management Scenario	Description	% Reduction from Baseline for Sediment (TSS)	% Reduction from Baseline for TP	% Reduction from Baseline for TN
E Nonpoint	**Conservation tillage** management practices applied to 30% of the cropland acres with the highest sediment yields	15%	12%	5%
F Nonpoint	**Cover crop** of cereal rye applied in the Fall to: -100% of cropland in Little Cannon and Belle Creek. -Remaining parts of the CRW applied 10% of the corn/soybean acres and 80% of the early harvested crops	14%	11%	8%
G Nonpoint	**Perennial additions**: -100% of marginal cropland (CPI<60) converted -100% implementation of stream bank 50-foot buffer rule -Green infrastructure implemented to treat 25% of MS4 storm water	12%	10%	12%
H Nonpoint	**Restored Wetlands** in the Upper and Middle Cannon, and Straight River Lobes. **New Sedimentation Ponds in** the Lower Cannon Lobe and Maple Creek. subbasin where there was highest sediment yields	7%	7%	7%
I Point + Nonpoint	**Combination #1** of F, G and major point source effluent TP loads set to current conditions	22%	20%	18%
J Point + Nonpoint	**Combination #2** of F, G and major point source effluent assumed to discharge at permitted limits of flow rate and TP load (Oct-May) and low flow phosphorus reduction (Jun-Sep)	22%	17%	17%

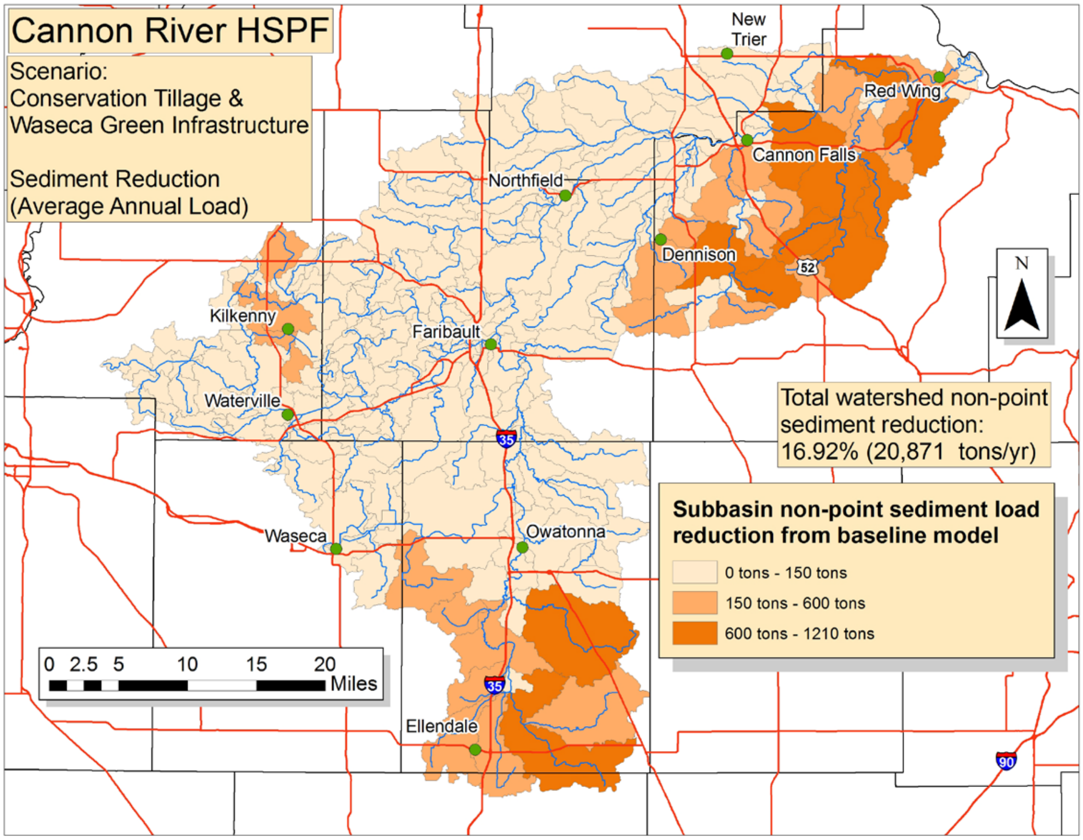
In order to show which geographical areas of the CRW would have the greatest load reduction potential for a particular management scenario, maps were developed depicting the range of reductions by subbasin for a specific scenario. For example in the map in Figure 35, management scenario G –perennial additions, a 12% overall TN reduction would occur for the CRW. Most of those load reductions would occur in the heavily shaded subbasins in Chub, Pine, Prairie, Little Cannon, Crane, and Upper Straight River subbasins. These subbasins would represent critical areas where the greatest reductions of TN would be attained in this management scenario.

Figure 35. CRW TN Load Reduction for Perennial Additions Management Scenario.



Similarly, Figure 36 represents a TSS load reduction map for HSPF basins for the conservation tillage management scenario (scenario E in Table 11). The map shows basins that can achieve the greatest TSS load reductions with the implementation of this scenario. It indicates that subbasins in the Little Cannon, Belle, Spring, and the Upper Straight River would achieve the greatest reduction of TSS if conservation tillage practices were applied to the crop acres with the highest sediment yield. The darkly highlighted basins would be considered critical areas for TSS reduction under this management scenario.

Figure 36. CRW TSS Load Reduction for Conservation Tillage Management Scenario



Targeting and Prioritization of Geographic Areas with Zonation

Zonation, a values-based model was used to prioritize areas for restoration and protection. This model was based on fundamental conservation principles, including biodiversity and connectivity. It used the DNR's five-component healthy watershed conceptual framework to facilitate an organized process to assess and review watershed problems and solutions. The five components for a healthy watershed are: biology, hydrology, water quality, geomorphology, and connectivity. This approach recognizes that attempts to solve our clean water needs are not separate from our other conservation needs; each conservation activity should provide multiple benefits. The Zonation model used in this process helps achieve this multiple benefits goal by identifying areas that optimize benefits by incorporating data valued by the community. For example, for both the restoration and protection prioritizations, goals were to obtain both clean water benefits and other conservation benefits. The model used a compilation of individual and aggregated criteria of valuable landscape features with the objective of providing data and maps that prioritize places on the landscape for restoration or protection.

Final prioritization maps are presented in Figure 37 and Figure 38. The restoration ranking map identified several general potential priority areas (Figure 39). First, high rankings were evident in the Lower Cannon associated with stream riparian areas and in areas with high-channelized flow erosive potential. Within the Middle Cannon, riparian and shoreland areas near and west of the city of Northfield were generally high priorities. Highly ranked areas were also identified around the lakes and the Upper Cannon River tributaries south of the city of Waterville. Finally, lands within or surrounding the cities of Faribault, Owatonna, Northfield, and Waseca had high rankings.

Figure 37. Protection priority map from Zonation analysis.

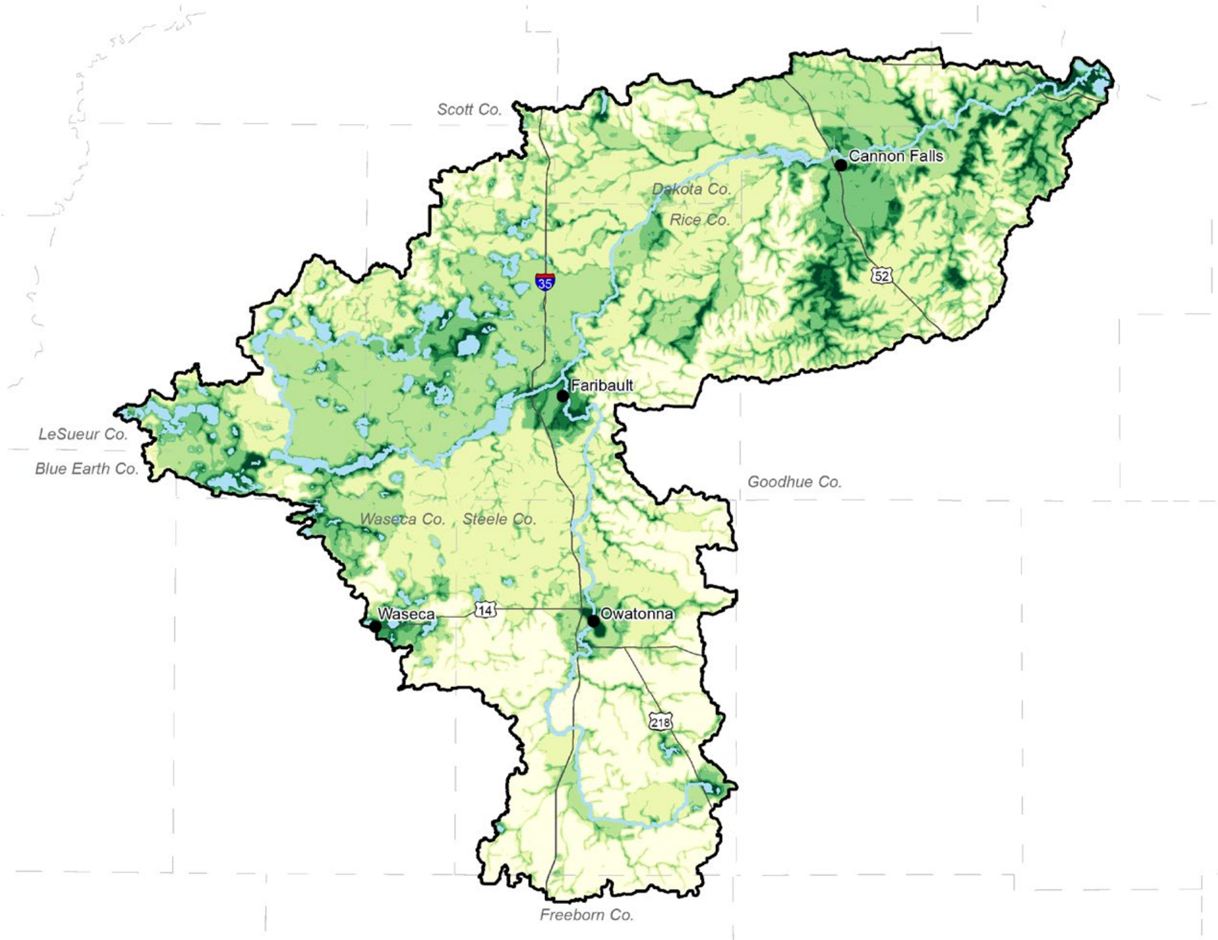
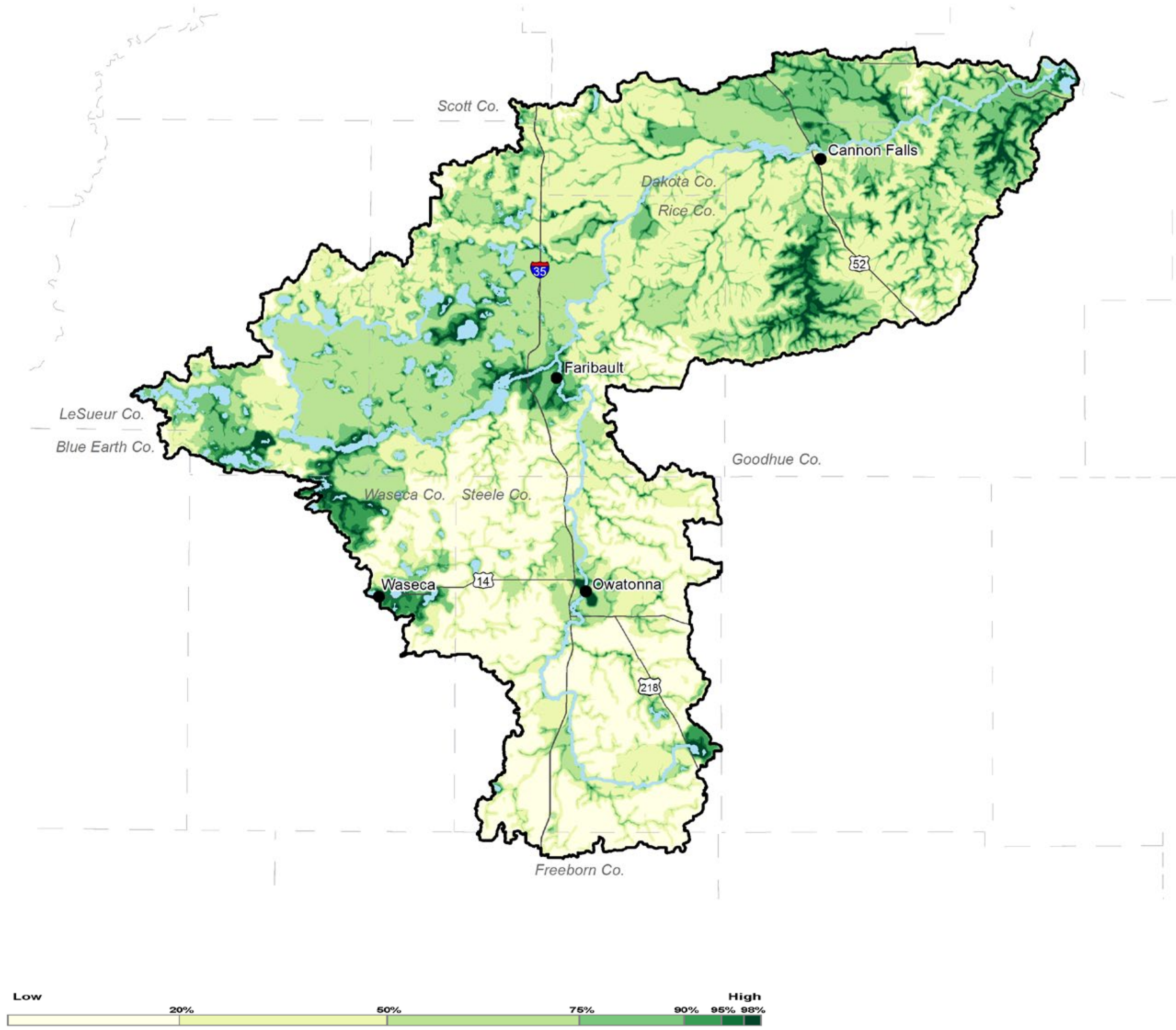
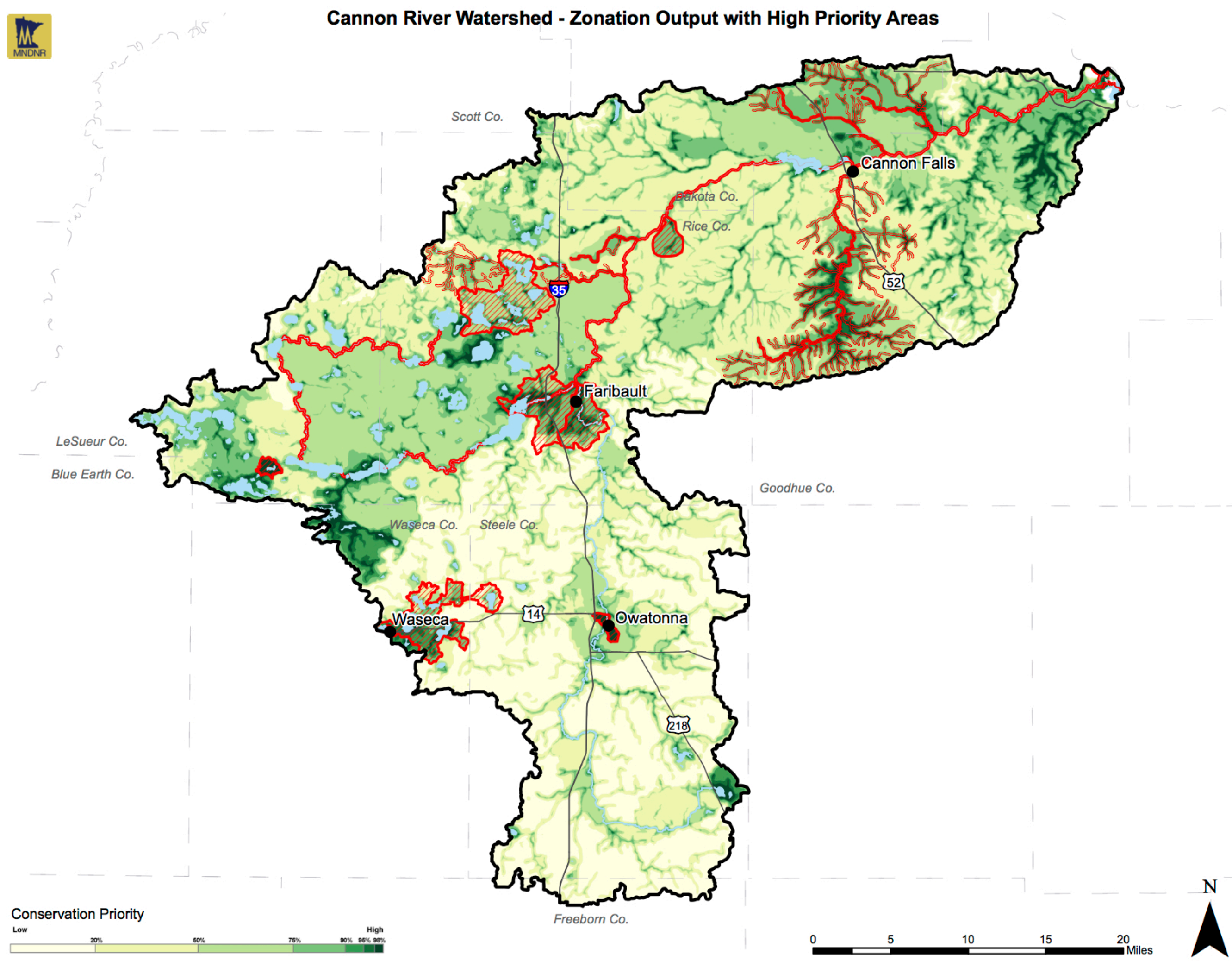


Figure 38. Restoration priority map from Zonation analysis.



Using the prioritization maps and feedback from Lobe meeting participants, several priority areas were identified (Figure 39) The main stem of the Cannon River was identified as a priority area across the watershed. In the Lower Cannon the priority areas included: Little Cannon River and associated tributaries; Trout Brook and associated tributaries; and Pine Creek and associated tributaries. In the Middle Cannon the priority areas included: Rice Creek; Northfield Drinking Water Supply Management Area (DWSMA) and Spring Creek; and the catchment containing Mazaska, Circle, and Fox Lakes. The Upper Cannon priority area includes the catchment of Fish Lake. The Straight River priority areas include: catchments around Loon, Clear, and Goose Lakes; a large catchment area around and encompassing the city of Faribault DWSMA and moderate size area around and including the city of Owatonna DWSMA. These priority areas can be utilized as zones to focus restoration or protection strategies during the next 10 years.

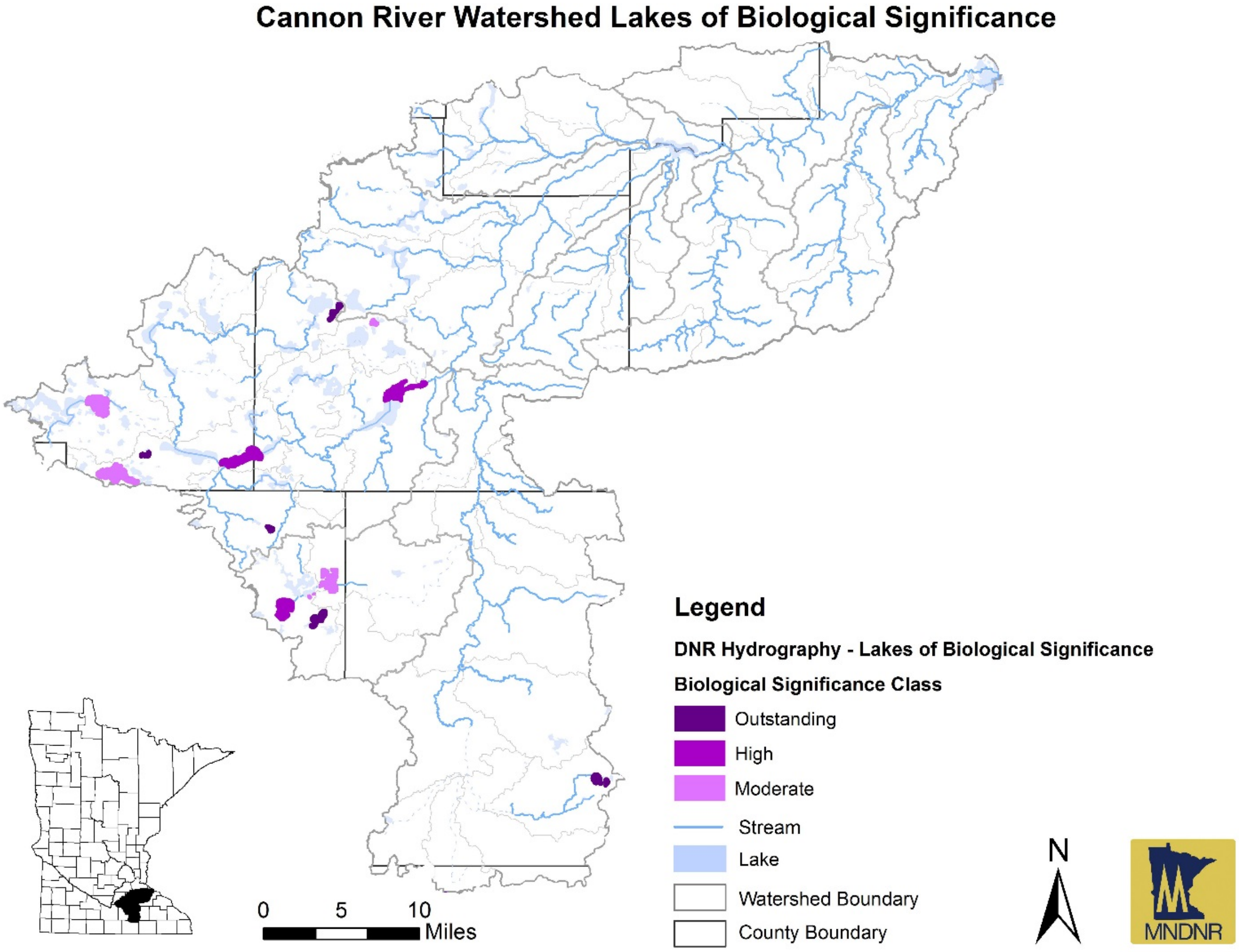
Figure 39. High Priority areas identified for the CRW. Red areas or red-hatched areas are high priority areas. Base map is restoration priority map from Zonation analysis.



DNR Lakes of Biological Significance

The DNR Fisheries Lakes of Biological Significance layer can be utilized to guide protection work in the Upper Cannon and Straight River lobes within the Cannon Watershed. High quality lakes were identified using biological sampling for plants and animals based on unique in-lake habitat features. Lakes were rated and grouped for each of the following communities: aquatic plants, fish, birds, and amphibians. Lakes were assigned one of three biological significance classes (outstanding, high, or moderate). Figure 40 indicates lakes determined to have high biological significance that are good candidates for more detailed planning for protection and restoration practices. See DNR (Waterville office) for more detail regarding these lakes and goals pertaining to their protection.

Figure 40. Lakes of biological significance (DNR Fisheries 2015).



Wildlife Action Plan

Minnesota's Wildlife Action Plan (2015 through 2025) was recently updated by the DNR and focuses on conservation and protection for rare, declining, or vulnerable to decline nongame wildlife species, including certain birds, mammals, reptiles, amphibians, fish, mussels, and other invertebrates. The plan focuses on prioritizing efforts within connected habitat networks to assist species movement and adaption as a result of climate change. It also provides a framework to advocate for the preservation of biological diversity through the acquisition, preservation, and management of important wildlife habitats. The WAN within the plan comprises terrestrial and aquatic habitat cores and corridors to support biological diversity and ecosystem resilience with a focus on Species of Greatest Conservation Need (SGCN). The mapped WAN illustrates high, medium-high, medium, low-medium, and low scores based on SGCN population viability, SGCN richness, spatially prioritized Sites of Biodiversity Significance, Lakes of Biological Significance, and Stream IBI. Focusing conservation efforts within the mapped WAN, especially the high to medium priority zones (red, yellow and orange polygons in the following maps), will result in projects and practices with multiple environmental benefits (i.e. protecting and restoring perennial vegetation for habitat enhancement and for clean water). Figures 41 through 44 indicate the WAN boundaries and scores in each of the four Cannon Watershed lobes. Additional information on the Minnesota Wildlife Action Plan can be found on the following webpage: http://www.dnr.state.mn.us/eco/.

Figure 41. Upper Cannon WAN Prioritization.

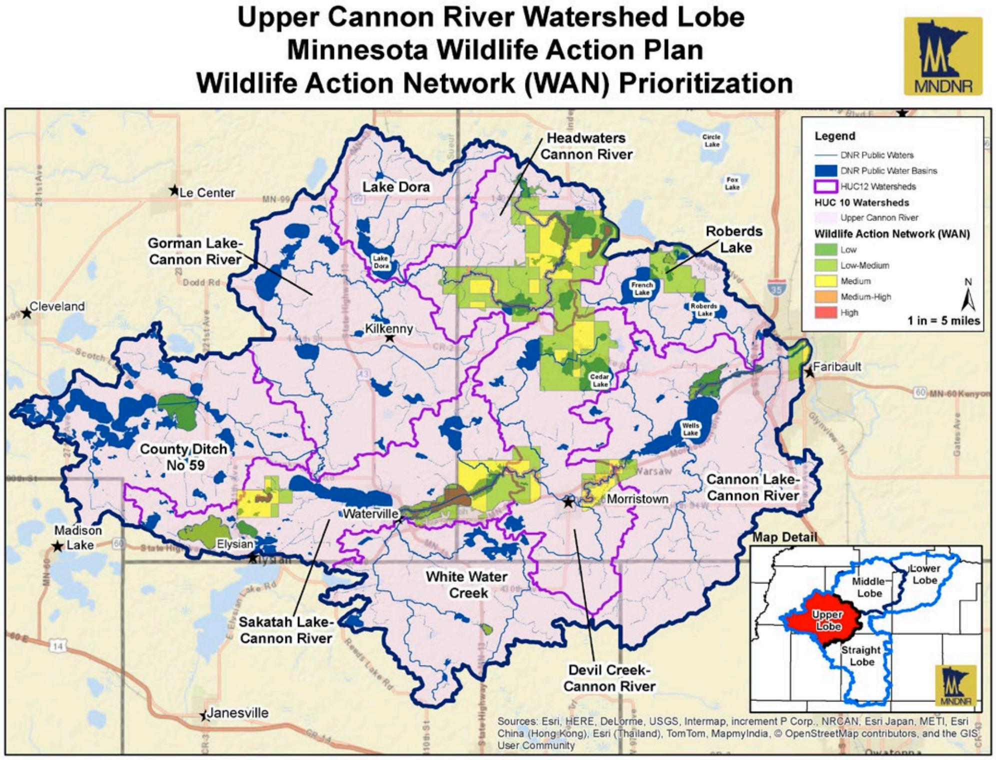


Figure 42. Middle Cannon WAN Prioritization.

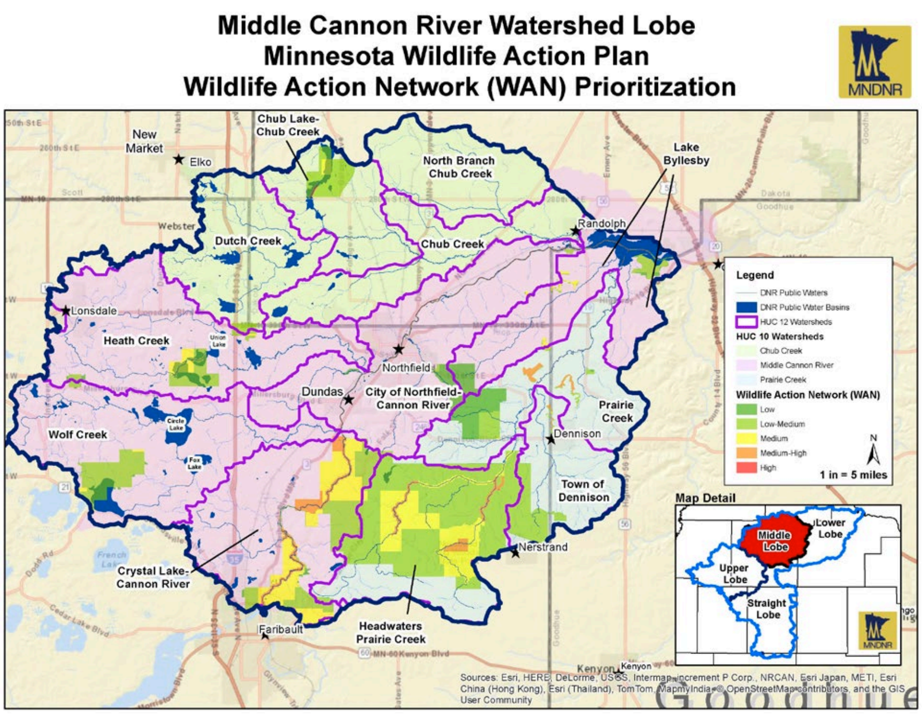


Figure 43. Lower Cannon WAN Prioritization.

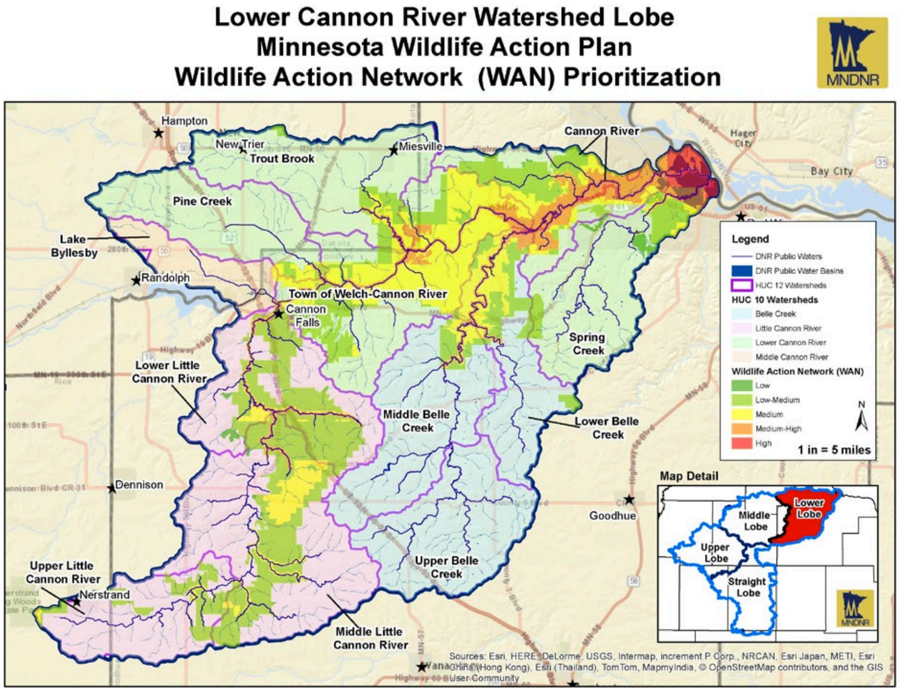


Figure 44. Straight River WAN Prioritization.

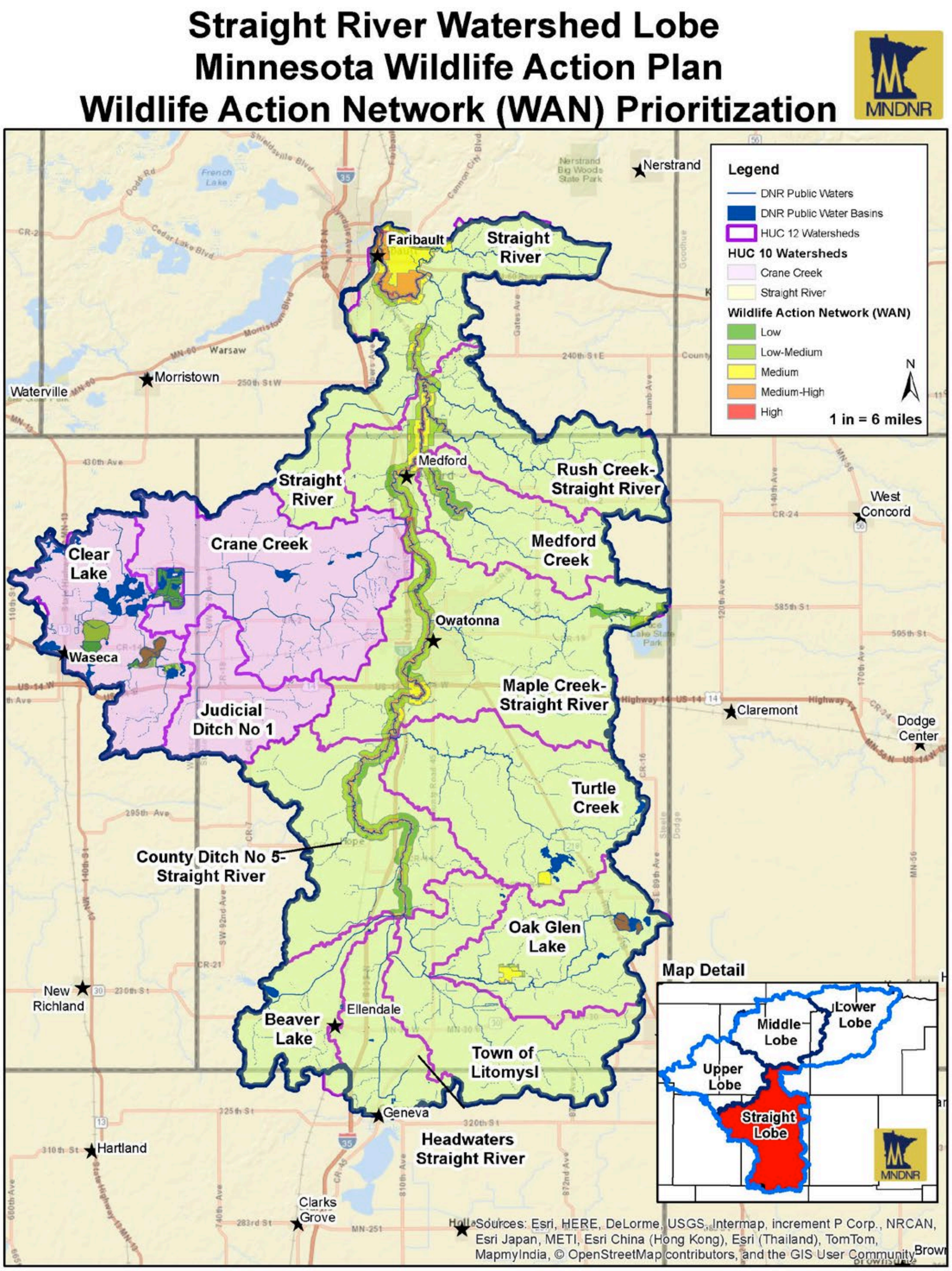


Table 12. Other tools for Targeting and Prioritization.

Resource	Utility	Location
Upper Cannon Terrain Analysis	High resolution focus for phosphorus and sediment reductions	Rice County
Straight River and tributaries *Gridded Surface/Subsurface Hydrologic Analysis (GSSHA)*	Examine BMP scenarios and critical areas for pollutant reduction, especially in Maple Creek	DNR
Little Cannon SWAT Model	Examine BMP scenarios and critical areas for pollutant reduction	MPCA & LimnoTech, Inc.
Nitrate impaired streams and streams with biota stressed by nitrate	Status indicators that could provide another "layer" of priority for N reduction	MPCA
Waters closest to standards	Status indicators that provide a high-level scoping of prioritization	MPCA
Volunteer well monitoring network	Grid of private drinking well nitrate data that could be used in examining N reduction priority areas	MDH
Nitrogen Fertilizer Management Plan monitoring data & maps	Private drinking well nitrate data that could be used in examining N reduction priority areas http://www.mda.state.mn.us/~/media/Files/chemicals/nfmp/nfmp2015.pdf	MDA
North Cannon River WMO Plan	Nitrate reduction work on the Trout Brook Watershed http://www.dakotaswcd.org/watersheds/ncrwmo/pdfs/NCRWMO%20Watershed%20Mgmt%20Plan%20Nov%202013%20full%20doc.pdf	Dakota SWCD and North Cannon WMO
Little CRW Geomorphology Assessment Report	Useful in examining sediment dynamics and prioritizing areas for natural stream channel work. January 2015.	DNR
Drinking Water Supply Management Areas (DWSMA) and Well Head Protection Areas for municipalities	http://www.health.state.mn.us/divs/eh/water/swp/swa/ http://www.health.state.mn.us/divs/eh/water/swp/whp/	MDH
Nitrate Risk Maps and Reports	http://www.health.state.mn.us/divs/eh/water/swp/nitrate/nitratemaps.html for Dakota, Goodhue, Rice and Steele Counties	MDH

3.2 Civic Engagement

Introduction

The CRW is unique in that it is one of the few major watersheds (HUC-8) in the state of Minnesota with a nonprofit organization focused on protecting and improving the water quality and natural systems in the watershed. The CRW Partnership (CRWP) is a 501 (c)(3), member-based organization founded in 1990. The CRWP Board includes elected officials (six County Commissioners, six SSWCD Supervisors) and citizen members (13 elected by the membership). CRWP's program areas include: wastewater, agriculture, and community engagement.

The CRWP has a long history of community engagement and partnering with local, regional, and state agencies in supporting their conservation programs and projects and at times serving in a coordinating role. One project that models this is the Southeast Minnesota Wastewater Initiative. Since 2002 this project has been helping small communities in the 11 counties of southeast Minnesota obtain adequate wastewater treatment. The CRWP provides the staffing for this effort with two Community Facilitators who work with citizen task forces to understand/define the problem, and then develop and implement solutions. This project won a Bush Community Innovation award in 2015.

Because agriculture is a dominant land use in the watershed, the CRWP has worked with farmers over the years to help improve soil and water quality. The CRWP has provided cost-share through the SWCDs and directly to landowners for conservation practices, hosted field days, educational workshops, and small-group discussions with farmers, collected water samples from farm fields to understand production systems, and most recently is helping to lead soil health groups and promote cover crops and other soil building practices. The CRWP's other community engagement work has focused on stormwater education and outreach through rain barrel and rain garden workshops, storm drain stenciling and removing debris from storm drains. The organization hosts an annual watershed-wide cleanup where citizens gather at various locations around the watershed to remove trash from local waterways.

In 2009, the CRWP was asked by the MPCA to help coordinate a pilot for watershed management efforts. Through a meeting process similar to that employed for WRAPS development, input from local partners produced a Watershed Management Strategy in 2011. This was not a state approved plan but served as a valuable exercise as to how the WRAPS might take shape and served as guidance for the CRWP and other local partners. It was this process that birthed the concept of "lobe meetings" that was applied during the course of WRAPS development.

The CRWP's history of engaging citizens, local and state partners provided a good platform for coordinating and convening stakeholders as the technical work and tools that are the foundation of the WRAPS were developed. The CRWP helped to include citizens in the collection of water quality data, local stakeholders in the review of the monitoring and assessment results, and extended invitations to participate in the WRAPS meetings to provide feedback that would inform the WRAPS document.

Planning and Process Design

The following are summaries of the main components of the planning and process design that was part of the WRAPS development process.

Gathering Information and Input

The CRW was fortunate to have a significant amount of data and information prior to the Watershed Assessment process. The 2011 CRW Management Strategy and other past work was reviewed and used to inform the process and content of the WRAPS. A process was developed for carrying out the Cannon WRAPS based on the pilot process CRWP had done to create the 2011 CRW Management Strategy. Because the Cannon Watershed is large and the landscape diverse, meetings and work sessions were held in each of the four "lobes" of the watershed (Upper Cannon, Middle Cannon, Lower Cannon, and the Straight River lobe) to facilitate more in-depth discussions with local partners and state agencies. A watershed wide "kick-off" meeting along with a series of three lobe meetings were held between (list dates). The lobe meetings were a time to share updates on the modeling work, discuss sources of pollution, restoration and protection priorities and implementation strategies. A finale meeting was held in February 2016 to present a draft document to attendees and solicit feedback.

A separate project sponsored by CRWP under a federal Section 319 of the Clean Water Act is currently underway through June 2017. This project is aimed at building a culture of civic participation that extends beyond individual interest in BMP adoption to better connect with local politics and identity. This focus is based on emerging results from social science research concerning natural resource conservation, especially things like leadership continuity, cross-jurisdictional coordination and trust.

Social Science Research

Results of the following research projects within the watershed or related to it informed discussions regarding the approach to WRAPS civic engagement:

- CRW: Landowner Survey on Water Resources and Conservation Action, Mae A. Davenport, Amit Pradhananga and Bjorn Olson, June 2014
- An Assessment of Agricultural Conservation Practices and Minnesota FarmWise in the CRW, Amit Pradhananga and Mae A. Davenport, July 2014
- Community Capacity Assessment in the CRW, Amit Pradhananga and Mae A. Davenport, 2015
- Landowner Motivations for Civic Engagement in Water Resource Protection, Amit K Pradhananga, Mae Davenport and Buorn Olson (December 2015) Journal of the American Water Resources Association, v.51, n.6

In 2013 and 2014, with funding from the MPCA, CRWP partnered with Mae Davenport from the University of Minnesota to conduct a landowner survey in the CRW. The purpose of the study was to assist water resource professionals and community decision-makers in better understanding landowners' beliefs, attitudes and behaviors associated with water resources and conservation action. Specific study objectives were to assess (1) landowner values and beliefs about their communities, the environment, water quality issues and water resource conservation; (2) landowner current and future conservation actions; and (3) who or what influences landowners' conservation decisions. Data were collected through a self-administered survey distributed to 1,082 landowners in the CRW. Findings from this report were used to help craft a project that received Section 319 Grant funding (see Recommendations section) in 2014 to implement some of the report recommendations in two subwatersheds.

A study specifically focused on agricultural practices and the Freshwater Society's FarmWise program conducted by University of Minnesota faculty, examined the capacity of agricultural communities to engage in sustainable watershed management, and developed a comprehensive decision framework that identifies drivers and constrains voluntary practices.

Lastly, CRWP and University of Minnesota faculty conducted a community capacity assessment using the Multilevel Community Capacity Model (MCCM) (Davenport and Seekamp 2013). The MPCA and CRWP staff has used the results of this study and the MCCM to help further identify gaps in community capacity or strengths to build on during upcoming community involvement efforts. The model provides a framework for talking about and assessing the capacity of individuals, groups, programs and organizations to engage the watershed management process. Fairness, legitimacy and trust are also addressed.

Implementation and Execution

Engagement via Tools

Engagement over the course of the CRW WRAPS was largely executed via three tools: HSPF modeling, Zonation and nitrogen best management practice (NBMP) and phosphorus best management practice (PBMP) spreadsheets. These tools, processes and results are discussed in detail in Chapters 3.1 and 3.3 and key meeting dates are tabulated in Table 13.

Stakeholder Outreach

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

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

CRWP Electronic Newsletter - *Cannon Currents*:

- July 2015 - Summary of WRAPS kickoff meeting
- September 2015 - WRAPS Round 2 Lobe Work Session announcement
- October 2015 - *WRAPS Process*
- January 2016 - WRAPS final watershed meeting in February CRWP Print Newsletter - *The Watershed Watcher* (last published in May 2014)
- May 2011 - *Watershed Report Card on the Way* - by MPCA staff, summary of IWM process
- November 2011 - *Health of the CRW* - by CRWP staff, summary of Surface Water Assessment Grant water chemistry and stream condition samples collected by CRWP staff and volunteers
- May 2012 - *Byllesby Reservoir Update: New Standard Adopted, Phosphorus Load Decreasing* - by Justin Watkins, MPCA, Byllesby Site Specific Standard and recent monitoring results
- May 2013 - *CRWP Partners with the University of Minnesota* - by CRWP staff, summary of surveys to assess citizen knowledge, behavior
- November 2013 - *The Current* -by CRWP Exec Director, update on survey project
- February 2014 - *2014 Minnesota 303(d) Impaired Waters List* - by CRWP staff, information about the draft list

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

Meetings

The CRWP hosted a series of meetings (Table 13) to provide information, receive feedback and input from a range of stakeholders in order to develop a WRAPS document that reflected local values and needs and summarized the current realities and possibilities for moving forward. The broad spectrum of stakeholders included local units of government, elected officials and staff, conservation professionals, urban residents, lakeshore owners, farmers, academics and others.

Table 13. WRAPS & TMDLs meetings summaries.

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

Date	Title/Topic	Attendees
February 17, 2016	Watershed Finale meeting covering feedback and comments on the draft WRAPS report, draft watershed TMDLs including phosphorus wasteload allocations, next step 1W1P overview, and a practitioner's perspective on growing cover crops in a corn-soybean rotation	County, city and SWCD staff, state agency staff, elected officials, urban residents, lakeshore residents, farmers, commodity group representatives, and CRWP Board members and staff

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

Progress Tracking

Overall the process of hosting public meetings in the lobe format worked well. It provided opportunities for interested stakeholders to learn about the watershed investigative work and provided an opportunity to solicit input and feedback. As the meetings played out the planning team offered to meet individually with groups to talk about various aspects of the models and tools if desired. Separate meetings were held with County and SWCD staff to help refine BMP combinations using the spreadsheet tools for nitrogen and phosphorus. A separate meeting was also held with municipalities to focus on TMDL wasteload allocations and questions related to wastewater effluent limits. Offers to meet with agricultural commodity groups were extended and WRAPS information will continue to be shared.

Coordination between WRAPS and Section 319 projects during event planning and debriefings was important in establishing how each project would engage or solicit community participation during the WRAPS process and beyond. Consequently, the Section 319 project is positioned to easily expand participation and focus more intentionally on engaging citizens as the watershed approach transitions to implementation planning. Using practices emerging from recent social science research, the Section 319 project is focused on shifting from customary outreach and education to inspiring local residents and others to take active roles in the watershed process over the long-haul with special attention to the common good. This shift is in response to, among other things, new challenges posed by a recent shift in programming from a focus on individual impaired waters to watershed-wide management.

Findings from the Outreach and Engagement Efforts

<u>WRAPS Meetings</u>

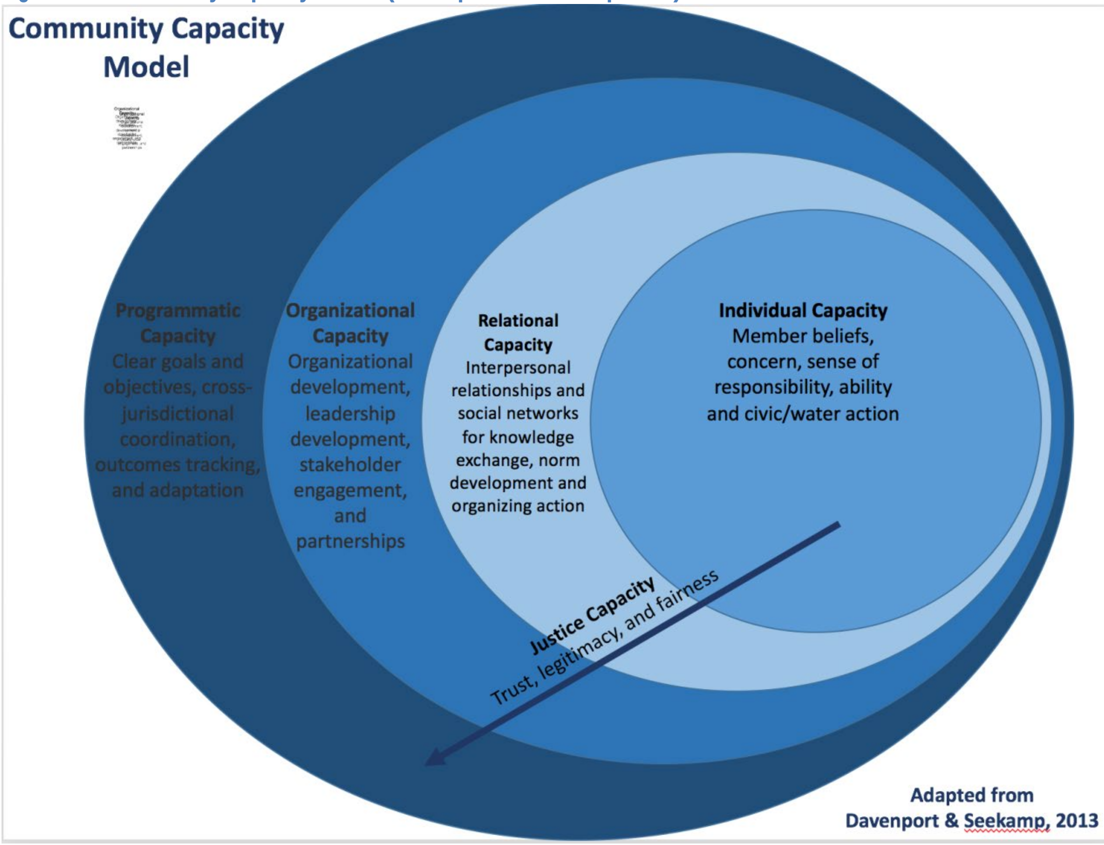
The meetings collected input and perspectives from stakeholders that inform the final document as well as help them understand and envision how they might participate or engage in implementation strategies.

During the lobe meetings a variety of topics were discussed (see Table 13), including sources of pollution, biological stressors, HSPF model development and scenario creation, NBMP Tool scenarios and Zonation, which informed strategies development. The strategies are presented in Chapter 3.3.

<u>Social Science Research</u>

The Multilevel Community Capacity Model (Davenport and Seekamp 2013) depicts five levels of community capacity that help project teams clarify the focus of and track public participation efforts. The WRAPS public meetings focused primarily on programmatic and organizational capacity with attention towards building trust and legitimacy in the process.

Figure 45. Community Capacity Model (Davenport & Seekamp 2013).



An in-depth understanding of insights depicted in concept maps like those provided below are used to inform the Watershed Management approach.

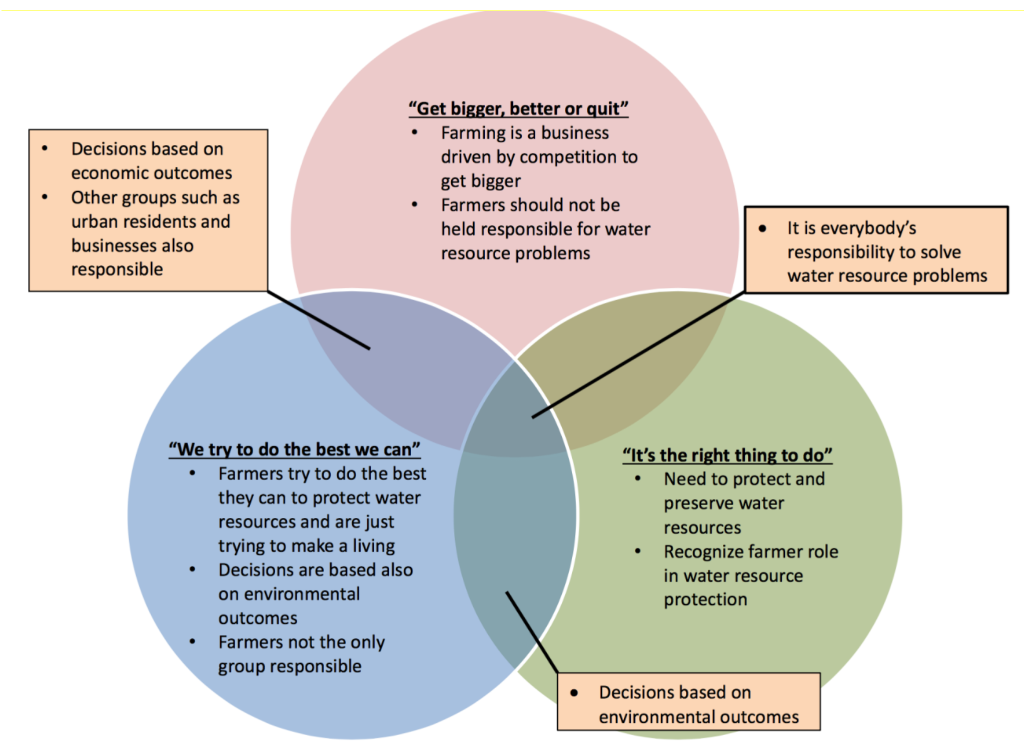


Figure 46. Agricultural Conservation Practices concept map (Pradhananga and Davenport 2014)

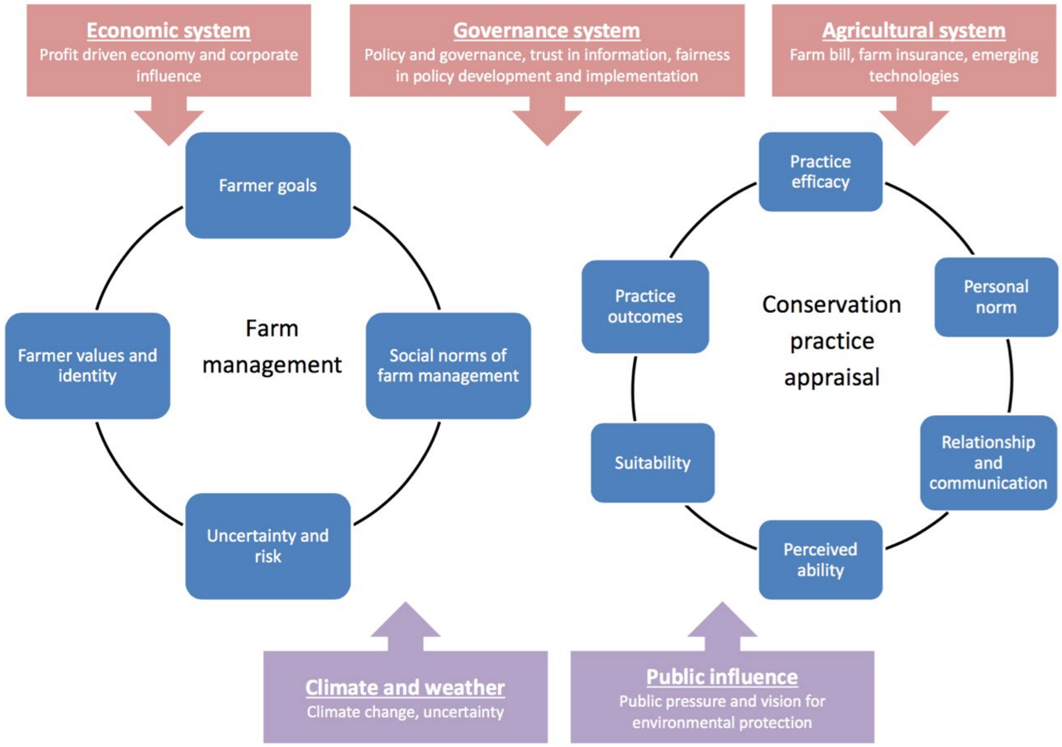


Figure 47. Community Capacity Assessment concept map (Pradhananga and Davenport 2015)

Discussion

The findings presented or referenced above indicate that there is willingness and interest on the part of stakeholders to participate in the Watershed Assessment and WRAPS process. By using actual social science qualitative analysis and a decision frameworks based on a social science framework like the Multilevel Community Capacity Model (Davenport and Seekamp 2013), the human dimension of the watershed management process can be more precise, intentional and reliable. These frameworks and models allow project teams to clarify desired outcomes and enable more meaningful progress tracking, increasing the chance of reaching project goals than more arbitrary approaches.

Recommendations

The watershed approach provides a context for more strategic capacity-building through application of a suite of social science and public participation principles and standards currently emerging within the natural resource management field. These are portrayed, in part, through the community assessment and other research projects referenced above. The Section 319 project, Building a Culture of Citizen Engagement, will explore this potential for more sustained and robust public participation. Focusing on two subwatersheds (Circle Lake and Waterville), the project will help inform the implementation by specifically exploring ways to overcome challenges to building a diverse and active base capable of providing local continuity over the long haul. Information and findings from the WRAPS process and/or presented in the WRAPS document along with other research noted in this section will help determine conditions influencing restoration and protection outlooks and practices.

The people-intensive aspect of watershed management work takes time, but more importantly precision and intentionality. In partnership with agencies overseeing implementation, the Section 319 project aims to provide this focus. By better utilizing and applying what is being learned through social science research, the goal is to ensure commitments from a more diverse and robust community presence as well as targeted capacity building for local conservation professionals and other local government officials and staff.

Funding through the Clean Water Legacy Fund and other avenues to continue the work begun by the CRW Partnership, MPCA, and other partners in this area is crucial. It is imperative that financial support be available to provide these "soft services" as well as monitoring and modeling.

Public Notice

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

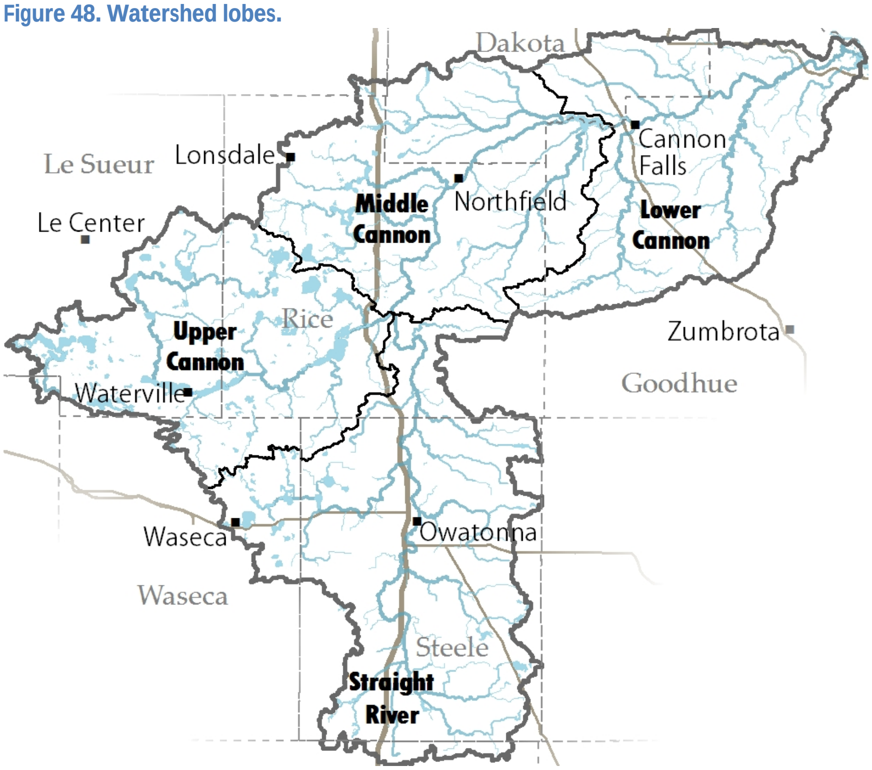
3.3 Restoration & Protection Strategies

The management strategies for the CRW are focused on protecting and improving local water and land resources, and take responsibility for a "fair share" of the needed pollutant load reductions in pursuit of downstream goals (i.e. Lake Pepin and Gulf Hypoxia). The following text provides explanation regarding the structure and content of Tables 16-20. Tools for examining priorities for both restoration and protection are discussed previously in Chapter 3.1.

Table Structure

Tables 16 through 20 describe watershed restoration and protection strategies and are divided by lobe with a map preceding each: All Watershed, Straight Rive Lobe, Upper Cannon Lobe, Middle Cannon Lobe, and Lower Cannon Lobe. This lobe format is consistent with planning and engagement efforts in the CRW to date and serves to break up the table thereby allowing for a wieldier examination of the rows and columns. Further, for strategies that apply generally and do not have attachment to specific impaired, supporting or priority waters, the All Watershed Table provides a useful summary (and reduces redundant entry of rows in the four lobe tables).

Figure 48. Watershed lobes.



Goals

Pollutant reduction goals for nitrogen (45% by 2040 with interim goal of 20% by 2025) and phosphorus (12% by 2025) were selected to be consistent with Minnesota's NRS (2014). For local impairments in the

CRW, the respective nutrient reduction goals are listed for each waterbody. Some HUC-10 watersheds do not include local nutrient-caused impairments, but example goal attainment scenarios are included because each watershed must pursue reductions per NRS goals. Example estimated scales of adoption of BMP combinations were carefully constructed with stakeholders to attain the interim goal of 20% nitrogen reduction and the final goal of 12% phosphorus reduction for one or more HUC-10 watershed each watershed lobe.

For nitrate impaired or stressed streams, the 20% reduction goal would approximate goal attainment. For many phosphorus impaired lakes, a 12% reduction in phosphorus may not attain goals, but more information is needed to understand the relative contributions of watershed and internal nutrient loads. While models and tools used during WRAPs development and engagement are good for targeting implementation to various scales (e.g. approximately HUC-12 with HSPF) they are not well-suited to estimate scales of adoption needed for goal attainment at very small scales (e.g. a small lake watershed). For these reasons stakeholders agreed that pursuit of the 12% reduction described in the NRS is an appropriate goal for 2025 (a year that coincides with the next Cannon WRAPS iteration, which will allow for re-examination of conditions and goals). Other tools like the terrain analysis in the upper Cannon lobe (developed by Rice County) may be developed and applied in the future.

While TSS and pathogen goals are described in the table, in most cases the strategies for addressing these pollutants are shared with those for phosphorus. This is consistent with other WRAPS in southeast Minnesota (e.g. the approved Mississippi River Lake Pepin WRAPS grouped *Strategies for addressing volume, sediment, phosphorus and pathogens*) in that the BMPs address runoff-driven pollutant loads. The Root River Field to Stream Partnership has found via five years of monitoring at numerous field edges in rural southeast Minnesota that approximately 90% of the runoff and associated nutrient and sediment losses often occur together over the four-month span of March through June (Kuehner 2016). Further, there is no available tool to estimate scales of adoption specific to TSS or pathogen goal attainment at small scales (e.g. HUC-10).

Core Strategies for Restoration

Restoration strategies are largely focused on nonpoint source nutrient reduction because (1) many CRW impairments are driven by nonpoint nutrient loads, (2) the best tools for examining estimated scales of adoption to achieve reduction goals are centered on nitrogen and phosphorus. The strategies included in Tables 17 through 20 are founded on core combinations of BMPs that were examined closely by technical practitioners and vetted with local stakeholders in both meeting and work session environments. The nutrient BMP spreadsheets for both nitrogen and phosphorus (developed by University of Minnesota) were used to iteratively examine the combinations of practices and the resultant load reductions. The spreadsheets represent the best available tools for engaging stakeholders in this context. The HSPF model scenario simulations show general agreement with the reduction estimates provided by the spreadsheets (see Chapter 3.1 for summary table depicting HSPF scenarios and respective load reduction estimates).

To achieve the 2025 nitrogen reduction goal, stakeholders made use of the following core strategies as starting points for constructing combinations of BMPs that together resulted in goal attainment. See Table 15 for more details:

- **Source reduction**: Greater than 50% of corn acres receive target N rate (University of MN Maximum Return to Nitrate fertilization rate) – this strategy did not include N-inhibitors or timing shift.

- **Vegetative changes:**
    - o Greater than 67% of short season crop acres (including corn silage) are planted to a cereal rye cover crop.
    - o Greater than 15% of corn and soybean acres planted to cereal rye cover crop.
    - o Greater than 20% of marginal corn and soybean acres are planted to perennial vegetation or crops.

To achieve the 2025 phosphorus reduction goal, the base combination of BMPs includes the nitrogen-focused practices above plus gains in reduced tillage on greater than 30% of row crop acres and full implementation of the buffer rule (see Table 14). The selected BMPs and estimated scales of adoption for both nitrogen and phosphorus were developed by local stakeholders and have been supported as attainable watershed goals. In the four watershed lobes, the example combinations of BMPs that attain the goals vary somewhat but are founded on these core strategies, which summarize *what needs to happen* with regard to nutrient reduction in the CRW.

Permits will describe the means for pursuing pollutant reductions from point sources (Municipal Separate Storm Sewer Systems (MS4s) and municipal and industrial wastewater). In the case of MS4s, it is important to note that loading reduced via some implementation actions is creditable to the load allocation and some to the wasteload allocation. Examples of non-WLA-creditable projects include strategies aimed at reducing in-lake loading (e.g. in-lake management). For clarification on a particular project, proposers should contact the MPCA Stormwater Program.

Figure 49. 10-digit HUCs.

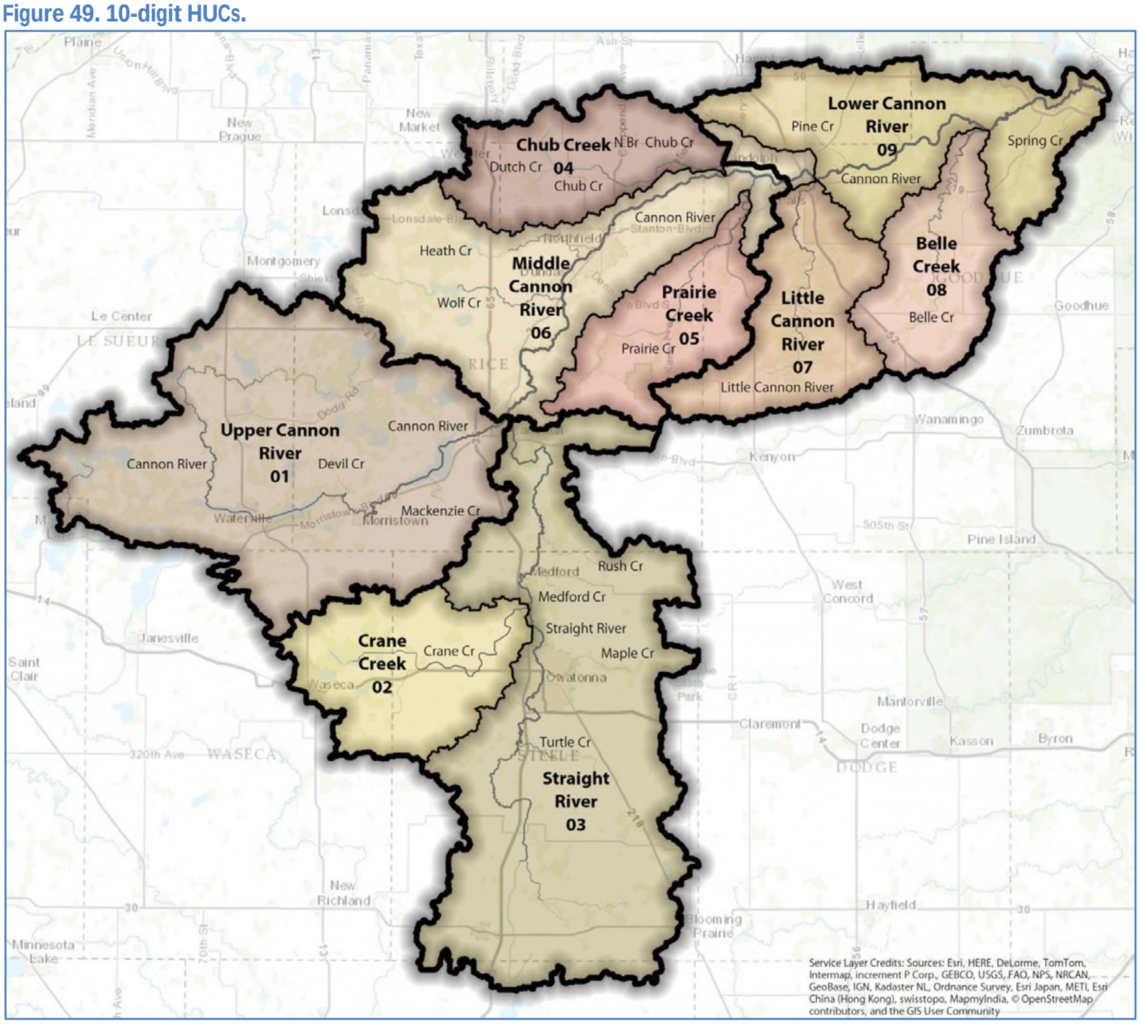


Table 14. Example scales of adoptions that attain phosphorus reduction goals.

Phosphorus (P) BMPs	Upper Cannon HUC 10 (01), % Adoption	Straight River HUC 10 (03), % Adoption	Chub Crk. HUC 10 (04), % Adoption	Prairie Creek HUC 10 (05), % Adoption	Little Cannon HUC 10 (07), % Adoption	Belle Creek HUC10 (08), % Adoption	Lower Cannon HUC 10 (09) % Adoption
Acres of Cropland	112,000	150,000	32,000	33,000	33,000	34,000	47,000
Target P205 rate				80%	80%	80%	
Fall corn fertilization to pre-plant/starter			100%	60%	50%	45%	100%
Use reduced tillage on corn, soy, and small grains >2%	10%	25%	10%	50%	50%	50%	10%
Riparian Buffers, 50ft wide	95%	95%	100%	100%	100%	100%	100%
Perennial crop % of marginal corn and soybean land	75%	10%	20%	5%	7%	2%	40%
C-B acres w/ cereal rye cover crop	15%	10%	10%	10%	15%	20%	10%
Short season crops planted to a rye cover crop	80%	80%	80%	50%	65%	65%	80%
Inject/incorporate manure				85%	85%	60%	20%
Control drainage			10%				10%
Cropland P load reduction with these adoption rates	13.8%	12.1%	12.8%	19.5%	21.2%	22.0%	12.2%
Treatment Cost/yr.	$1,730,000	$1,470,000	$490,000	$350,000	$370,000	$430,000	$890,000
P fertilizer cost savings from reduced inputs	$0	$0	$0	$380,000	$430,000	$410,000	$0
Net BMP Treatment Cost	$1,730,000	$1,470,000	$490,000	$30,000	$60,000	$20,000	$890,000

Table 15. Example scales of adoptions that attain nitrogen reduction goals.

Nitrogen (N) BMPs	Upper Cannon HUC 10 (01), % Adoption	Straight River HUC 10 (03), %Adoption	Chub Creek HUC 10 (04), % Adoption	Prairie Creek HUC 10 (05), % Adoption	Little Cannon HUC 10 (07), % Adoption	Belle Creek HUC10 (08), % Adoption	Lower Cannon HUC 10 (09), % Adoption
Acres of Cropland	112,000	150,000	32,000	33,000	33,000	34,000	47,000
Corn acres receiving N rate, no inhibitor/timing shift	40%	70%	50%	75%	75%	75%	50%
Fall N applications switched to Spring	40%	30%		60%	60%	60%	100%
Fall N switch to Spring/side dressing		30%	50%	20%	20%	20%	
Restored Wetlands	10%		30%				
Saturated Buffers	20%			2%	2%	2%	10%
Riparian Buffers, 100/2= 50ft wide [model adjmt.]	48%	48%	50%	48%	48%	48%	50%
Corn and soy acres w/ cereal rye cover crop	15%	10%	10%	10%	15%	20%	10%
Short season crops planted to a rye cover	80%	80%	80%	50%	65%	65%	80%
Perennial crop % of marginal c-b land	100%	10%	20%	5%	7%	2%	20%
Cropland N load reduction with these adoption rates	20.9%	20.2%	19.9%	19.2%	19.6%	21.8%	20.7%
Treatment Cost/yr.	$2,110,000	$1,660,000	$400,000	$330,000	$490,000	$620,000	$680,000
N fertilizer cost savings from reduced inputs	$590,000	$710,000	$90,000	$170,000	$200,000	$220,000	$260,000
Net BMP Treatment Cost	$1,520,000	$950,000	$300,000	$160,000	$290,000	$400,000	$410,000

Core Strategies for Protection

Protection considerations and strategies are overviewed in Chapter 2.5. Specific strategies included in subsequent tables are summarized below.

- Maintain and preserve perennial lands
    - o Keep existing pastures and rangeland; look for opportunities to convert marginal row crop acres. Pasture is a working-lands BMP that is an integral part of local economies
    - o Encourage re-enrollment of expiring CRP contracts
    - o Manage forest acres with stewardship planning
    - o Keep the watersheds of the five remaining fully supporting lakes in perennial cover (i.e. no net loss of perennial cover)
- Protect high quality water and land resources via easements and fee title acquisition with focus provided by tools summarized in Section 3.1
- Pursue DNR Fisheries management easements on streams as a protection measure and a means of focusing habitat improvement money
- Enforce the Wetlands Conservation Act and work toward no net loss of wetlands in the watershed (i.e. mitigation of wetland impacts to be kept within the confines of the CRW)
- Protect the base flow of the CRW trout streams

Broad Watershed Strategies

There are no tools (like those available for phosphorus and nitrogen) for estimating scales of adoption required for habitat work, pathogen reduction or protection strategies. The WRAPS engagement process was focused on estimating scales of adoption needed to achieve nutrient reduction goals; those details are included in subsequent watershed lobe tables. It should be noted that many strategies to address nutrient reduction will likely have positive impacts in terms of both *E. coli* load reductions and habitat improvements.

The presence of fecal pathogens in surface water is a regional problem in southeast Minnesota. The issue was well-described in a stakeholder-driven process that culminated in approval of 39 approved fecal coliform TMDLs for streams and rivers in the region. The *Revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota*, approved in 2006, can be reviewed at the MPCA web site: http://www.pca.state.mn.us/index.php/view-document.html?gid=8006. Subsequent to TMDL approval, stakeholders completed an implementation plan: http://www.pca.state.mn.us/index.php/view-document.html?gid=8013. According to the findings and strategies summarized in these documents, numerous projects have been executed in efforts to reduce pathogen loading to the region's surface waters. Feedlot runoff, unsewered communities and over-grazed pastures (among others) have all been addressed via grant funding. The WRAPS engagement process in the CRW did not describe new strategies for *E. coli* reduction; nor were any stream reaches specified as priority (and as such there is not a need to include individual table rows for each impairment). Rather, the additional *E. coli* TMDLs in the CRW (see Appendix A) should be considered (for planning purposes) an addendum to the Regional TMDL work.

Habitat as a stressor of aquatic life (fish and "bugs") is ubiquitous in the CRW (and in southeast Minnesota). Strategies and prioritization for habitat improvement at various scales is managed by the DNR. Appendix B includes IBI values for stream reaches that have confirmed aquatic life impairments and associated habitat stressors; they provide some measure going forward as habitat improvement efforts continue.

Table 16. Broad strategies for entire CRW.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy Type
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goal		
All	All	All	Parameters cited in permit	-	-	Municipal & Industrial Wastewater	Compliance with NPDES permits which will reflect WLAs.
			Parameters cited in permit	-	-	Urban Stormwater	Compliance with NPDES permits which will reflect WLAs. http://stormwater.pca.state.mn.us/index.php/Main_Page
			Parameters cited in permit	-	-	Construction and Industrial Stormwater permittees -- compliance with general permits	Compliance with NPDES permits
	See Appendix B that lists all streams stressed by habitat impacts (22 AUIDs)	All	**Habitat**	See Appendix B for fish and macroinvertebrate IBI values	IBI values at or above thresholds	**Address Physical Habitat and Channel Geometry following Natural Channel Design Principals**	Stream habitat improvements when needed to address local stressor or cause of impairment
							Stream Restorations
							Bank shaping and Floodplain Reconnection for incised channels

						Improve Connectivity	Address road crossing structures causing connectivity issues to biological movement, sediment transport and/or alter local hydrology
						Protect recovering ditch systems	Avoid or minimize ditch clean-out
						Vegetation Changes	Implement buffer rule
	See appendix A for list of E. coli impairments	All	**E. coli**	See appendix A for E. coli geomeans	Geomeans <126 org/100ml	**Regional Strategies for Pathogen Reduction**	SE Fecal TMDL - 2007 SEMN Bacteria Implementation Plan https://www.pca.state.mn.us/sites/default/files/wq-iw9-02c.pdf
						Inspect Feedlots	Focus on shoreland feedlots with Open Lot Agreements in place
	All	All	**All conventional parameters**	-	-	**Maintain and Preserve Perennial Lands**	No net loss of pasture and rangeland
							Forest Stewardship Plans for wooded acres
							Land Covenants e.g. Sustainable Forestry Incentive Act
							Agricultural and Land Management Leases
							Property Tax credits and reductions e.g. Managed Forest Land 2c and Native Prairie Tax Exemption

							Encourage re-enrollment of expiring CRP contracts
						Protect unique land and water features	Easement and acquisition
						Shoreland and Floodplain Management	Enforce MN rule 6120: Shoreland and Floodplain Management
			Flow	-	Diversion limit of no more than 10% of the August median base flow will preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions.	**Protect baseflow of trout streams**	Focused monitoring and application of water appropriation analysis
			All conventional parameters	-	-	**Keep existing water storage**	No net loss of wetlands; keep wetland banking transactions within CRW

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

3.3.1 Upper Cannon River

Figure 50. Upper Cannon lobe map.

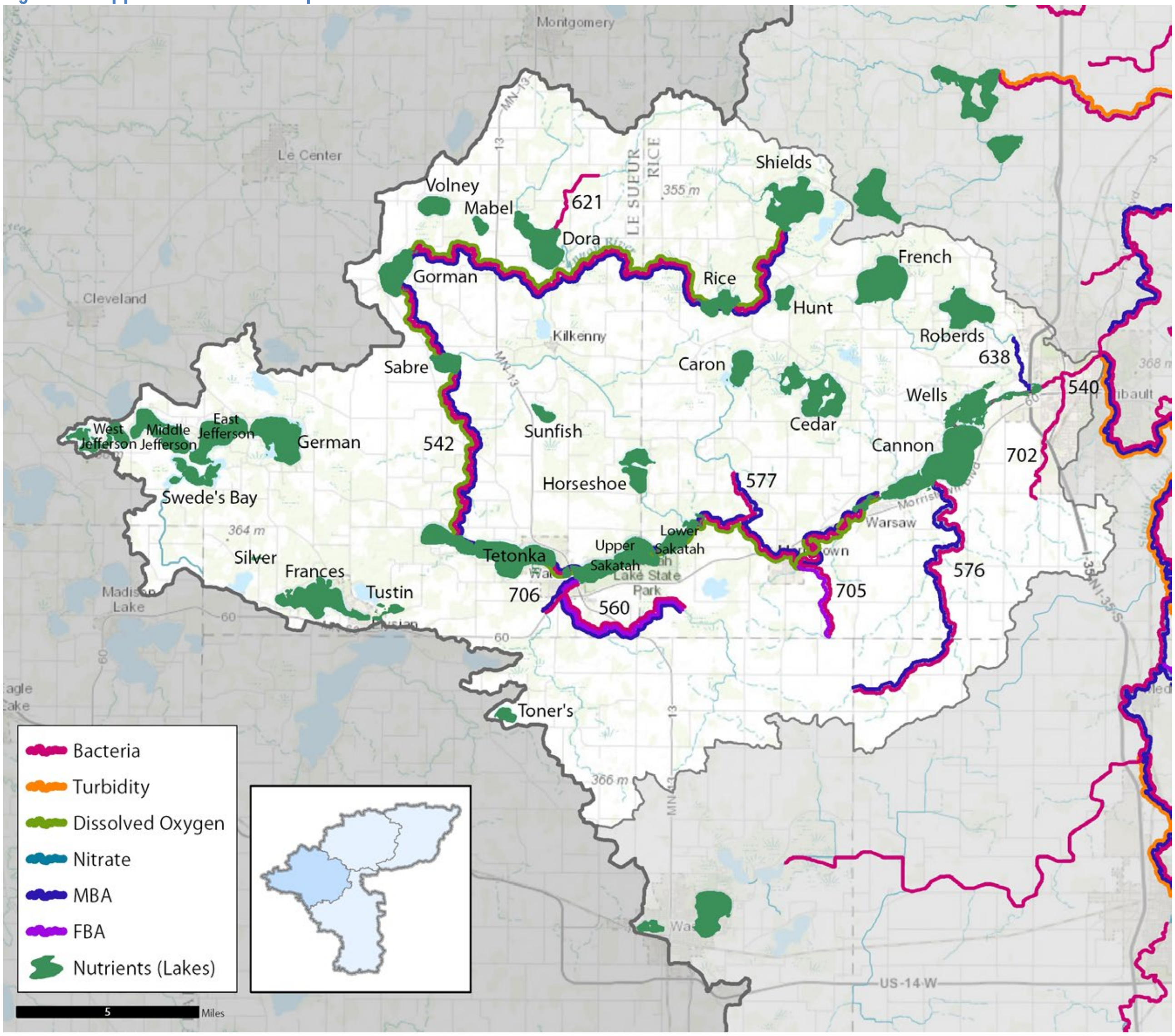


Table 17. Strategies and actions proposed for the Upper CRW.

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter	Water Quality: Current Conditions	Water Quality: Goal	Strategies (see key below)	Specific Strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	LeSueur	Rice	Waseca	BWSR	MDA	Estimated Year to Achieve Water Quality Target
						Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.					Governmental Units with Primary Responsibility									
0704000201 Upper Cannon	All	Rice, Steele, Waseca and Le Sueur Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.														
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	40% [103,000]		•		•					•	2040 per NRS
						Shift Fall N applications	Switch to spring			40% [57,000]		•		•					•	
							Switch to split spring/sidedressing					•		•					•	
						Structural N reduction BMPs	Restored wetlands			10% [11,000]	•	•		•				•		
							Saturated buffers			20% [12,000]		•		•				•		
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Convert riparian lands to perennials per 50 foot buffer rule			100% [19,000]		•		•	•	•	•	•		
							Cover crops on corn/soybean acres			15% [54,000]		•		•				•	•	
							Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			80% [26,000]		•		•				•	•	
							Perennial crop applied to marginal (cultivated lands with Crop Productivity Index< 60) corn/soybean acres			100% [96,000]		•		•				•		
	All	Rice, Steele, Waseca and Le Sueur Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe goal of 12% load reduction per Nutrient Reduction Strategy	The PBMP tool was applied to examine 12% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.														
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines	28%	12% phosphorus load reduction by 2025 per NRS			•		•					•	2025 per NRS

	Cannon	Rice		78706 kg/yr TP	1568 kg/yr TP	Vegetation Changes	Convert riparian lands to perennials per buffer rule	6%		100% [5,000]		•		•	•	•	•	•		
	Caron	Rice		4779 kg/yr TP	421 kg/yr TP															
	Cedar	Rice		1123 kg/yr TP	701 kg/yr TP															
	Dora	Le Sueur		9374 kg/yr TP	841 kg/yr TP															
	East Jefferson	Le Sueur		1700 kg/yr TP	534 kg/yr TP		Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			75% [1,500]		•		•						
	Frances	Le Sueur		2280 kg/yr TP	490 kg/yr TP															
	French	Rice		7619 kg/yr TP	580 kg/yr TP															
	German	Le Sueur		1477 kg/yr TP	583 kg/yr TP															
	Gorman	Le Sueur		27028 kg/yr TP	1760 kg/yr TP															
	Horseshoe	Le Sueur and Rice		939 kg/yr TP	438 kg/yr TP															
	Hunt	Rice		408 kg/yr TP	72 kg/yr TP		Cover crops on corn/soybean acres			15% [500]		•		•					•	
	Lower Sakatah	Rice		46184 kg/yr TP	5763 kg/yr TP															
	Mabel	Le Sueur		368 kg/yr TP	127 kg/yr TP															
	Middle Jefferson	Le Sueur		1340 kg/yr TP	254 kg/yr TP															
	Rice	Rice		7637 kg/yr TP	591 kg/yr TP		Short season crops planted to a cereal rye cover crop			80% [500]		•		•					•	
	Roberds	Rice		9529 kg/yr TP	496 kg/yr TP															
	Sabre	Le Sueur		35476 kg/yr TP	2306 kg/yr TP															
	Shields	Rice		13536 kg/yr TP	571 kg/yr TP															
	Silver	Le Sueur		33 kg/yr TP	12 kg/yr TP															
	Sunfish	Le Sueur		840 kg/yr TP	287 kg/yr TP	Structural Changes	Use reduced tillage on corn, soybeans and small grains > 2% slope	23%		10% [500]		•		•						
	Swede's Bay	Le Sueur		3566 kg/yr TP	286 kg/yr TP															
	Tetonka	Le Sueur		82779 kg/yr TP	3913 kg/yr TP															
	Toner's	Waseca		291 kg/yr TP	39 kg/yr TP															
	Tustin	Le Sueur		932 kg/yr TP	207 kg/yr TP															
	Upper Sakatah	Le Sueur and Rice		56836 kg/yr TP	8924 kg/yr TP															
	Volney	Le Sueur		773 kg/yr TP	291 kg/yr TP		Structural impoundment BMP			30% of cropland acres	•	•		•						
	Wells	Rice		59957 kg/yr TP	8460 kg/yr TP															
	West Jefferson	Le Sueur		396 kg/yr TP	140 kg/yr TP															
	Dudley	Rice	Phosphorus	146 kg/yr TP	128 kg/yr TP	Vegetation Maintenance	Maintain or increase perennial vegetation in watersheds				•	•	•	•				•		
							Protect or restore native riparian vegetation				•	•	•	•		•		•		

	Fish	Le Sueur		21 kg/yr TP	18 kg/yr TP	Policy & Ordinance	Avoid or mitigate for future proposed agricultural drainage improvement projects					•	•	•	•	•			•		
	Kelly	Rice		182 kg/yr TP	160 kg/yr TP		Require land in the shore impact zone to be established, maintained, or restored in native/perennial riparian buffer at the time of development or at the time of permit issuance					•	•	•	•		•		•		
	Roehmildts	Le Sueur		318 kg/yr TP	280 kg/yr TP		Adhere/increase shoreland setbacks.					•	•	•	•	•			•		

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

HUC-10 Subwatershed	Waterbody and Location		Parameter	Water Quality		Strategies (see key below)	Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.				Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate												
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goal		Specific Strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	LeSueur	Rice	Waseca	BWSR	MDA	
0704000201 Upper Cannon	All	Rice, Steele, Waseca and Le Sueur Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.														
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	40% [103,000]		•		•					•	2040 per NRS
						Shift Fall N applications	Switch to spring			40% [57,000]		•		•					•	
							Switch to split spring/sidedressing					•		•					•	
						Structural N reduction BMPs	Restored wetlands			10% [11,000]	•	•		•				•		
							Saturated buffers			20% [12,000]		•		•				•		
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Convert riparian lands to perennials per 50 foot buffer rule			100% [19,000]		•		•	•	•	•	•		
							Cover crops on corn/soybean acres			15% [54,000]		•		•				•	•	

							Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			80% [26,000]		•		•				•	•	
							Perennial crop applied to marginal (cultivated lands with Crop Productivity Index< 60) corn/soybean acres			100% [96,000]		•		•				•		
						The PBMP tool was applied to examine 12% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.														
	All	Rice, Steele, Waseca and Le Sueur Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe goal of 12% load reduction per Nutrient Reduction Strategy	**Reduced Inputs**	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines	28%	12% phosphorus load reduction by 2025 per NRS			•		•					•	2025 per NRS
	Cannon	Rice		78706 kg/yr TP	1568 kg/yr TP	**Vegetation Changes**	Convert riparian lands to perennials per buffer rule	6%		100% [5,000]		•		•	•	•	•	•		
	Caron	Rice		4779 kg/yr TP	421 kg/yr TP															
	Cedar	Rice		1123 kg/yr TP	701 kg/yr TP															
	Dora	Le Sueur		9374 kg/yr TP	841 kg/yr TP															
	East Jefferson	Le Sueur		1700 kg/yr TP	534 kg/yr TP		Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			75% [1,500]		•		•						
	Frances	Le Sueur		2280 kg/yr TP	490 kg/yr TP															
	French	Rice		7619 kg/yr TP	580 kg/yr TP															
	German	Le Sueur		1477 kg/yr TP	583 kg/yr TP															
	Gorman	Le Sueur		27028 kg/yr TP	1760 kg/yr TP															
	Horseshoe	Le Sueur and Rice		939 kg/yr TP	438 kg/yr TP															
	Hunt	Rice		408 kg/yr TP	72 kg/yr TP		Cover crops on corn/soybean acres			15% [500]		•		•					•	
	Lower Sakatah	Rice		46184 kg/yr TP	5763 kg/yr TP															
	Mabel	Le Sueur		368 kg/yr TP	127 kg/yr TP															
	Middle Jefferson	Le Sueur		1340 kg/yr TP	254 kg/yr TP															
	Rice	Rice		7637 kg/yr TP	591 kg/yr TP		Short season crops planted to a cereal rye cover crop			80% [500]		•		•					•	
	Roberds	Rice		9529 kg/yr TP	496 kg/yr TP															
	Sabre	Le Sueur		35476 kg/yr TP	2306 kg/yr TP															
	Shields	Rice		13536 kg/yr TP	571 kg/yr TP															
	Silver	Le Sueur		33 kg/yr TP	12 kg/yr TP															

	Sunfish	Le Sueur		840 kg/yr TP	287 kg/yr TP	Structural Changes	Use reduced tillage on corn, soybeans and small grains > 2% slope	23%		10% [500]		•		•							
	Swede's Bay	Le Sueur		3566 kg/yr TP	286 kg/yr TP																
	Tetonka	Le Sueur		82779 kg/yr TP	3913 kg/yr TP																
	Toner's	Waseca		291 kg/yr TP	39 kg/yr TP																
	Tustin	Le Sueur		932 kg/yr TP	207 kg/yr TP																
	Upper Sakatah	Le Sueur and Rice		56836 kg/yr TP	8924 kg/yr TP																
	Volney	Le Sueur		773 kg/yr TP	291 kg/yr TP																
	Wells	Rice		59957 kg/yr TP	8460 kg/yr TP		Structural impoundment BMP			30% of cropland acres	•	•		•							
	West Jefferson	Le Sueur		396 kg/yr TP	140 kg/yr TP																
	Dudley	Rice	Phosphorus	146 kg/yr TP	128 kg/yr TP	Vegetation Maintenance	Maintain or increase perennial vegetation in watersheds					•	•	•	•				•		
							Protect or restore native riparian vegetation					•	•	•	•		•		•		
	Fish	Le Sueur		21 kg/yr TP	18 kg/yr TP	Policy & Ordinance	Avoid or mitigate for future proposed agricultural drainage improvement projects					•	•	•	•	•			•		
	Kelly	Rice		182 kg/yr TP	160 kg/yr TP		Require land in the shore impact zone to be established, maintained, or restored in native/perennial riparian buffer at the time of development or at the time of permit issuance					•	•	•	•		•		•		
	Roehmildts	Le Sueur		318 kg/yr TP	280 kg/yr TP		Adhere/increase shoreland setbacks.					•	•	•	•	•			•		

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

HUC-10 Subwatershed	Waterbody and Location		Parameter	Water Quality		Strategies (see key below)	Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.				Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate												
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goal		Specific Strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	LeSueur	Rice	Waseca	BWSR	MDA	
0704000201 Upper Cannon	All	Rice, Steele, Waseca and Le Sueur Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.														2040 per NRS
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	40% [103,000]		•		•					•	
						Shift Fall N applications	Switch to spring			40% [57,000]		•		•					•	
							Switch to split spring/sidedressing					•		•					•	
						Structural N reduction BMPs	Restored wetlands			10% [11,000]	•	•		•				•		
							Saturated buffers			20% [12,000]		•		•				•		
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Convert riparian lands to perennials per 50 foot buffer rule			100% [19,000]		•		•	•	•	•	•		
							Cover crops on corn/soybean acres			15% [54,000]		•		•				•	•	
							Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			80% [26,000]		•		•				•	•	

							Perennial crop applied to marginal (cultivated lands with Crop Productivity Index< 60) corn/soybean acres			100% [96,000]		•		•				•		
						The PBMP tool was applied to examine 12% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.														
	All	Rice, Steele, Waseca and Le Sueur Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe goal of 12% load reduction per Nutrient Reduction Strategy	**Reduced Inputs**	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines	28%	12% phosphorus load reduction by 2025 per NRS			•		•					•	2025 per NRS
	Cannon	Rice		78706 kg/yr TP	1568 kg/yr TP	**Vegetation Changes**	Convert riparian lands to perennials per buffer rule	6%		100% [5,000]		•		•	•	•	•	•		
	Caron	Rice		4779 kg/yr TP	421 kg/yr TP															
	Cedar	Rice		1123 kg/yr TP	701 kg/yr TP															
	Dora	Le Sueur		9374 kg/yr TP	841 kg/yr TP															
	East Jefferson	Le Sueur		1700 kg/yr TP	534 kg/yr TP		Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			75% [1,500]		•		•						
	Frances	Le Sueur		2280 kg/yr TP	490 kg/yr TP															
	French	Rice		7619 kg/yr TP	580 kg/yr TP															
	German	Le Sueur		1477 kg/yr TP	583 kg/yr TP															
	Gorman	Le Sueur		27028 kg/yr TP	1760 kg/yr TP															
	Horseshoe	Le Sueur and Rice		939 kg/yr TP	438 kg/yr TP															
	Hunt	Rice		408 kg/yr TP	72 kg/yr TP		Cover crops on corn/soybean acres			15% [500]		•		•					•	
	Lower Sakatah	Rice		46184 kg/yr TP	5763 kg/yr TP															
	Mabel	Le Sueur		368 kg/yr TP	127 kg/yr TP															
	Middle Jefferson	Le Sueur		1340 kg/yr TP	254 kg/yr TP															
	Rice	Rice		7637 kg/yr TP	591 kg/yr TP		Short season crops planted to a cereal rye cover crop			80% [500]		•		•					•	
	Roberds	Rice		9529 kg/yr TP	496 kg/yr TP															
	Sabre	Le Sueur		35476 kg/yr TP	2306 kg/yr TP															
	Shields	Rice		13536 kg/yr TP	571 kg/yr TP															
	Silver	Le Sueur		33 kg/yr TP	12 kg/yr TP															
	Sunfish	Le Sueur		840 kg/yr TP	287 kg/yr TP			23%		10% [500]		•		•						

	Swede's Bay	Le Sueur		3566 kg/yr TP	286 kg/yr TP	**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope												
	Tetonka	Le Sueur		82779 kg/yr TP	3913 kg/yr TP														
	Toner's	Waseca		291 kg/yr TP	39 kg/yr TP														
	Tustin	Le Sueur		932 kg/yr TP	207 kg/yr TP														
	Upper Sakatah	Le Sueur and Rice		56836 kg/yr TP	8924 kg/yr TP														
	Volney	Le Sueur		773 kg/yr TP	291 kg/yr TP														
	Wells	Rice		59957 kg/yr TP	8460 kg/yr TP		Structural impoundment BMP			30% of cropland acres	•	•		•					
	West Jefferson	Le Sueur		396 kg/yr TP	140 kg/yr TP														
	Dudley	Rice	Phosphorus	146 kg/yr TP	128 kg/yr TP	**Vegetation Maintenance**	Maintain or increase perennial vegetation in watersheds				•	•	•	•				•	
							Protect or restore native riparian vegetation				•	•	•	•		•		•	
	Fish	Le Sueur		21 kg/yr TP	18 kg/yr TP	**Policy & Ordinance**	Avoid or mitigate for future proposed agricultural drainage improvement projects				•	•	•	•	•			•	
	Kelly	Rice		182 kg/yr TP	160 kg/yr TP		Require land in the shore impact zone to be established, maintained, or restored in native/perennial riparian buffer at the time of development or at the time of permit issuance				•	•	•	•		•		•	
	Roehmildts	Le Sueur		318 kg/yr TP	280 kg/yr TP		Adhere/increase shoreland setbacks.				•	•	•	•	•			•	

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

3.3.2 Straight River

Figure 51. Straight River lobe map.

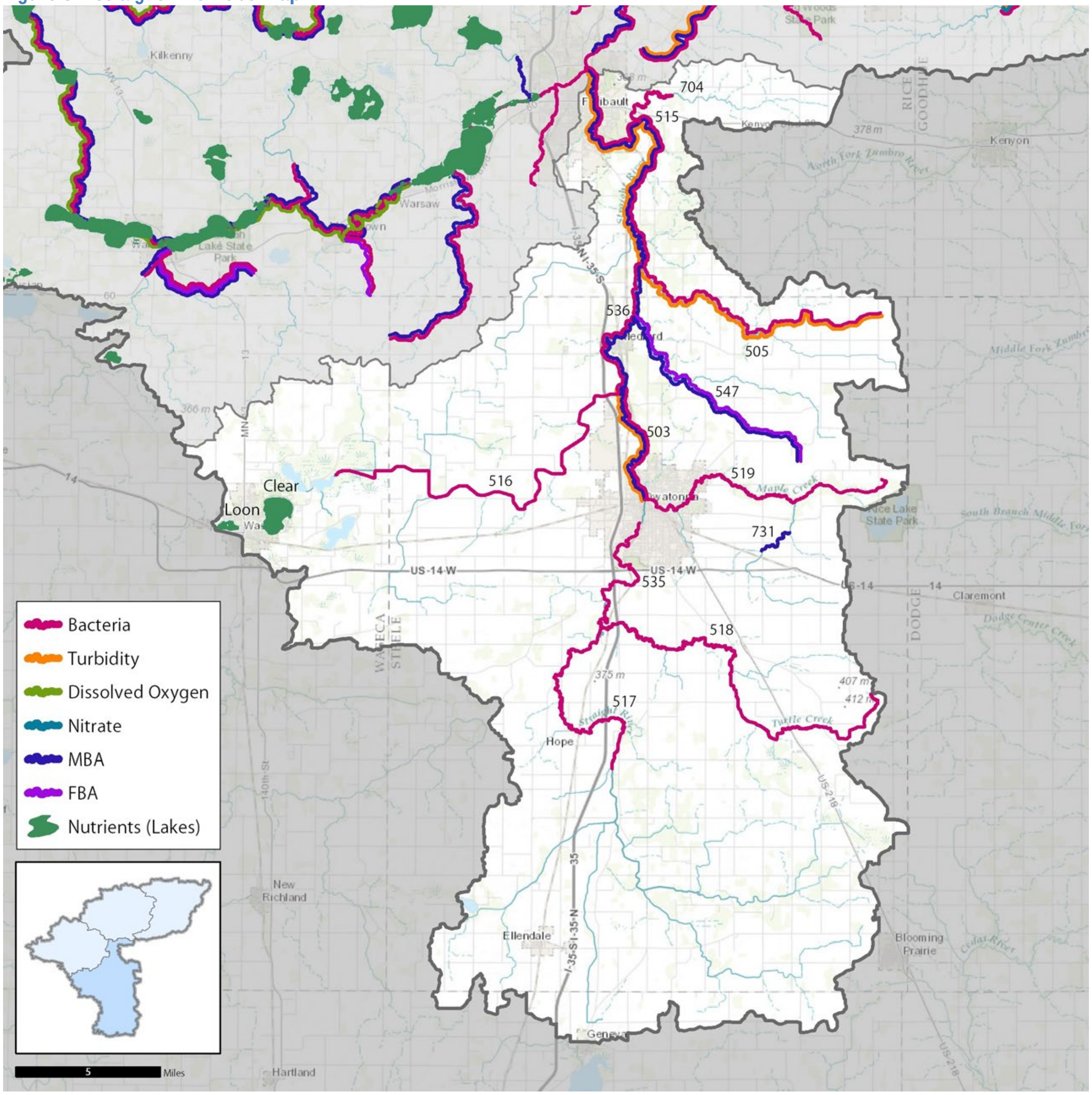


Table 18. Strategies and actions proposed for the Straight River Watershed.

HUC-10 Subwatershed	Waterbody and Location		Parameter	Water Quality		Strategies (see key below)	Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.				Governmental Units with Primary Responsibility										Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate													
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goal		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Rice County	Steele County	Waseca County	MS4s	BWSR	MDA	
Crane Creek 0704000202 and Straight River 0704000203	All	Rice, Steele and Waseca Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe		The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.														
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	70% [238,000]		•		•						•	2040 per NRS
						Shift fall N applications	Switch to spring			30% [50,000]		•		•						•	
							Switch to split spring/sidedressing			30% [53,000]		•		•						•	
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			80% [47,000]		•		•						•	
							Cover crops on corn/soybean acres			10% [50,000]		•		•						•	
							Convert riparian lands to perennials per buffer rule			100% [27,000]		•		•	•	•	•		•		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			10% [23,000]		•		•							
	All	Rice, Steele and Waseca Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	12% load reduction per Nutrient Reduction Strategy		The PBMP tool was applied to examine 12% phosphorus load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.														
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines		12% phosphorus load reduction			•		•					•	•	2025 per NRS
						Vegetation Changes	Convert riparian lands to perennials per buffer rule	7%		100% [6,000]		•		•	•	•	•		•		

							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)	0%	by 2025 per NRS	10% [500]		•		•					•		
							Cover crops on corn/soybean acres	0%		10% [500]		•		•					•	•	
							Short season crops planted to a cereal rye cover crop	0%		80% [1,000]		•		•					•	•	
	Rush Ck -505	Rice and Steele	TSS	5% exceedance of 65 mg/l	<10% exceedance of 65 mg/l	**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	22%		25% [2,000]		•		•					•		
	Straight R -503	Steele		10% exceedance of 65 mg/l			Inject/incorporate manure	8%				•		•					•		
	Straight R -515	Rice and Steele		11% exceedance of 65 mg/l			Structural impoundment BMP			30% of cropland acres		•		•					•		
	Straight R -536	Rice and Steele		9% exceedance of 65 mg/l								•		•					•		
	Clear Lake 81-0014	Waseca	Phosphorus	998 kg/r TP	683 kg/yr TP	**Urban Stormwater**	Compliance with NPDES permits which will reflect WLAs. http://stormwater.pca.state.mn.us/index.php/Main_Page		12% phosphorus load reduction by 2025 per NRS				•				•	•			
	Loon Lake 81-0015	Waseca		364 kg/yr TP	122 kg/yr TP								•				•	•			
	Beaver	Steele	Phosphorus	19 kg/yr TP	17 kg/yr TP	**Vegetation Maintenance**	Maintain or increase perennial vegetation in watersheds				•	•	•	•				•			
							Protect or restore native riparian vegetation				•	•	•	•		•		•			
						Policy & Ordinance	Avoid or mitigate for future proposed agricultural drainage improvement projects				•	•	•	•	•			•			
							Require land in the shore impact zone to be established, maintained, or restored in native/perennial riparian buffer at the time of development or at the time of permit issuance				•	•	•	•		•		•			
							Adhere/increase shoreland setbacks.				•	•	•	•	•			•			

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter	Water Quality: Current Conditions	Water Quality: Goal	Strategies (see key below)	Strategy Type	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Rice County	Steele County	Waseca County	MS4s	BWSR	MDA	Estimated Year to Achieve Water Quality Target
						Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.															
Crane Creek 0704000202 and Straight River 0704000203	All	Rice, Steele and Waseca Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.															
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	70% [238,000]		•		•						•	2040 per NRS
						Shift fall N applications	Switch to spring			30% [50,000]		•		•						•	
							Switch to split spring/sidedressing			30% [53,000]		•		•						•	
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			80% [47,000]		•		•						•	
							Cover crops on corn/soybean acres			10% [50,000]		•		•						•	
							Convert riparian lands to perennials per buffer rule			100% [27,000]		•		•	•	•	•		•		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			10% [23,000]		•		•							
	All	Rice, Steele and Waseca Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	12% load reduction per Nutrient Reduction Strategy	The PBMP tool was applied to examine 12% phosphorus load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.															
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines		12% phosphorus load reduction by			•		•					•	•	2025 per NRS
						Vegetation Changes	Convert riparian lands to perennials per buffer rule	7%		100% [6,000]		•		•	•	•	•		•		

							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)	0%	2025 per NRS	10% [500]		•		•					•		
							Cover crops on corn/soybean acres	0%		10% [500]		•		•					•	•	
							Short season crops planted to a cereal rye cover crop	0%		80% [1,000]		•		•					•	•	
	Rush Ck -505	Rice and Steele	TSS	5% exceedance of 65 mg/l	<10% exceedance of 65 mg/l	**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	22%		25% [2,000]		•		•					•		
	Straight R -503	Steele		10% exceedance of 65 mg/l			Inject/incorporate manure	8%				•		•					•		
	Straight R -515	Rice and Steele		11% exceedance of 65 mg/l			Structural impoundment BMP			30% of cropland acres		•		•					•		
	Straight R -536	Rice and Steele		9% exceedance of 65 mg/l								•		•					•		
	Clear Lake 81-0014	Waseca	Phosphorus	998 kg/r TP	683 kg/yr TP	**Urban Stormwater**	Compliance with NPDES permits which will reflect WLAs. http://stormwater.pca.state.mn.us/index.php/Main_Page		12% phosphorus load reduction by 2025 per NRS				•				•	•			
	Loon Lake 81-0015	Waseca		364 kg/yr TP	122 kg/yr TP								•				•	•			
	Beaver	Steele	Phosphorus	19 kg/yr TP	17 kg/yr TP	**Vegetation Maintenance**	Maintain or increase perennial vegetation in watersheds				•	•	•	•				•			
							Protect or restore native riparian vegetation				•	•	•	•		•		•			
						Policy & Ordinance	Avoid or mitigate for future proposed agricultural drainage improvement projects				•	•	•	•	•			•			
							Require land in the shore impact zone to be established, maintained, or restored in native/perennial riparian buffer at the time of development or at the time of permit issuance				•	•	•	•		•		•			
							Adhere/increase shoreland setbacks.				•	•	•	•	•			•			

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

3.3.3 Middle Cannon River

Figure 52. Middle Cannon lobe map.

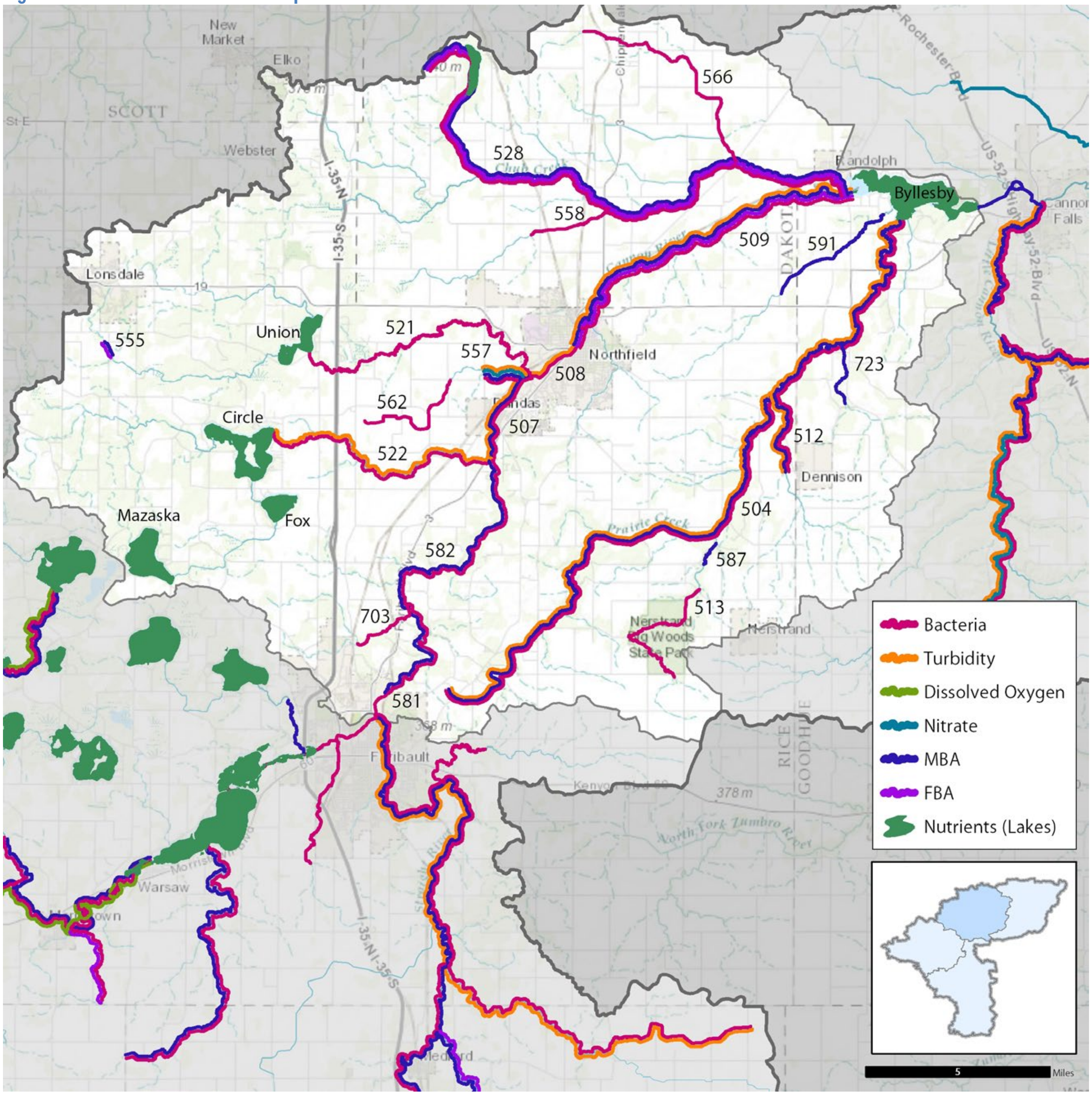


Table 19. Strategies and actions proposed for the Middle CRW.

HUC-10 Subwatershed	Waterbody and Location		Parameter	Water Quality		Strategies (see key below)	Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.				Governmental Units with Primary Responsibility										Estimated Year to Achieve Water Quality Target
								Estimated Adoption Rate													
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goal		Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Dakota	Rice	Goodhue	MS4s	BWSR	MDA	
Chub Creek 0704000204 Prairie Creek 0704000205 Middle Cannon 0704000206	All	Rice, Dakota and Goodhue Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.															
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	50-75% [36-58,000]		•		•						•	2040 per NRS
						Shift fall N applications	Switch to spring			0-60% [0-16,000]		•		•						•	
							Switch to split spring/sidedressing			20-50% [6-17,000]		•		•						•	
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			50-80% [8-13,000]		•		•						•	
							Cover crops on corn/soybean acres			10% [11-12,0000]		•		•						•	
							Convert riparian lands to perennials per buffer rule			100% [6-7,000]		•		•	•	•	•		•		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			5-20% [3-14,000]		•		•							
	Rice Creek - 557	Rice County	Nitrates	Baseflow concentration 10-11 mg/l nitrate	<10 mg/l baseflow nitrate concentration		Restored Wetlands			30% [8,000]	•	•		•					•		
	All	Rice, Dakota and Goodhue Counties	Phosphorus	See Appendix E for TP Loading information which will	Lobe goal of 12% load reduction per Nutrient	The PBMP tool was applied to examine 12% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.															
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines		12% phosphorus	0-80% [0-1,000]		•		•						•	2025 per NRS

				be tracked indefinitely at four sites in the CRW	Reduction Strategy		Fall corn fertilization to pre-plant/starter	27%	load reduction by 2025 per NRS	60-100% [50-100]		•		•						•	
						Vegetation Changes	Convert riparian lands to perennials per buffer rule	8%		100% [1,500]		•		•	•	•	•		•		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			5-20% [50-200]		•		•							
	Cannon River -509	Rice, Dakota and Goodhue Counties	TSS (<10% exceedance of standard applies April - September)	12% exceedance of 65 mg/l	<10% exceedance of applicable TSS standard		Cover crops on corn/soybean acres			10% [100]		•		•						•	
	Prairie Ck Headwater - 512	Rice		10% exceedance of 65 mg/l																	
	Wolf CK -522	Rice		4% exceedance of 65 mg/l			Short season crops planted to a cereal rye cover crop			50-80% [100-200]		•		•						•	
	Chub Ck -528	Dakota		7% exceedance of 65 mg/l																	
	Byllesby Reservoir 19-0006	Rice, Dakota, Steele, Waseca, Le Sueur, and Goodhue Counties	Phosphorus	Lower Flow: 95670 kg/yr TP Higher Flow: 227930 kg/yr TP (Estimated loads from 1996-2012 can be reviewed in HSPF model output)	Lower Flow: 54190 kg/yr TP Higher Flow: 91520 kg/yr TP	**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	43%		10-50% [100-1,000]		•		•							
	Chub Lk 19-0020	Dakota		764 kg/yr TP	123 kg/yr TP																
	Circle Lk 66-0027	Rice		15071 kg/yr TP	1389 kg/yr TP		Inject/incorporate manure	8%		0-85% [0-200]		•		•							
	Fox Lk 66-0029	Rice		1779 kg/yr TP	742 kg/yr TP		Structural impoundment BMP			30% of cropland acres	•	•	•	•							
	Mazaska Lk 66-0039	Rice		3581 kg/yr TP	444 kg/yr TP	**Urban Stormwater**	Compliance with NPDES permits which will reflect WLAs. http://stormwater.pca.state.mn.us/index.php/Main_Page						•			•					
	Union Lk 66-0032	Rice		18322 kg/yr TP	1987 kg/yr TP																
	Heath Ck Headwater - 555	Rice	Chloride	Maximum observed chloride 417 mg/l	<230 mg/l	**Municipal & Industrial Wastewater**	Compliance with NPDES permits which will reflect WLAs.						•					•			

												DNR	SWCD	MPCA	NRCS	Dakota	Rice	Goodhue	MS4s	BWSR	MDA	
	Rice Creek - 557	Rice	Fish IBI	Three visits produced Fish IBI values of 80, 68 and 65	No decrease in Fish IBI (threshold is 45)	**Protect Unique Brook Trout Fishery**	Easements to protect/improve habitat and WQ; protect baseflow via monitoring and application of water appropriation analysis					•	•	•			•			•		

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

HUC-10 Subwatershed	Waterbody and Location		Parameter	Water Quality		Strategies (see key below)	Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.				Governmental Units with Primary Responsibility										Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goal		Strategy Type	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Dakota	Rice	Goodhue	MS4s	BWSR	MDA	
Chub Creek 0704000204 Prairie Creek 0704000205 Middle Cannon 0704000206	All	Rice, Dakota and Goodhue Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.															2040 per NRS
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure		20% load reduction by 2025 per NRS	50-75% [36-58,000]		•		•						•	
						Shift fall N applications	Switch to spring			0-60% [0-16,000]		•		•						•	
							Switch to split spring/sidedressing			20-50% [6-17,000]		•		•						•	
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			50-80% [8-13,000]		•		•						•	
							Cover crops on corn/soybean acres			10% [11-12,0000]		•		•						•	

							Convert riparian lands to perennials per buffer rule			100% [6-7,000]		●		●	●	●	●		●		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			5-20% [3-14,000]		●		●							
	Rice Creek - 557	Rice County	Nitrates	Baseflow concentration 10-11 mg/l nitrate	<10 mg/l baseflow nitrate concentration		Restored Wetlands			30% [8,000]	●	●		●					●		
	All	Rice, Dakota and Goodhue Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe goal of 12% load reduction per Nutrient Reduction Strategy	The PBMP tool was applied to examine 12% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 14 for more details.															
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines			0-80% [0-1,000]		●		●						●	
							Fall corn fertilization to pre-plant/starter	27%		60-100% [50-100]		●		●						●	
						Vegetation Changes	Convert riparian lands to perennials per buffer rule	8%		100% [1,500]		●		●	●	●	●		●		
							Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			5-20% [50-200]		●		●							
	Cannon River -509	Rice, Dakota and Goodhue Counties	TSS (<10% exceedance of standard applies April - September)	12% exceedance of 65 mg/l	<10% exceedance of applicable TSS standard		Cover crops on corn/soybean acres		12% phosphorus load reduction by 2025 per NRS	10% [100]		●		●						●	2025 per NRS
	Prairie Ck Headwater - 512	Rice		10% exceedabnce of 65 mg/l																	
	Wolf CK -522	Rice		4% exceedance of 65 mg/l			Short season crops planted to a cereal rye cover crop			50-80% [100-200]		●		●						●	
	Chub Ck - 528	Dakota		7% exceedance of 65 mg/l																	
	Byllesby Reservoir 19-0006	Rice, Dakota, Steele, Waseca, Le Sueur, and Goodhue Counties	Phosphorus	Lower Flow: 95670 kg/yr TP Higher Flow: 227930 kg/yr TP (Estimated loads from 1996-2012 can be reviewed in HSPF model output)	Lower Flow: 54190 kg/yr TP Higher Flow: 91520 kg/yr TP	**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	43%		10-50% [100-1,000]		●		●							
	Chub Lk 19-0020	Dakota		764 kg/yr TP	123 kg/yr TP																

	Circle Lk 66-0027	Rice		15071 kg/yr TP	1389 kg/yr TP		Inject/incorporate manure	8%		0-85% [0-200]		•		•							
	Fox Lk 66-0029	Rice		1779 kg/yr TP	742 kg/yr TP		Structural impoundment BMP			30% of cropland acres	•	•	•	•							
	Mazaska Lk 66-0039	Rice		3581 kg/yr TP	444 kg/yr TP	**Urban Stormwater**	Compliance with NPDES permits which will reflect WLAs. http://stormwater.pca.state.mn.us/index.php/Main_Page						•			•					
	Union Lk 66-0032	Rice		18322 kg/yr TP	1987 kg/yr TP																
	Heath Ck Headwater - 555	Rice	Chloride	Maximum observed chloride 417 mg/l	<230 mg/l	**Municipal & Industral Wastewater**	Compliance with NPDES permits which will reflect WLAs.						•					•			
	Rice Creek - 557	Rice	Fish IBI	Three visits produced Fish IBI values of 80, 68 and 65	No decrease in Fish IBI (threshold is 45)	**Protect Unique Brook Trout Fishery**	Easements to protect/improve habitat and WQ; protect baseflow via monitoring and application of water appropriation analysis				•	•	•			•			•		

(pink)	Restoration
(green)	Protection
(blue)	Strategies to address downstream impairments
(white)	Point Sources

3.3.4 Lower Cannon River

Appendix H includes a summary of DNR strategies and priorities for the Lower Cannon River lobe.

Figure 53. Lower Cannon River lobe map.

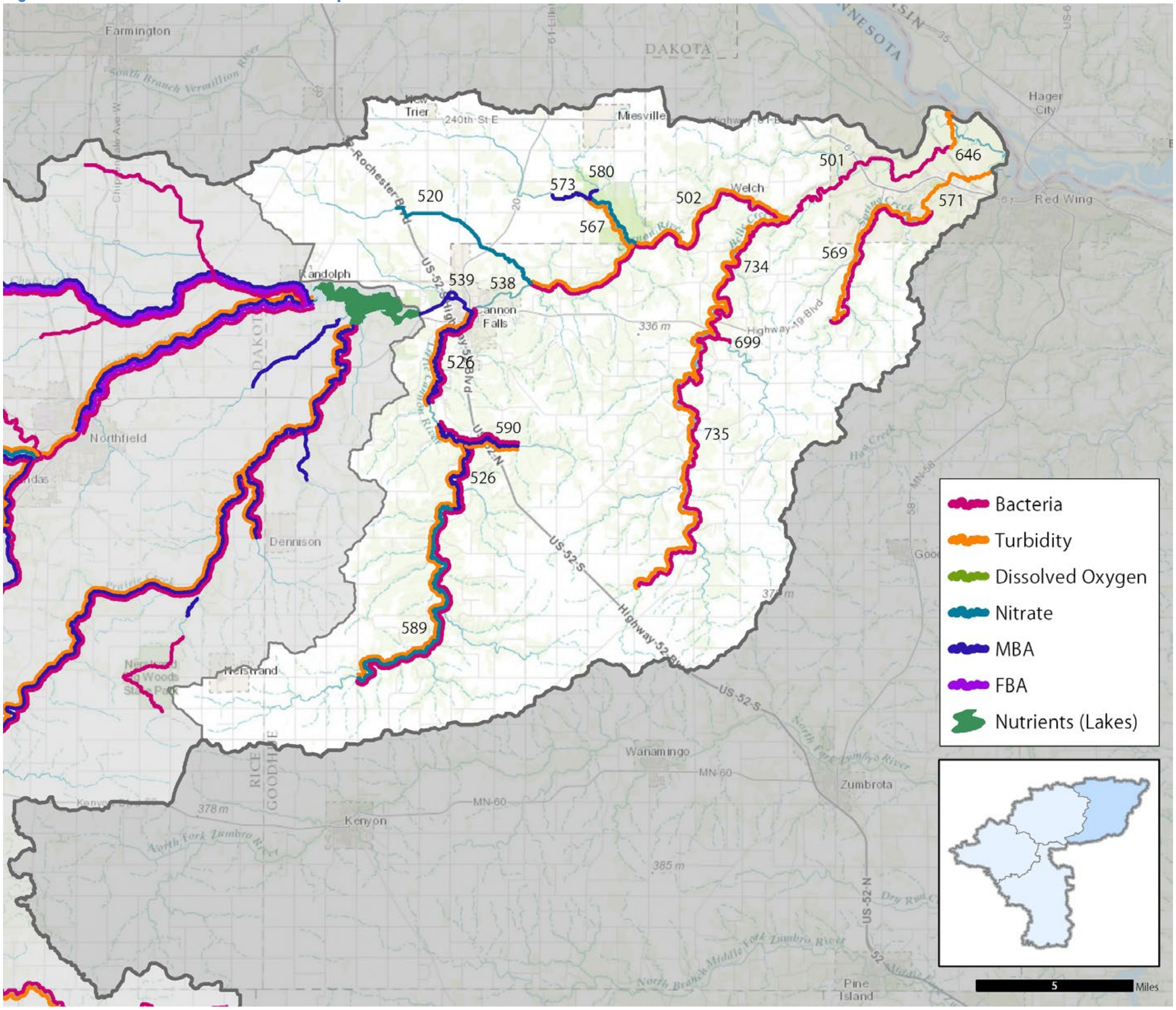


Table 20. Strategies and actions proposed for the Lower CRW.

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter	Water Quality: Current Conditions	Water Quality: Goal	Strategies (see key below)	Strategy Type	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Dakota Cnty	Goodhue	Rice	NCRWMO	MDA	Estimated Year to Achieve Water Quality Target
						Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.														
Little Cannon 0704000207 Belle Creek 0704000208 Lower Cannon 0704000209	All	Dakota, Goodhue and Rice Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Table 15 for more details.														
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure	NA	20% load reduction by 2025 per NRS	50-75% [63-97,000]		•		•				•	•	2040 per NRS
						Shift fall N applications	Switch to spring			60-100% [4-26,000]		•		•				•	•	
							Switch to split spring/sidedressing			0-20% [2,000]		•		•				•	•	
						Increase vegetative cover/root duration [to reduce nitrate leaching]	Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			65-80% [14-24,000]		•		•				•	•	
	Pine Creek -520	Dakota and Goodhue Counties	Nitrate	Baseflow concentration 10-11 mg/l nitrate	<10 mg/l baseflow nitrate concentration		Cover crops on corn/soybean acres			10-20% [16-30,000]		•		•				•	•	

	Trout Brook headwater -567	Dakota County		Baseflow concentration 12-14 mg/l nitrate			Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			2-20% [1-21,000]		•		•				•		
	Trout Brook headwater -573	Dakota County		Baseflow concentration 18-20 mg/l nitrate			Convert riparian lands to perennials per buffer rule			100% [17-22,000]		•		•	•	•	•	•		
	Little Cannon River -589	Goodhue and Rice Counties		Baseflow concentration 10-11 mg/l nitrate		**Structural Changes**	Saturated Buffers			2% [0]		•		•				•		
	All	Dakota, Goodhue and Rice Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe Goal of 12% load reduction per Nutrient Reduction Strategy	The PBMP tool was applied to examine 12% phosphorus load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. These strategies address sediment in addition to phosphorus, although local TSS goals are expressed in terms of percent exceedance of water quality standard. See Table 14 for more details.														
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines	NA	12% phosphorus load reduction by 2025 per NRS	80% [1,000]		•		•				•	•	2025 per NRS
	Cannon R -502	All watershed counties	TSS (<10% exceedance of standard applies April - September)	15% exceedance of 65 mg/l	<10% exceedance of applicable TSS standard	**Vegetation Changes**	Convert riparian lands to perennials per buffer rule	9%		100% [500-1,500]		•		•	•	•	•	•		
	Cannon R -646*	All watershed counties		20% exceedance of 65 mg/l			Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)	0%		2-40% [0-500]		•		•				•		
	Little Cannon River -526	Goodhue and Rice Counties		28% exceedance of 65 mg/l																
	Little Cannon River -589	Goodhue and Rice Counties		42% exceedance of 10 mg/l			Cover crops on corn/soybean acres	0%		10-20% [100-200]		•		•				•	•	
	Butler Ck -590	Goodhue County		21% exceedance of 65 mg/l			Short season crops planted to a cereal rye cover crop	0%		65-80% [100-500]		•		•				•	•	
	Belle Ck -734	Goodhue County		40% exceedance of 10 mg/l		**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	23%		10-50% [100-500]		•		•				•		
	Belle Ck -735	Goodhue County		25% exceedance of 65 mg/l			Inject/incorporate manure	9%		20-85% [100-500]		•		•				•		

							Structural impoundment BMP			30% of cropland acres		•		•				•		
	All	All	All	NA	NA	**Protect Trout Streams**	Easements to protect/improve habitat and WQ; protect baseflow via monitoring and application of water appropriation analysis				•	•			•	•		•		

* AUID -646 was formerly 07040001-511, one of the two AUIDs addressed in the Lower Cannon TMDL.

(pink)	Restoration
(green)	Protection
(blue)	Downstream impairments
(white)	Point Sources

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter	Water Quality: Current Conditions	Water Quality: Goal	Strategies (see key below)	Strategy Type	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal — Units are Percent Adoption of Suitable Acres and [lbs removed]	DNR	SWCD	MPCA	NRCS	Dakota Cnty	Goodhue	Rice	NCRWMO	MDA	Estimated Year to Achieve Water Quality Target
						Scenarios and adoption levels may change with additional local planning, research showing new BMPs, changing financial support and policies.														
Little Cannon 0704000207 Belle Creek 0704000208 Lower Cannon 0704000209	All	Dakota, Goodhue and Rice Counties	Nitrogen (TN) or Nitrate	See Appendix E for TN Loading information which will be tracked indefinitely at four sites in the CRW	45% load reduction per Nutrient Reduction Strategy; 20% reduction is interim milestone and working goal for lobe	The NBMP tool was applied to examine 20% nitrogen load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. See Tabe 15 for more details.														2040 per NRS
						Reduced Fertilizer Inputs	Use the U of MN nitrogen fertilizer BMPs relevant for the area and specific crop rotation, including crediting of all legumes and manure	NA	20% load reduction by 2025 per NRS	50-75% [63-97,000]		•		•				•	•	
						Shift fall N applications	Switch to spring			60-100% [4-26,000]		•		•				•	•	

							Switch to split spring/sidedressing			0-20% [2,000]		•		•				•	•	
							Short season crops (corn silage, small grains, peas, sweet corn, potatoes, dry edible beans, and sugar beets) planted to a cereal rye cover crop			65-80% [14-24,000]		•		•				•	•	
	Pine Creek -520	Dakota and Goodhue Counties	Nitrate	Baseflow concentration 10-11 mg/l nitrate	<10 mg/l baseflow nitrate concentration	**Increase vegetative cover/root duration [to reduce nitrate leaching]**	Cover crops on corn/soybean acres			10-20% [16-30,000]		•		•				•	•	
	Trout Brook headwater -567	Dakota County		Baseflow concentration 12-14 mg/l nitrate			Convert marginal lands to perennial cover (marginal lands as determined by <60 on Crop Productivity Index)			2-20% [1-21,000]		•		•				•		
	Trout Brook headwater -573	Dakota County		Baseflow concentration 18-20 mg/l nitrate			Convert riparian lands to perennials per buffer rule			100% [17-22,000]		•		•	•	•	•	•		
	Little Cannon River -589	Goodhue and Rice Counties		Baseflow concentration 10-11 mg/l nitrate		**Structural Changes**	Saturated Buffers			2% [0]		•		•				•		
	All	Dakota, Goodhue and Rice Counties	Phosphorus	See Appendix E for TP Loading information which will be tracked indefinitely at four sites in the CRW	Lobe Goal of 12% load reduction per Nutrient Reduction Strategy	The PBMP tool was applied to examine 12% phosphorus load reduction goal attainment. The primary strategies examined are included as rows below, and one example scenario is depicted in the adoption rate columns. Note that these adoption rates vary relatively and there are many combinations that would result in goal attainment. These strategies address sediment in addition to phosphorus, although local TSS goals are expressed in terms of percent exceedance of water quality standard. See Table 14 for more details.														
						Reduced Inputs	Target BMP P2O5 Rate using soil testing and U of MN fertilizer guidelines	NA	12% phosphorus load reduction by 2025 per NRS	80% [1,000]		•		•				•	•	2025 per NRS
	Cannon R -502	All watershed counties	TSS (<10% exceedance of standard applies April - September)	15% exceedance of 65 mg/l	<10% exceedance of applicable TSS standard	**Vegetation Changes**	Convert riparian lands to perennials per buffer rule	9%		100% [500-1,500]		•		•	•	•	•	•		
	Cannon R -646*	All watershed counties		20% exceedance of 65 mg/l			Convert marginal lands to perennial cover (marginal lands	0%		2-40% [0-500]		•		•				•		

	Little Cannon River -526	Goodhue and Rice Counties		28% exceedance of 65 mg/l			as determined by <60 on Crop Productivity Index)														
	Little Cannon River -589	Goodhue and Rice Counties		42% exceedance of 10 mg/l			Cover crops on corn/soybean acres	0%		10-20%	[100-200]		•		•				•	•	
	Butler Ck -590	Goodhue County		21% exceedance of 65 mg/l			Short season crops planted to a cereal rye cover crop	0%		65-80%	[100-500]		•		•				•	•	
	Belle Ck -734	Goodhue County		40% exeedance of 10 mg/l		**Structural Changes**	Use reduced tillage on corn, soybeans and small grains > 2% slope	23%		10-50%	[100-500]		•		•				•		
	Belle Ck -735	Goodhue County		25% exceedance of 65 mg/l			Inject/incorporate manure	9%		20-85%	[100-500]		•		•				•		
							Structual impoundment BMP			30% of cropland acres			•		•				•		
	All	All	All	NA	NA	**Protect Trout Streams**	Easements to protect/improve habitat and WQ; protect baseflow via monitoring and application of water appropriation analysis					•	•			•	•		•		

* AUID -646 was formerly 07040001-511, one of the two AUIDs addressed in the Lower Cannon TMDL.

(pink)	Restoration
(green)	Protection
(blue)	Downstream impairments
(white)	Point Sources

Table 21: Key for Strategies Column.

Strategy	Description
Nonpoint Source	
Nitrogen Reduction Strategies These strategies are taken directly from the NBMP spreadsheet (see the tool for further examination).	Manage marginal lands in perennials, optimize nutrient management planning, timing and implementation, expand the use of cover crops, encourage managed grazing throughout the watershed NRCS Job Codes; Nutrient Management (590), Prescribed Grazing (528), Cover Crop (340), Filter Strip (393), Waste Storage Facility (313)
Phosphorus Reduction Strategies These strategies are taken directly from the PBMP spreadsheet (see the tool for further examination).	Reduce sediment transport from row crop lands and promote sound residue management practices. Impoundments, contour farming, no-till farming, and grassed buffer strips, etc. are all BMPs used to reduce soil erosion. NRCS Job Codes Cover Crop (340), Residue and Tillage Management (345 & 329), Filter Strip (393), Contour Farming (330), Contour Buffer Strips (332)
SE Minnesota Bacteria Implementation Plan (2007)	http://www.pca.state.mn.us/index.php/view-document.html?gid=8013
Structural Impoundment BMP	Water impoundment structures that reduce peak flows of rain events. These impoundments are located within row crop fields as well as edge of fields and in managed pastures. Using the information gathered from the Little Cannon River SWAT Model, as well as professional observations of stream conditions in MRLP subwatersheds, BMP treatment of 40% of land surface is the goal for this strategy. These practices include but are not limited to Water and Sediment Control Basins (638), Grade Control Structures (410), Terraces (600) and Diversions (632) (as a component)
Address Physical Habitat and Channel Geometry following Natural Channel Design Principals	Provide habitat improvement practices in an effort to reach a stream's full potential of sustaining game and non-game species. Incorporating natural design concepts to restoration projects as well as working with a stream's evolution should be a priority in the well treated watersheds. Stabilize/restore channels within the headwater/upper parts of a given watershed first. Target channels that are either stuck within the middle of stream channel succession scenarios (see attached) and are far from recovery. Practices referenced: All practices listed in the Nongame Wildlife Habitat Guide (TU), Toewood design concept and cedar tree revetments. Also referenced NRCS Job Code; Stream Habitat Improvement and Management (395)
Point Source	
NPDES point source compliance	All NPDES-permitted sources shall comply with conditions of their permits, which are written to be consistent with any assigned wasteload allocations
Stormwater Manual	http://stormwater.pca.state.mn.us/index.php/Main_Page

4. Monitoring Plan

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

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

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

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

4.1 Focused Monitoring & Research Needs

In addition to monitoring for both assessment and effectiveness purposes, there are research needs to better understand pollutant loads and dynamics in the CRW. Primary amongst these are (1) low flow phosphorus loading in the upper Straight River Watershed (see Chapter 2.3), (2) internal loading in the lakes of the watershed (see Chapter 2.3) and (3) streamflow monitoring, groundwater level monitoring, and aquifer tests in the Pine Creek and Trout Brook Watersheds to further form the basis for activities that are needed to protect the health of Pine Creek and Trout Brook. Regarding pathogens, the *Revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota Implementation Plan* notes that research needs include, but are not limited to:

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

Cannon River Watershed Monitoring Plan Summary	
	•Aquatic life use support: IMW every 10 years. •Aquatic recreation use support: IWM provide milestone check-points, other monitoring focused on research needs and better understanding. •Nitrogen in groundwater: monitoring wells (e.g. volunteer network) and springs (e.g. Spring Creek headwater). •Tracking goals in pollutant load reductions: load monitoring sites, on-going. •BMP tracking: SWCD inventories, BWSR eLink, NRCS reporting at watershed scale . •Citizen Lake and Stream Monitoring.

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Cannon River Watershed Reports

Many of the CRW reports referenced in this watershed report are available at the CRW webpage: https://www.pca.state.mn.us/water/watersheds/cannon-river

The Cannon River Watershed Partnership Library is another collection of resources: http://crwp.net/library/

Appendices

A. *E. coli* geometric means.
B. Stream IBI values.
C. Stream IBIs close to thresholds.
D. CLMP trend analysis summary.
E. Watershed load monitoring program data.
F. HSPF Summary Report
G. Methodology for TNC protection prioritization.
H. DNR summary of strategies and priorities for Lower Cannon lobe.
I. Stressor table.

Appendix A: *E. coli* geometric means.

HUC-10 Watershed	Listed Waterbody Name	Reach (AUID)	# Samples Above 126 MPN/100 mL	E. Coli Geomean (MPN/100 mL)	Sample Date
Belle Creek	Unnamed Creek	07040002-699	23/33	253.72	2008-2009
Belle Creek	Belle Creek	07040002-734	28/67	151.05	2007-2008; 2011-2012
Belle Creek	Belle Creek	07040002-735	43/52	461.80	2007-2008
Chub Creek	Mud Creek	07040002-558	*36/45	659.12	1999-2000; 2004-2005
Chub Creek	Chub Creek	07040002-566	*31/49	414.53	1999-2000; 2004-2005
Little Cannon River	Little Cannon River	07040002-526	37/53	215.73	2007-2008
Little Cannon River	Little Cannon River	07040002-589	21/23	491.78	2007
Little Cannon River	Butler Creek	07040002-590	21/33	289.38	2008-2009
Lower Cannon River	Cannon River	07040002-501	23/71	86.76	2007-2008; 2011-2012
Lower Cannon River	Spring Creek	07040002-569	28/36	306.27	2008-2009
Middle Cannon River	Cannon River	07040002-507	22/53	99.47	2007-2008
Middle Cannon River	Cannon River	07040002-508	29/55	133.89	2007-2008
Middle Cannon River	Heath Creek	07040002-521	36/57	137.49	2007-2008; 2011-2012
Middle Cannon River	Wolf Creek	07040002-522	14/15	451.80	2011-2012
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-557	50/59	376.08	2007-2008
Middle Cannon River	Unnamed Creek (Spring Brook)	07040002-562	22/47	62.85	2007-2008
Middle Cannon River	Cannon River	07040002-581	25/53	112.14	2007-2008
Middle Cannon River	Cannon River	07040002-582	42/75	178.09	2007-2009
Middle Cannon River	Unnamed Creek	07040002-703	25/51	105.37	2008-2009
Straight River	Falls Creek	07040002-704	26/49	111.06	2008-2009
Upper Cannon River	Cannon River	07040002-540	15/47	58.73	2007-2008
Upper Cannon River	Cannon River	07040002-542	8/15	178.00	2011-2012
Upper Cannon River	Waterville Creek	07040002-560	27/43	172.19	2008-2009
Upper Cannon River	MacKenzie Creek	07040002-576	20/31	149.03	2008-2009
Upper Cannon River	Devils Creek	07040002-577	13/34	97.06	2008-2009
Upper Cannon River	County Ditch 63	07040002-621	12/31	51.51	2008-2009
Upper Cannon River	Unnamed Creek	07040002-702	36/51	331.20	2008-2009
Upper Cannon River	Unnamed Creek	07040002-705	28/38	246.60	2008-2009
Upper Cannon River	Whitewater Creek	07040002-706	23/43	121.44	2008-2009
* Counted # of samples above 200 #/100 mL					

Appendix B: Stream IBI Values

Appendix B1: F-IBI values and thresholds for streams with habitat stressors.

AUID	NAME	MENT_LEN	USE_CLASS	FieldNum	WBName	VisitYear	VisitDate	FishClass	FishClassName	FishIBI	Threshold	dist_from_threshold
07040002-509	Cannon River	10.52	2B, 3C	11LM097	Cannon River	2011	06-Sep-11	1	Southern Rivers	42	49	-7
07040002-521	Heath Creek	13.39	2B, 3C	04LM076	Heath Creek	2013	8/5/2013	2	Southern Streams	32	50	-18
07040002-521	Heath Creek	13.39	2B, 3C	11LM005	Heath Creek	2011	07-Sep-11	2	Southern Streams	58	50	8
07040002-521	Heath Creek	13.39	2B, 3C	13LM001	Heath Creek	2013	8/5/2013	2	Southern Streams	44	50	-6
07040002-528	Chub Creek	24.74	2B, 3C	11LM016	Chub Creek	2011	13-Sep-11	2	Southern Streams	39	50	-11
07040002-528	Chub Creek	24.74	2B, 3C	11LM012	Chub Creek	2011	11-Aug-11	2	Southern Streams	56	50	6
07040002-528	Chub Creek	24.74	2B, 3C	10EM087	Chub Creek	2010	02-Aug-10	2	Southern Streams	36	50	-14
07040002-528	Chub Creek	24.74	2B, 3C	00LM007	Chub Creek	2011	10-Aug-11	2	Southern Streams	65	50	15
07040002-547	Medford Creek	12.06	2B, 3C	10EM075	Medford Creek	2010	14-Jul-10	3	Southern Headwaters	70	55	15
07040002-547	Medford Creek	12.06	2B, 3C	10EM075	Medford Creek	2010	25-Aug-10	3	Southern Headwaters	73	55	18
07040002-547	Medford Creek	12.06	2B, 3C	11LM063	Medford Creek	2011	02-Aug-11	3	Southern Headwaters	39	55	-16
07040002-547	Medford Creek	12.06	2B, 3C	11LM065	Medford Creek	2011	02-Aug-11	3	Southern Headwaters	69	55	14
07040002-555	Unnamed ditch	0.57	2B, 3C	04LM083	Unnamed ditch (Heath Creek)	2004	18-Jun-04	3	Southern Headwaters	44	55	-11
07040002-555	Unnamed ditch	0.57	2B, 3C	04LM083	Unnamed ditch (Heath Creek)	2011	15-Aug-11	3	Southern Headwaters	32	55	-23
07040002-560	Waterville Creek	6.44	2B, 3C	04LM080	Waterville Creek	2004	05-Aug-04	3	Southern Headwaters	35	55	-20
07040002-560	Waterville Creek	6.44	2B, 3C	04LM080	Waterville Creek	2011	09-Aug-11	3	Southern Headwaters	55	55	0
07040002-589	Little Cannon River (Goodhue County)	12.05	1B, 2A, 3B	04LM086	Little Cannon River	2004	01-Jul-04	2	Southern Streams	58	50	8
07040002-589	Little Cannon River (Goodhue	12.05	1B, 2A, 3B	04LM086	Little Cannon River	2004	19-Aug-04	2	Southern Streams	54	50	4
07040002-589	Little Cannon River (Goodhue County)	12.05	1B, 2A, 3B	04LM086	Little Cannon River	2011	09-Aug-11	2	Southern Streams	57	50	7
07040002-589	Little Cannon River (Goodhu	12.05	1B, 2A, 3B	11LM025	Little Cannon River	2011	14-Sep-11	3	Southern Headwaters	65	55	10
07040002-589	Little Cannon River (Goodhue County)	12.05	1B, 2A, 3B	11LM024	Little Cannon River	2011	10-Aug-11	3	Southern Headwaters	77	55	22
07040002-705	Unnamed creek	2.91	2B, 3C	11LM058	Trib. to Cannon River	2011	03-Aug-11	3	Southern Headwaters	40	55	-15

Appendix B2: M-IBI values and thresholds for streams with habitat stressors.

AUID	NAME	length	WBName	FieldNum	VisitDate	InvertClassName	InvertClass	MIBI	Threshold	dist_from_threshold
07040002-503	Straight River	5.77	Straight River	04LM120	10-Aug-11	Southern Streams RR	5	35.3	37	-1.7
07040002-503	Straight River	5.77	Straight River	04LM120	03-Sep-04	Southern Streams RR	5	46.1	37	9.1
07040002-503	Straight River	5.77	Straight River	10EM011	10-Aug-10	Southern Streams RR	5	29.3	37	-7.7
07040002-504	Prairie Creek	28.76	Prairie Creek	11LM009	11-Aug-11	Southern Streams RR	5	45.4	37	8.4
07040002-504	Prairie Creek	28.76	Prairie Creek	11LM055	11-Aug-11	Southern Streams RR	5	29.7	37	-7.3
07040002-504	Prairie Creek	28.76	Prairie Creek	11LM009	11-Aug-11	Southern Streams RR	5	30.8	37	-6.2
07040002-504	Prairie Creek	28.76	Prairie Creek	04LM059	17-Aug-04	Southern Forest Streams GP	6	63.0	43	20.0
07040002-507	Cannon River	3	Cannon RIver	11LM086	16-Aug-11	Prairie Forest Rivers	2	22.8	31	-8.2
07040002-509	Cannon River	10.52	Cannon River	11LM097	01-Sep-11	Prairie Forest Rivers	2	22.8	31	-8.2
07040002-512	Unnamed creek	2.95	Trib. to Prairie Creek	11LM075	03-Aug-11	Southern Forest Streams GP	6	16.6	43	-26.4
07040002-515	Straight River	13.33	Straight River	04LM014	07-Sep-04	Southern Streams RR	5	40.2	37	3.2
07040002-515	Straight River	13.33	Straight River	11LM010	16-Aug-11	Southern Streams RR	5	26.8	37	-10.2
07040002-515	Straight River	13.33	Straight River	11LM092	15-Aug-11	Southern Streams RR	5	45.1	37	8.1
07040002-521	Heath Creek	13.39	Heath Creek	11LM005	03-Aug-11	Southern Streams RR	5	43.2	37	6.2
07040002-521	Heath Creek	13.39	Heath Creek	04LM076	18-Aug-04	Southern Forest Streams GP	6	26.0	43	-17.0
07040002-526	Little Cannon River (Goodhue County)	11.87	Little Cannon River	04LM038	17-Aug-04	Southern Streams RR	5	45.8	37	8.8
07040002-526	Little Cannon River (Goodhue County)	11.87	Little Cannon River	11LM089	16-Aug-11	Southern Forest Streams GP	6	42.1	43	-0.9
07040002-528	Chub Creek	24.74	Chub Creek	11LM012	16-Aug-11	Southern Streams RR	5	35.7	37	-1.3
07040002-528	Chub Creek	24.74	Chub Creek	00LM007	16-Aug-11	Southern Streams RR	5	50.5	37	13.5
07040002-528	Chub Creek	24.74	Chub Creek	11LM016	17-Aug-11	Southern Forest Streams GP	6	30.9	43	-12.1
07040002-528	Chub Creek	24.74	Chub Creek	11LM016	17-Aug-11	Southern Forest Streams GP	6	40.4	43	-2.6
07040002-528	Chub Creek	24.74	Chub Creek	10EM087	31-Aug-10	Southern Forest Streams GP	6	54.6	43	11.6
07040002-536	Straight River	6.73	Straight River	11LM088	11-Aug-11	Southern Forest Streams GP	6	37.1	43	-5.9
07040002-539	Cannon River	2.75	Cannon River	00LM002	01-Sep-11	Prairie Forest Rivers	2	28.6	31	-2.4
07040002-542	Cannon River	52.01	Cannon River	11LM082	17-Aug-11	Southern Forest Streams GP	6	14.8	43	-28.2
07040002-542	Cannon River	52.01	Cannon River	04LM081	25-Aug-04	Southern Forest Streams GP	6	9.4	43	-33.6
07040002-542	Cannon River	52.01	Cannon River	11LM095	16-Aug-11	Southern Forest Streams GP	6	12.1	43	-30.9
07040002-542	Cannon River	52.01	Cannon River	11LM083	09-Aug-11	Southern Forest Streams GP	6	9.3	43	-33.7
07040002-547	Medford Creek	12.06	Medford Creek	11LM065	11-Aug-11	Southern Streams RR	5	38.6	37	1.6
07040002-547	Medford Creek	12.06	Medford Creek	10EM075	10-Aug-10	Southern Streams RR	5	44.7	37	7.7
07040002-547	Medford Creek	12.06	Medford Creek	11LM065	11-Aug-11	Southern Streams RR	5	37.1	37	0.1
07040002-547	Medford Creek	12.06	Medford Creek	11LM063	10-Aug-11	Southern Forest Streams GP	6	30.8	43	-12.2
07040002-555	Unnamed ditch	0.57	Unnamed ditch (Heath Creek)	04LM083	18-Aug-04	Southern Forest Streams GP	6	44.8	43	1.8
07040002-557	Unnamed creek (Spring Brook)	1.9	Unnamed Creek (Spring Brook)	04LM077	03-Aug-11	Southern Coldwater	9	38.3	43	-4.7
07040002-557	Unnamed creek (Spring Brook)	1.9	Unnamed Creek (Spring Brook)	04LM077	18-Aug-04	Southern Coldwater	9	47.9	43	4.9

AUID	NAME	length	WBName	FieldNum	VisitDate	InvertClassName	InvertClass	MIBI	Threshold	dist_from_threshold
07040002-557	Unnamed creek (Spring Brook)	1.9	Unnamed Creek (Spring Brook)	11LM099	03-Aug-11	Southern Coldwater	9	56.1	43	13.1
07040002-560	Waterville Creek	6.44	Waterville Creek	04LM080	16-Aug-11	Southern Streams RR	5	39.6	37	2.6
07040002-560	Waterville Creek	6.44	Waterville Creek	04LM080	25-Aug-04	Southern Streams RR	5	18.0	37	-19.0
07040002-573	Unnamed creek (Trout Brook)	1.56	Trout Brook	04LM144	07-Sep-04	Southern Coldwater	9	23.2	43	-19.8
07040002-573	Unnamed creek (Trout Brook)	1.56	Trout Brook	04LM144	04-Aug-11	Southern Coldwater	9	30.1	43	-12.9
07040002-573	Unnamed creek (Trout Brook)	1.56	Trout Brook	04LM144	17-Aug-04	Southern Coldwater	9	37.4	43	-5.6
07040002-576	MacKenzie Creek	12.32	Mackenzie Creek	11LM056	15-Aug-11	Southern Forest Streams GP	6	42.4	43	-0.6
07040002-577	Devils Creek	2.48	Devil Creek	11LM045	17-Aug-11	Southern Forest Streams GP	6	29.8	43	-13.2
07040002-577	Devils Creek	2.48	Devil Creek	11LM045	17-Aug-11	Southern Forest Streams GP	6	20.4	43	-22.6
07040002-580	Unnamed creek (Trout Brook)	0.45	Trib. to Trout Brook	99LM005	04-Aug-11	Southern Coldwater	9	33.3	43	-9.7
07040002-582	Cannon River	11.23	Cannon River	11LM068	01-Sep-11	Prairie Forest Rivers	2	17.0	31	-14.0
07040002-587	Unnamed creek	0.79	Unnamed creek	11LM077	11-Aug-11	Southern Streams RR	5	31.5	37	-5.5
07040002-589	Little Cannon River (Goodhue County)	12.05	Little Cannon River	04LM086	07-Sep-04	Southern Streams RR	5	51.2	37	14.2
07040002-589	Little Cannon River (Goodhue County)	12.05	Little Cannon River	04LM086	15-Aug-11	Southern Streams RR	5	24.0	37	-13.0
07040002-589	Little Cannon River (Goodhue County)	12.05	Little Cannon River	11LM025	16-Aug-11	Southern Streams RR	5	28.1	37	-8.9
07040002-589	Little Cannon River (Goodhue County)	12.05	Little Cannon River	11LM024	15-Aug-11	Southern Streams RR	5	22.2	37	-14.8
07040002-589	Little Cannon River (Goodhue County)	12.05	Little Cannon River	04LM086	17-Aug-04	Southern Streams RR	5	31.7	37	-5.3
07040002-590	Butler Creek	2.11	Butler Creek	04LM085	15-Aug-11	Southern Streams RR	5	22.3	37	-14.7
07040002-590	Butler Creek	2.11	Butler Creek	04LM085	17-Aug-04	Southern Streams RR	5	39.9	37	2.9
07040002-591	Spring Creek	4.12	Spring Creek	04LM046	18-Aug-04	Southern Forest Streams GP	6	39.3	43	-3.7
07040002-591	Spring Creek	4.12	Spring Creek	11LM094	11-Aug-11	Southern Forest Streams GP	6	36.8	43	-6.2
07040002-638	Unnamed creek	1.96	Trib. to Cannon River	11LM078	17-Aug-11	Southern Forest Streams GP	6	38.2	43	-4.8
07040002-639	Unnamed creek (Little Cannon River Tribuatry)	0.59	Trib. to Little Cannon River	11LM027	16-Aug-11	Southern Streams RR	5	36.3	37	-0.7
07040002-670	Unnamed creek (Little Cannon River Tributary)	0.38	Trib. to Little Cannon River	11LM023	16-Aug-11	Southern Streams RR	5	29.0	37	-8.0
07040002-706	Whitewater Creek	0.73	White Water Creek	11LM057	09-Aug-11	Southern Forest Streams GP	6	27.5	43	-15.5
07040002-723	Unnamed creek	2.06	Trib. to Prairie Creek	11LM054	03-Aug-11	Southern Forest Streams GP	6	23.2	43	-19.8
07040002-731	Unnamed creek	1.85	Trib. to Maple Creek	11LM061	10-Aug-11	Southern Forest Streams GP	6	43.5	43	0.5
07040002-732	Unnamed creek	6.65	Unnamed creek	11LM038	01-Aug-11	Southern Forest Streams GP	6	31.6	43	-11.4
07040002-734	Belle Creek	7.85	Belle Creek	11LM006	04-Aug-11	Southern Coldwater	9	47.5	43	4.5
07040002-734	Belle Creek	7.85	Belle Creek	11LM006	04-Aug-11	Southern Coldwater	9	41.3	43	-1.7
07040002-735	Belle Creek	18.64	Belle Creek	04LM090	08-Aug-11	Southern Streams RR	5	33.8	37	-3.2
07040002-735	Belle Creek	18.64	Belle Creek	04LM090	08-Aug-11	Southern Streams RR	5	37.5	37	0.5
07040002-735	Belle Creek	18.64	Belle Creek	11LM026	04-Aug-11	Southern Streams RR	5	39.8	37	2.8
07040002-735	Belle Creek	18.64	Belle Creek	11LM029	04-Aug-11	Southern Streams RR	5	29.0	37	-8.0
07040002-735	Belle Creek	18.64	Belle Creek	11LM030	15-Aug-11	Southern Streams RR	5	35.9	37	-1.1
07040002-735	Belle Creek	18.64	Belle Creek	04LM090	17-Aug-04	Southern Streams RR	5	32.1	37	-4.9

Appendix C: Stream IBIs near thresholds.

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
04LM120	503		20040323	29-Jun-04			40	45
04LM120	503	Straight River	20040210	03-Sep-04	53.98	46.8		
04LM120	503	Straight River	20111303	10-Aug-11	50.29	46.8		
10EM011	503		20100165	21-Jul-10			45	45
10EM011	503	Straight River	20101890	10-Aug-10	29.34	35.9		
11LM009	504	Prairie Creek	20110278	11-Aug-11	30.84	35.9		
11LM009	504	Prairie Creek	20110279	11-Aug-11	45.45	35.9		
11LM055	504	Prairie Creek	20110276	11-Aug-11	29.73	35.9		
11LM055	504		20110171	07-Sep-11			50	45
11LM097	509	Cannon River	20111296	01-Sep-11	22.83	30.7		
11LM097	509		20110170	06-Sep-11			42	46
04LM014	515	Straight River	20040122	07-Sep-04	40.25	35.9		
04LM014	515		20040446	13-Sep-04			39	46
11LM010	515	Straight River	20110331	16-Aug-11	26.80	35.9		
11LM010	515		20110114	18-Aug-11			54	46
11LM007	516	Crane Creek	20111310	11-Aug-11	48.57	46.8		
11LM007	516		20110115	15-Aug-11			50	45
11LM032	516	Crane Creek	20111311	11-Aug-11	35.00	46.8		
11LM032	516		20110202	22-Aug-11			54	45
04LM131	517		20040468	29-Jun-04			43	45
04LM131	517	Straight River	20040221	03-Sep-04	37.49	46.8		
04LM131	517		20110005	14-Jun-11			48	45
04LM131	517	Straight River	20111261	02-Aug-11	37.93	46.8		
11LM004	518		20110004	14-Jun-11			44	45
11LM004	518	Turtle Creek	20111262	02-Aug-11	48.78	46.8		
11LM011	519	Maple Creek	20111305	10-Aug-11	38.08	35.9		
11LM011	519		20110120	15-Aug-11			49	45

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
11LM062	519	Maple Creek	20111302	10-Aug-11	54.12	46.8		
11LM062	519		20110187	13-Sep-11			56	51
99LM002	520		19990178	19-Jun-99			49	45
99LM002	520	Pine Creek	20111280	04-Aug-11	59.78	46.1		
11LM003	522	Wolf Creek	20110389	16-Aug-11	36.22	35.9		
11LM003	522	Wolf Creek	20110391	16-Aug-11	39.37	35.9		
11LM003	522		20110156	13-Sep-11			50	45
11LM041	524		20110046	01-Aug-11			51	51
11LM041	524	County Ditch 64	20111259	02-Aug-11	37.90	46.8		
11LM089	526		20111093	09-Aug-11			47	45
11LM089	526	Little Cannon River	20110403	16-Aug-11	42.12	46.8		
10EM087	528		20100013	02-Aug-10			36	45
10EM087	528	Chub Creek	20101938	31-Aug-10	54.64	46.8		
11LM016	528	Chub Creek	20110373	17-Aug-11	40.42	46.8		
11LM016	528		20110157	13-Sep-11			39	45
11LM037	534	Straight River	20111255	02-Aug-11	38.93	35.9		
11LM037	534	Straight River	20111254	02-Aug-11	47.20	35.9		
11LM088	536	Straight River	20111314	11-Aug-11	37.06	46.8		
11LM088	536		20110179	17-Aug-11			46	46
11LM065	547	Medford Creek	20111315	11-Aug-11	37.10	35.9		
11LM065	547	Medford Creek	20111316	11-Aug-11	38.65	35.9		
04LM083	555		20040308	18-Jun-04			44	51
04LM083	555	Unnamed ditch (Heath Creek)	20040165	18-Aug-04	44.82	46.8		
04LM084	555	Unnamed creek	20040166	18-Aug-04	47.79	46.8		
04LM084	555		20130074	05-Aug-13			47	51
11LM060	556		20110049	02-Aug-11			58	51

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
11LM060	556	Judicial Ditch 1	20111267	03-Aug-11	38.13	46.8		
04LM077	557	Unnamed creek (Rice Creek)	20040160	18-Aug-04	47.86	46.1		
04LM077	557	Unnamed creek (Rice Creek)	20111561	03-Aug-11	38.26	46.1		
04LM080	560		20110130	09-Aug-11			55	51
04LM080	560	Waterville Creek	20110335	16-Aug-11	39.64	35.9		
11LM018	566	Chub Creek, North Branch	20110396	16-Aug-11	38.80	46.8		
11LM018	566		20110111	25-Aug-11			49	51
04LM079	574		20110047	02-Aug-11			50	51
04LM079	574	Mud Creek	20110347	15-Aug-11	45.05	46.8		
11LM051	578		20110043	03-Aug-11			32	40
11LM051	578	Little Cannon River	20111308	09-Aug-11	33.64	46.8		
04LM044	629	Wolf Creek	20040140	18-Aug-04	43.10	46.8		
04LM044	629	Wolf Creek	20110361	17-Aug-11	34.37	46.8		
11LM078	638		20110166	16-Aug-11			58	51
11LM078	638	Trib. to Cannon River	20110320	17-Aug-11	38.24	46.8		
11LM069	704	Falls Creek	20110329	16-Aug-11	38.62	35.9		
11LM069	704		20110162	16-Aug-11			57	51
11LM071	719	Unnamed creek	20110382	17-Aug-11	45.75	46.8		
11LM071	719		20110155	13-Sep-11			57	51
11LM013	720		20110025	13-Jun-11			50	51
11LM013	720	Unnamed ditch	20110380	17-Aug-11	44.51	46.8		
11LM022	729		20110038	02-Aug-11			56	51
11LM022	729	Trib. to Maple Creek	20111304	10-Aug-11	47.93	46.8		
11LM006	734	Belle Creek	20111274	04-Aug-11	41.26	46.1		
11LM006	734	Belle Creek	20111564	04-Aug-11	47.46	46.1		

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
11LM006	734		20111091	09-Aug-11			57	45
04LM090	735	Belle Creek	20040173	17-Aug-04	32.09	35.9		
04LM090	735	Belle Creek	20110272	08-Aug-11	33.81	35.9		
04LM090	735	Belle Creek	20110273	08-Aug-11	37.53	35.9		
11LM026	735	Belle Creek	20111275	04-Aug-11	39.78	35.9		
11LM026	735		20110159	17-Aug-11			50	51
04LM139	904		20040014	30-Jun-04			46	51
04LM139	904		20110001	13-Jun-11			52	51
04LM139	904	Straight River	20111257	02-Aug-11	36.32	46.8		
13LM001	?		20130032	05-Aug-13			44	45
13LM001	?	Heath Creek	20131778	05-Sep-13	35.08	46.8		
00LM002		Cannon River	20111297	01-Sep-11	28.57	30.7		
00LM003			20000129	10-Oct-00			35	46
00LM006			20000132	18-Sep-00			39	45
00LM007			20000142	16-Sep-00			53	45
02LM017		Cannon River	20111293	01-Sep-11	36.10	30.7		
04LM004		Pine Creek	20040115	18-Aug-04	38.33	46.1		
04LM033			20040487	07-Oct-04			43	45
04LM038		Little Cannon River	20040138	17-Aug-04	45.83	35.9		
04LM046		Spring Creek	20040141	18-Aug-04	39.27	46.8		
04LM055		Cannon River	20111298	01-Sep-11	35.77	30.7		
04LM059			20040004	06-Jul-04			49	45
04LM081			20040447	17-Aug-04			53	45
04LM085		Butler Creek	20040167	17-Aug-04	39.93	35.9		
04LM086			20040430	19-Aug-04			32	45
04LM119		Crane Creek	20040209	25-Aug-04	45.07	46.8		
04LM144		Trout Brook	20040234	17-Aug-04	37.37	46.1		
04LM145		Little Cannon River	20040276	24-Aug-04	45.05	35.9		

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
07LM001			20110031	01-Aug-11			51	51
07LM002			20070182	14-Aug-07			43	45
07LM017			20070181	13-Aug-07			44	45
07LM020		Crane Creek	20111312	08-Aug-11	36.33	35.9		
10EM023			20100174	07-Sep-10			54	45
10EM075		Medford Creek	20101931	10-Aug-10	44.67	35.9		
10EM175			20100028	26-Aug-10			52	46
11LM005		Heath Creek	20111269	03-Aug-11	43.24	35.9		
11LM008		Unnamed creek	20111252	01-Aug-11	48.83	46.8		
11LM012		Chub Creek	20110394	16-Aug-11	35.67	35.9		
11LM015		Spring Creek	20111294	01-Sep-11	40.14	46.8		
11LM017		Mud Creek	20110393	16-Aug-11	58.35	46.8		
11LM023		Trib. to Little Cannon River	20110405	16-Aug-11	29.00	35.9		
11LM027		Trib. to Little Cannon River	20110404	16-Aug-11	36.34	35.9		
11LM028		Trib. to Belle Creek	20110410	15-Aug-11	28.01	35.9		
11LM029		Belle Creek	20111276	04-Aug-11	28.96	35.9		
11LM030		Belle Creek	20110411	15-Aug-11	35.86	35.9		
11LM033		Prairie Creek	20110275	11-Aug-11	44.83	46.8		
11LM034		Straight River	20111263	02-Aug-11	42.99	35.9		
11LM035		Turtle Creek	20111260	02-Aug-11	36.30	35.9		
11LM036		Unnamed creek	20111253	01-Aug-11	38.80	35.9		
11LM042		Unnamed ditch	20111256	02-Aug-11	36.03	46.8		
11LM043		Straight River	20111265	03-Aug-11	48.05	35.9		
11LM050		County Ditch 63 (Lake Dora Creek)	20111309	09-Aug-11	47.93	46.8		
11LM052			20110129	09-Aug-11			48	51
11LM054			20110163	18-Aug-11			57	51

FieldNum	AUID	WBName	VisitNum	VisitDate	MIBI	Threshold	FIBI	Threshold
11LM056		Mackenzie Creek	20110343	15-Aug-11	42.43	46.8		
11LM058		Trib. to Cannon River	20110332	16-Aug-11	35.85	46.8		
11LM061		Trib. to Maple Creek	20111301	10-Aug-11	43.54	46.8		
11LM063			20130080	05-Aug-13			58	51
11LM064		Trib. to Medford Creek	20111317	11-Aug-11	48.44	46.8		
11LM067		Rush Creek	20111313	11-Aug-11	40.54	35.9		
11LM068			20110193	20-Sep-11			47	46
11LM077		Unnamed creek	20110274	11-Aug-11	31.47	35.9		
11LM081			20110178	12-Sep-11			41	45
11LM086		Cannon RIver	20110392	16-Aug-11	22.81	30.7		
11LM092		Straight River	20110344	15-Aug-11	45.09	35.9		
11LM094		Spring Creek	20110277	11-Aug-11	36.78	46.8		
11LM096		Trib. to Cannon River	20110387	17-Aug-11	32.08	35.9		
11LM099		Unnamed creek (Rice Creek)	20111270	03-Aug-11	56.12	46.1		
99LM005		Trib. to Trout Brook	20111277	04-Aug-11	33.31	46.1		

Below threshold (within CL)

Above threshold (within CL)

33 AUIDs with fish and bug scores in the middle

Appendix D: CLMP Trend Analysis

Lake ID	Sig	Slope Description	Evidence Description
19-0006-00	0	No Evidence of Trend	No evidence of trend
19-0020-00		Insufficient Data	
40-0001-00	1	No Evidence of Trend	No evidence of trend
40-0002-00	-3	Decreasing Trend	Evidence for possible trend
40-0009-00		Insufficient Data	
40-0010-00		Insufficient Data	
40-0011-00		Insufficient Data	
40-0013-00		Insufficient Data	
40-0014-00		Insufficient Data	
40-0031-00	0	No Evidence of Trend	No evidence of trend
40-0032-00		Insufficient Data	
40-0033-00	4	Increasing Trend	Evidence for trend
40-0039-00		Insufficient Data	
40-0044-00		Insufficient Data	
40-0048-00		Insufficient Data	
40-0051-00	0	No Evidence of Trend	No evidence of trend
40-0054-00		Insufficient Data	
40-0056-00		Insufficient Data	
40-0057-00	0	No Evidence of Trend	No evidence of trend
40-0059-00		Insufficient Data	
40-0061-00		Insufficient Data	
40-0063-00	0	No Evidence of Trend	No evidence of trend
66-0007-00		Insufficient Data	
66-0008-00	0	No Evidence of Trend	No evidence of trend
66-0010-00	0	No Evidence of Trend	No evidence of trend
66-0014-00	0	No Evidence of Trend	No evidence of trend
66-0015-00	0	No Evidence of Trend	No evidence of trend
66-0018-00	0	No Evidence of Trend	No evidence of trend
66-0027-00	0	No Evidence of Trend	No evidence of trend
66-0029-00	-5	Decreasing Trend	Strong evidence for trend
66-0032-00	0	No Evidence of Trend	No evidence of trend
66-0038-00	0	No Evidence of Trend	No evidence of trend
66-0039-00	0	No Evidence of Trend	No evidence of trend
66-0044-00		Insufficient Data	
66-0045-00		Insufficient Data	
66-0047-00	0	No Evidence of Trend	No evidence of trend
66-0048-00		Insufficient Data	
66-0050-00		Insufficient Data	
66-0052-00	0	No Evidence of Trend	No evidence of trend
66-0055-00	0	No Evidence of Trend	No evidence of trend
66-0057-00		Insufficient Data	

Lake ID	Sig	Slope Description	Evidence Description
74-0023-00	0	No Evidence of Trend	No evidence of trend
81-0013-00		Insufficient Data	
81-0014-01	0	No Evidence of Trend	No evidence of trend
81-0015-00	0	No Evidence of Trend	No evidence of trend
81-0016-00		Insufficient Data	
81-0022-00		Insufficient Data	
81-0058-00		Insufficient Data	

Appendix E: Watershed load monitoring program data.

FLX: FLUX computational program used for estimating loads.
FWMC: Flow Weighted Mean Concentration.

Cannon River at Morristown, CSAH16 (S003-487 in the upper Cannon lobe 0704000201)

FLX_PARAM	FLX_START	FLX_END	FWMC (mg/L)	Mass (kg)	Vol (acre ft)	Yield (lbs/ac)
TSS	4/5/2013	10/31/2013	9.4	995024	85704	13.8
DOP	4/5/2013	10/31/2013	0.17	18008	85704	0.249
TP	4/5/2013	10/31/2013	0.255	26979	85704	0.374
NO2+NO3	4/5/2013	10/31/2013	1.3	136492	85704	1.89
TKN	4/5/2013	10/31/2013	1.8	190238	85704	2.64
TSS	4/3/2014	10/29/2014	11	1773969	133547	24.6
TP	4/3/2014	10/29/2014	0.24	39595	133547	0.548
DOP	4/3/2014	10/29/2014	0.161	26570	133547	0.368
NO2+NO3	4/3/2014	10/29/2014	1.7	272696	133547	3.78
TKN	4/3/2014	10/29/2014	1.53	252561	133547	3.5

Straight River near Faribault (S003-557 in the Straight River lobe 0704000203)

FLX_PARAM	FLX_START	FLX_END	FWMC (mg/L)	Mass (kg)	Vol (acre ft)	Yield (lbs/ac)
TP	1/1/2008	12/31/2008	0.227	52246	186186	0.414
DOP	1/1/2008	12/31/2008	0.141	32335	186186	0.256
TSS	1/1/2008	12/31/2008	48	11122370	186186	88.1
NO2+NO3	1/1/2008	12/31/2008	7.2	1649483	186186	13.1
TKN	1/1/2008	12/31/2008	1.15	263245	186186	2.08
TSS	1/1/2009	12/31/2009	37	4295502	95130	34
TP	1/1/2009	12/31/2009	0.249	29215	95130	0.231
DOP	1/1/2009	12/31/2009	0.183	21449	95130	0.17
TKN	1/1/2009	12/31/2009	1.07	125668	95130	0.995
NO2+NO3	1/1/2009	12/31/2009	4.9	573172	95130	4.54
TSS	1/1/2010	12/31/2010	34	16442020	390313	130
TP	1/1/2010	12/31/2010	0.293	140941	390313	1.12
DOP	1/1/2010	12/31/2010	0.246	118212	390313	0.936
NO2+NO3	1/1/2010	12/31/2010	6.2	2999458	390313	23.8
TKN	1/1/2010	12/31/2010	1.33	647780	390313	5.13
TSS	1/1/2011	12/31/2011	43	19489070	367925	154
NO2+NO3	1/1/2011	12/31/2011	7.7	3477619	367925	27.5
TKN	1/1/2011	12/31/2011	1.21	550898	367925	4.36
TP	1/1/2011	12/31/2011	0.222	100683	367925	0.797
DOP	1/1/2011	12/31/2011	0.155	70292	367925	0.557
TSS	1/1/2012	12/31/2012	104	13585810	105755	108
NO2+NO3	1/1/2012	12/31/2012	9.8	1273715	105755	10.1
TKN	1/1/2012	12/31/2012	1.41	184344	105755	1.46
DOP	1/1/2012	12/31/2012	0.211	27583	105755	0.218
TSS	1/1/2013	12/31/2013	43	14159470	268905	112
NO2+NO3	1/1/2013	12/31/2013	11	3502254	268905	27.7
TKN	1/1/2013	12/31/2013	1.45	480992	268905	3.81
DOP	1/1/2013	12/31/2013	0.196	65071	268905	0.515
TSS	1/1/2014	12/31/2014	88	30188600	279275	239
TP	1/1/2014	12/31/2014	0.299	102874	279275	0.815
DOP	1/1/2014	12/31/2014	0.205	70596	279275	0.559
NO2+NO3	1/1/2014	12/31/2014	8.3	2865491	279275	22.7
TKN	1/1/2014	12/31/2014	1.48	510389	279275	4.04

Cannon River at Northfield, 2nd Street West (S001-582 in the middle Cannon lobe 0704000206)

FLX_PARAM	FLX_START	FLX_END	FWMC (mg/L)	Mass (kg)	Vol (acre ft)	Yield (lbs/ac)
NO2+NO3	3/7/2013	10/31/2013	6.1	3848446	514899	14.3
TKN	3/7/2013	10/31/2013	1.89	1198620	514899	4.44
TSS	3/7/2013	10/31/2013	88	55886750	514899	207
TP	3/7/2013	10/31/2013	0.306	194223	514899	0.72
DOP	3/7/2013	10/31/2013	0.151	96131	514899	0.356
TSS	3/9/2014	10/31/2014	66	48040760	588548	178
NO2+NO3	3/9/2014	10/31/2014	5.3	3816752	588548	14.2
TKN	3/9/2014	10/31/2014	1.77	1283465	588548	4.76
TP	3/9/2014	10/31/2014	0.329	239016	588548	0.886
DOP	3/9/2014	10/31/2014	0.153	110974	588548	0.411

Cannon River at Welch (S000-003, Lower Cannon lobe 0704000209)

FLX_PARAM	FLX_START	FLX_END	FWMC (mg/L)	Mass (kg)	Vol (acre ft)	Yield (lbs/ac)
NO2+NO3	1/1/2007	12/31/2007	4.7	4234247	726356	10.9
TKN	1/1/2007	12/31/2007	1.75	1570161	726356	4.04
TDP	1/1/2007	12/31/2007	0.163	145985	726356	0.375
TP	1/1/2007	12/31/2007	0.354	317552	726356	0.816
TSS	1/1/2007	12/31/2007	169	151189100	726356	389
NO2+NO3	1/1/2008	12/31/2008	4.9	3105365	513380	7.98
TKN	1/1/2008	12/31/2008	1.34	849825	513380	2.18
TDP	1/1/2008	12/31/2008	0.132	83745	513380	0.215
TP	1/1/2008	12/31/2008	0.237	150215	513380	0.386
TSS	1/1/2008	12/31/2008	70	44159780	513380	114
NO2+NO3	1/1/2009	12/31/2009	3.1	1037723	272733	2.67
TKN	1/1/2009	12/31/2009	1	336683	272733	0.865
TDP	1/1/2009	12/31/2009	0.139	46687	272733	0.12
TP	1/1/2009	12/31/2009	0.195	65581	272733	0.169
TSS	1/1/2009	12/31/2009	25	8476983	272733	21.8
TKN	1/1/2010	12/31/2010	1.55	2079526	1089680	5.35
TP	1/1/2010	12/31/2010	0.31	416128	1089680	1.07
TSS	1/1/2010	12/31/2010	143	192417600	1089680	495
NO2+NO3	1/1/2010	12/31/2010	5.2	7009447	1089680	18
TDP	1/1/2010	12/31/2010	0.141	189724	1089680	0.488
TDP	1/1/2011	12/31/2011	0.141	185408	1067790	0.477
TKN	1/1/2011	12/31/2011	1.46	1926158	1067790	4.95
TP	1/1/2011	12/31/2011	0.273	360093	1067790	0.926
NO2+NO3	1/1/2011	12/31/2011	5	6545763	1067790	16.8
TSS	1/1/2011	12/31/2011	140	185029200	1067790	476
TSS	1/1/2012	12/31/2012	131	83095650	512533	214
TDP	1/1/2012	12/31/2012	0.112	70733	512533	0.182
TP	1/1/2012	12/31/2012	0.255	161048	512533	0.414
NO2+NO3	1/1/2012	12/31/2012	4.5	2824175	512533	7.26
TKN	1/1/2012	12/31/2012	1.32	836522	512533	2.15
NO2+NO3	1/1/2013	12/31/2013	5	5095766	833332	13.1
TKN	1/1/2013	12/31/2013	1.65	1690758	833332	4.35
TP	1/1/2013	12/31/2013	0.3	308348	833332	0.793
TSS	1/1/2013	12/31/2013	152	155751400	833332	400
TDP	1/1/2013	12/31/2013	0.117	119962	833332	0.308

See Metropolitan Council (2014) figures CN-5 through CN-10 for more loading information at the Welch site.

Appendix F: HSPF Summary Report

Minnesota Pollution Control Agency

Cannon River Watershed HSPF and Little Cannon SWAT Model Report

1/28/2015

Hydrologic models were used to support decision-making for potential sediment and nutrient reduction strategies in the Cannon River basin. An HSPF (Hydrological Simulation Program – FORTRAN) model was developed for the watershed and a SWAT (Soil Water Assessment Tool) model was developed for the Little Cannon River basin within the greater Cannon watershed. This document describes the development of these models as well as some of the modeled data output. For information regarding these models or for any data/reports relating to them, please contact Dr. Charles Regan (chuck.regan@state.mn.us) or Ben Roush (benjamin.roush@state.mn.us) at the Minnesota Pollution Control Agency (MPCA).

HSPF Development

HSPF models allow for advanced hydrologic simulation of a basin through multiple sources of spatial and temporal observed data. The model was developed and continues to be supported by the EPA and has been consistently used in peer-reviewed watershed studies. More on HSPF can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=21398. This model was completed by the engineering firm LimnoTech, Inc. in 2016 and all data is part of the public domain.

Subwatershed Delineation and Land Segment Development

The watershed was separated into subwatersheds based on hydrography data (from GIS analysis) and could also be adjusted based on specific stream concerns (such as impairments). Pervious and impervious land segments within each subwatershed divide the subwatersheds into distinct sections based on land use, soil properties, feedlot operations, and tillage practices. This data was compiled from multiple federal, state, and local organizations and government entities. Land cover data for land segments originated from the National Land Cover Database of 2001 and 2006. Hydrology and water quality data was also collected from three major and 35 minor point source facilities in the watershed.

Calibration - Hydrology

Data from eight flow calibration gages was used for hydrologic calibration. U.S. Geological Survey (USGS) gages on the Cannon River at Welch and on the Straight River at Faribault were used as primary calibration points. The modeled period was between 1995 and 2012. Calibration involves determining annual water balance, modifying for seasonal changes in hydrology, ensuring high and low flow volumes are accurate, and modifying hydrograph to storm flows. Snow and snowmelt are also factored into the model based on meteorological inputs as well as calibrating for lake level accuracy.

Calibration – Water Quality

Multiple constituents of water quality were modeled, including biochemical oxygen demand, dissolved oxygen, sediment, temperature, and various nutrients. The simulated data were compared with multiple observed data points throughout the watershed and with observed water quality data from watershed point source facilities.

<u>Sediment</u>
Multiple sediment parameters were considering during calibration, including watershed loading, sediment delivery characteristics, trapping in lakes and reservoirs, and scour and deposition properties. Lake Byllesby acts as a trap for sediment in the watershed, and was assigned an estimated trapping efficiency of 34% for model parameterization. Sediment loading was also differentiated between gully/ravine loss and washoff/upland sources. Sediment through tile drainage was also simulated. In order to compare HSPF simulated sediment load data, the USGS Load Estimator (LOADEST) and the US Army Corps of Engineers FLUX32 model were used to calculate sediment loads based on observed flow and sediment concentration data.

<u>Nutrients and Water Temperature</u>
For certain water quality constituents, initial parameterization was based on regional HSPF models previously developed in Minnesota. The calibration process then allowed for the adjustment of water quality parameters to match observed data in the watershed. Nutrients simulated included nitrogen, phosphorus, and a variety of subspecies of these two nutrients. Nutrient simulation can be very challenging because of interdependence with other water quality characteristic and irregular schedule of in-stream observations. Nitrate and ammonia atmospheric deposition was also included from the National Atmospheric Deposition Program and the Environmental Protection Agency.

Calibration Results
At the primary gages (Cannon River at Welch and Straight River at Faribault) annual, monthly, and daily flow data was calibrated between “very good” and “fair” according to statistical performance metrics produced by LimnoTech. Such metrics included r-squared analysis and relative percent error determination comparing observed and modeled data. *Figure 1* is a comparison of HSPF-simulated flow and observed flow. Overall, the model was well calibrated for hydrology and water quality and has been approved to be used for both point source and non-point source nutrient reduction and hydrologic investigations.

Sediment calibration for the same time intervals (annual, monthly, and daily) was also “very good” to “fair.” Water temperature calibration was “good” to “very good;” phosphorus calibration was “good” to “very good;” nitrogen calibration was “fair” to “very good.”(For more information on the calibration process, contact Dr. Charles Regan or Ben Roush at the MPCA.)

HSPF Scenarios
Along with simulation of current watershed conditions (known as the “baseline” model), HSPF can be used to simulate changes in non-point and point source loading. These adjusted watershed conditions are known as scenarios and can be used to guide efforts to meet water quality standards.

Scenarios were developed by the MPCA with the technical support of LimnoTech as well as consultation from watershed partners, including the Minnesota Department of Natural Resources, municipalities, local county soil water conservation districts, local industry professionals, and landowners. Gathering information from watershed partners insures scenarios will more likely be utilized for future watershed conservation activities.

Figure 1: HSPF scenarios for the Cannon watershed. (Figure produced by LimnoTech.)

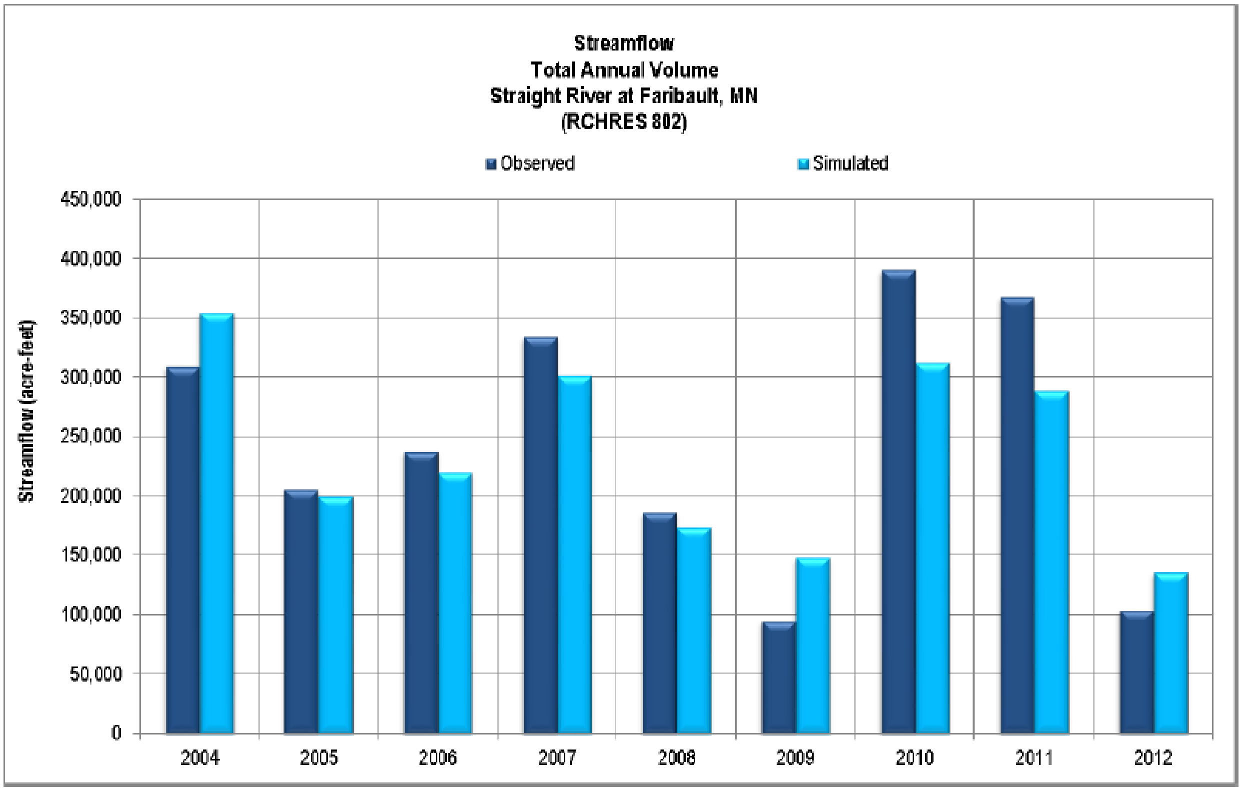


Table 1 below describes the scenarios developed for the Cannon River HSPF model.

Table 1: HSPF scenarios for the Cannon watershed. (Figure produced by LimnoTech.)

Scenario ID	Scenario Abbreviation	Description of Scenario Changes	Proportion of Land Segment Type Undergoing Treatment		Proportion of Land Segment Type Undergoing Land Conversion		Proportion of Watershed Undergoing Treatment / Conversion
			Cropland	Developed	Cropland	Developed	
A	"Adjusted" Baseline	Major WWTPs at Current TP Loads	-	-	-	-	-
B	Point Source Limits	All Point Sources at Permitted Limits	-	-	-	-	-
C	Point Sources RES	All Point Sources at RES & 70% AWWDF (Jun-Sep), Permitted TP Limits & 70% AWWDF (Oct-May)	-	-	-	-	-
D	Pre-Settlement Vegetation	Pre-Settlement Vegetation	-	-	100%	100%	84.0%
E	Consv. Tillage & Waseca G.I.	Conservation Tillage, Green Infrastructure in City of Waseca MS4 Areas, Major WWTPs at Current TP Loads	31.1%	1.2%	-	-	19.4%
F	Cover Crops	Cover Crops, Major WWTPs at Current TP Loads	23.4%	-	-	-	14.5%
G	Perennials & 25% G.I.	Conversion of Marginal Cropland & 50 ft Buffers to Perennial Vegetation, Green Infrastructure in 25% of MS4 Areas, Major WWTPs at Current TP Loads	25.0%	6.6%	12.3%	-	21.8%
H	Wetlands & Ponds	Wetland Restoration, Sedimentation Ponds, Major WWTPs at Current TP Loads	6.9%	-	8.5%	-	9.2%
I	Combined 1	Cover Crops, Conversion of Marginal Cropland & 50 ft Buffers to Perennial Vegetation, Low Flow Phosphorus Load Reduction, Major WWTPs at Current TP Loads	43.1%	-	12.3%	-	31.1%
J	Combined 2	Cover Crops, Conversion of Marginal Cropland & 50 ft Buffers to Perennial Vegetation, Low Flow Phosphorus Load Reduction, Major WWTPs at Current TP Loads (Jun-Sep), Major WWTPs at Permitted Flow & TP Limits (Oct-May),	43.1%	-	12.3%	-	31.1%

The scenarios were developed in two "waves," or stages of development, with scenarios A through E initially simulated and then used to inform the development of scenarios F through J. Scenario A, the "Adjusted" Baseline scenario, simulates point source loading data after major point source facilities in Owatonna and Faribault were renovated in 2012 (and Northfield facilities in 2003). These renovations resulted in major reductions in nutrient effluent from these facilities, and provided a more realistic simulation of current conditions in the watershed. An additional scenario not included in *Table 1* was also developed to better understand phosphorus load-response relationship in the creation of waste load allocations. *Figure 2* and *Figure 3* below show phosphorus and nitrogen reduction for scenarios A through J.

Figure 2: Phosphorus loading at the Cannon outlet between 1996 and 2012. (Figure provided by LimnoTech.)

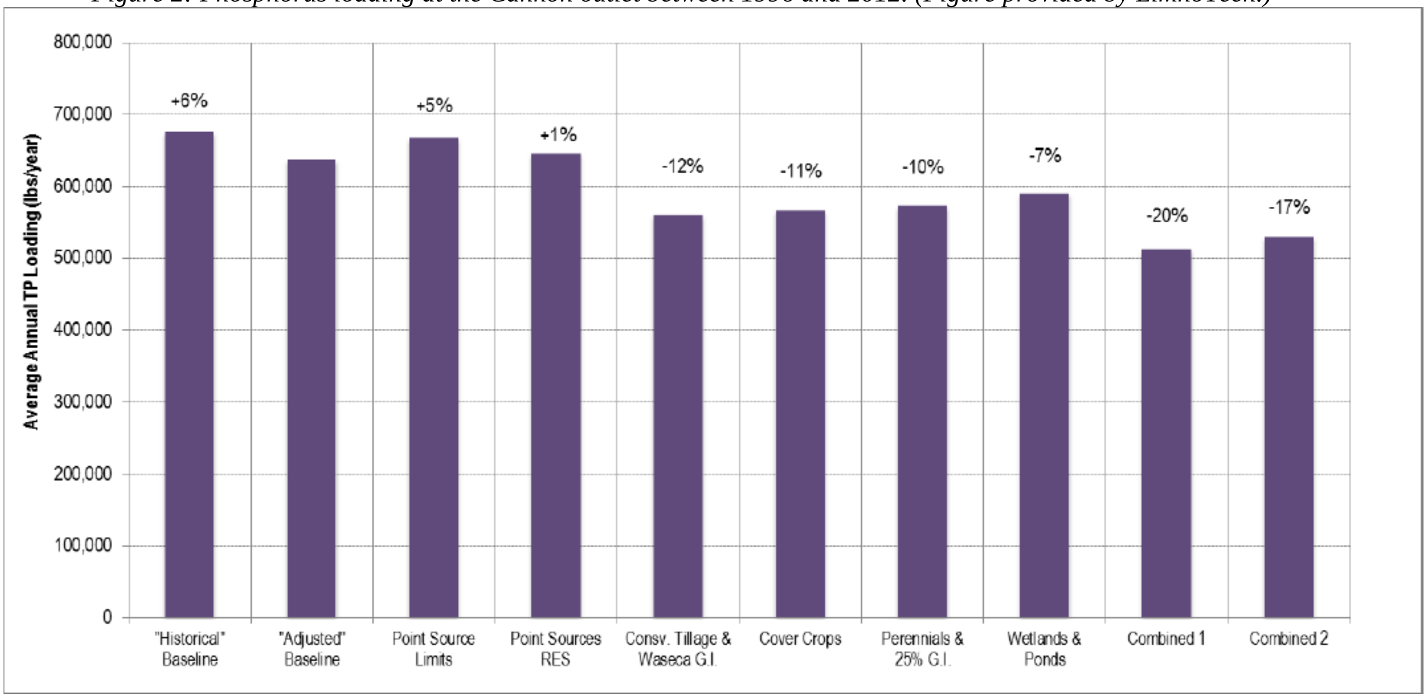
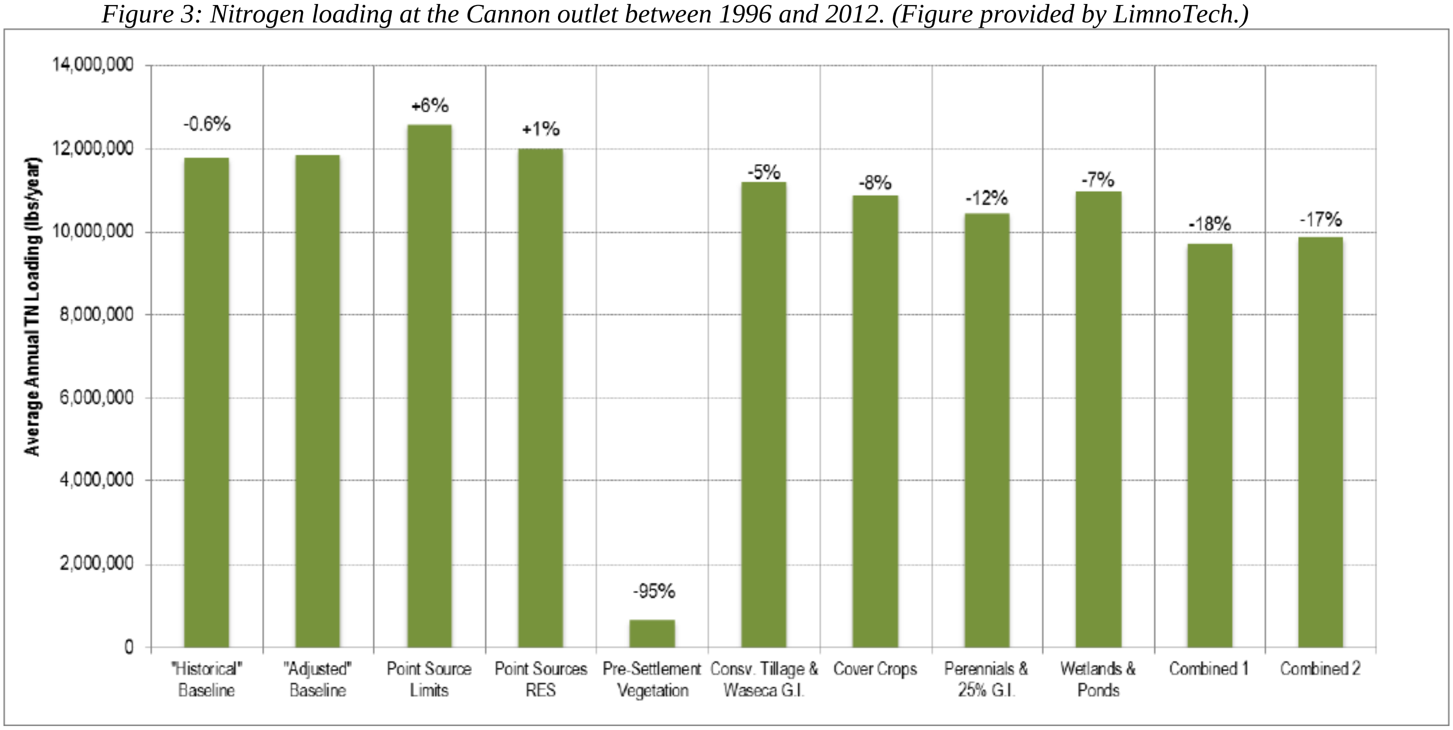


Figure 3: Nitrogen loading at the Cannon outlet between 1996 and 2012. (Figure provided by LimnoTech.)

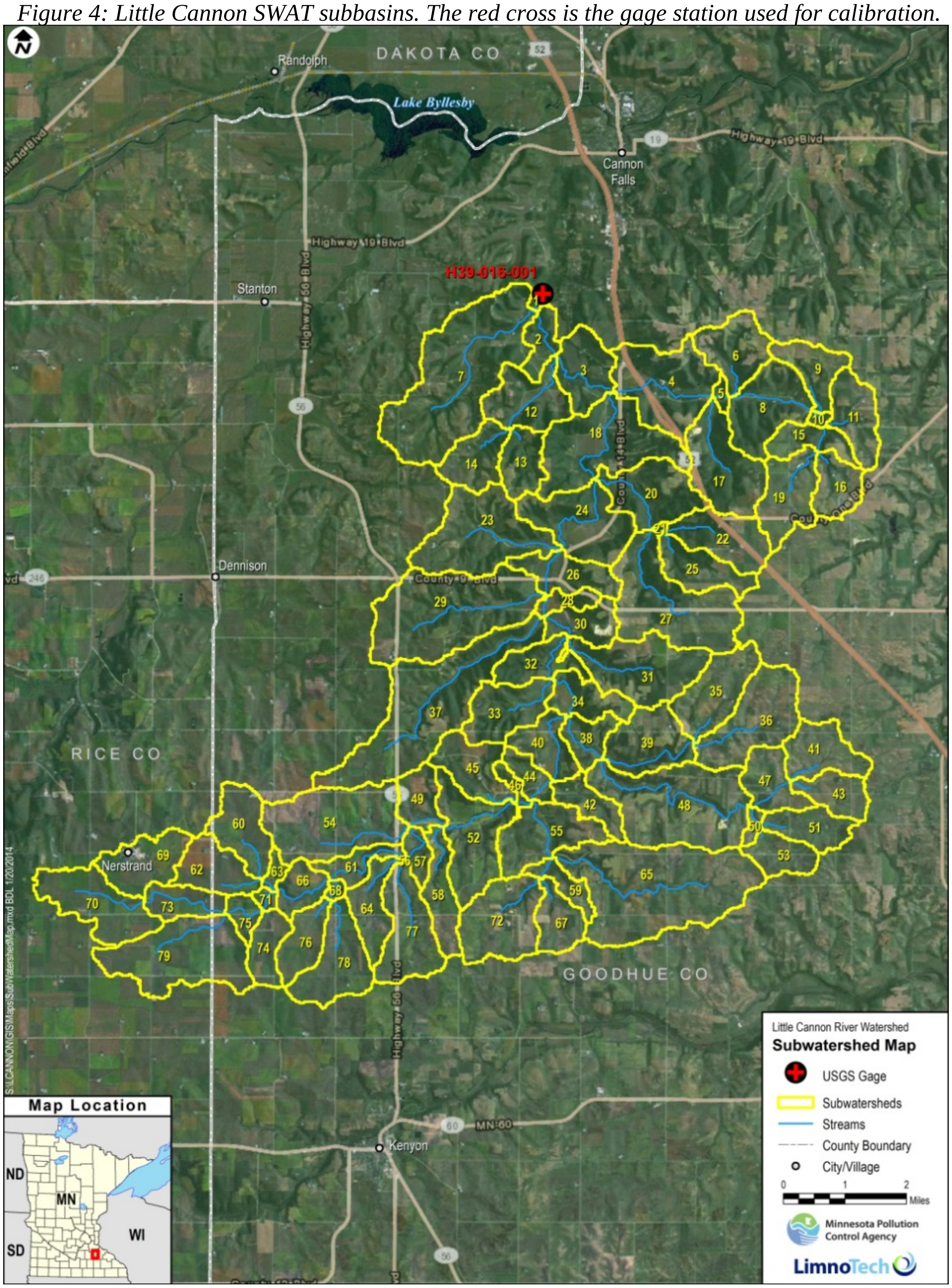


SWAT Development

A SWAT model of the Little Cannon watershed was also completed by LimnoTech in 2014. SWAT models are similar to HSPF, but are considered to be better at simulating specific agricultural practices and are generally weaker in the simulation of in-stream hydrological processes. For example, SWAT is more appropriate for sediment erosion rates based on a specific tillage regime than for the corresponding stream sediment transport. SWAT models only simulate on a daily time-step as well, while HSPF can simulate continuous data.

As with HSPF, SWAT is divided into subbasins. *Figure 4* shows the delineation of these SWAT subbasins as well as the location of the main calibration station for the watershed.

Figure 4: Little Cannon SWAT subbasins. The red cross is the gage station used for calibration.



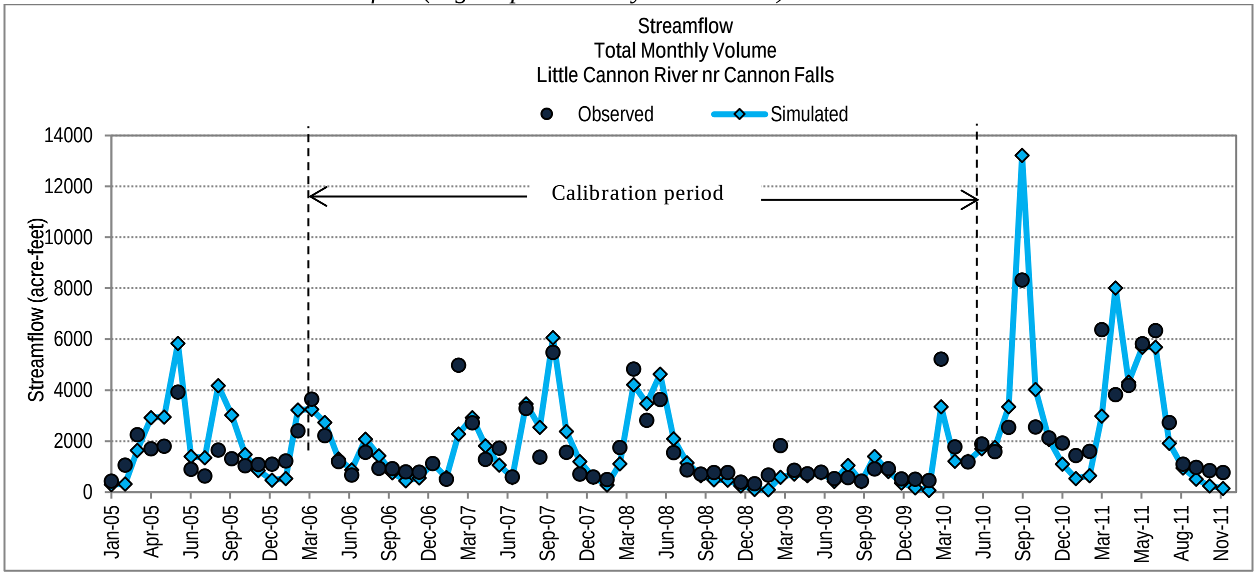
There are a total of 79 subbasins, with each subbasin then divided into hydrologic response units, which are characterized by different land use and land cover. This model was developed from previous SWAT modeling efforts for the Little Cannon, with updated meteorological inputs. The watershed was modeled between 2005 and 2011.

SWAT explicitly models crop rotations, tillage regimes, and fertilizer application rates. Ninety percent of cropland acres watershed is in corn-soybean rotation or continuous corn. Ten percent of cropland acres are simulated as two years of corn operations followed by three years of alfalfa. Tillage operations were simulated in the pre-planting and post-harvest periods for corn and soybean rotations. Fertilizer simulation (during corn cultivation) includes the application of 46-00-00 commercial fertilizer and dairy manure application of 29,299 lbs/acre in the fall on 15% of cropland acres.

Calibration

LimnoTech uses statistical calibration metrics similar those in HSPF for SWAT modeling, again including r-squared analysis and relative percent error determination. Annual and monthly flow examination resulted in a "very good" calibration performance by the SWAT model. However, some specific high-flow events were over predicted by the model outside of the calibration period. *Figure 5* demonstrates monthly flow comparison of simulated and observed data.

Figure 5: SWAT modeled (light blue) and observed (dark blue) flow in the Little Cannon River between January 2005 and November 2011 in acre-feet. (Figure produced by LimnoTech.)



Annual and monthly calibration was also "very good" for sediment, nitrogen, and phosphorus using the same statistical methodology. Because of the very strong calibration for nutrients, sediment, and flow, the model was deemed as a "suitable" method to examine conservation and land management in the Little Cannon watershed. This is done with the use of SWAT scenarios.

SWAT Scenarios

Seven scenarios were developed for the Little Cannon watershed. These scenarios were developed with the aid of local watershed partners, including the Goodhue County Soil and

Water Conservation District. Five of the scenarios were determined by the local watershed partners specifically. *Table 2* lists the scenarios, which include variations in tillage, installed BMPs, fertilizer changes, and land use/cover changes.

Table 2: Little Cannon SWAT scenarios (Figure produced by LimnoTech.)

Scenario ID	Scenario Description	Category
A	No-till soybean rotation	Stakeholders choice
B	No-till practice on slopes >2%	Stakeholders choice
C	Cropland converted to perennials on slopes > 2%	Stakeholders choice
D	Detention pond	Stakeholders choice
E	Natural background	Stakeholders choice
F	Cover crops	General
G	Conservation easement	General
H	Increasing fertilizer use efficiency	General

Figure 6 and *Figure 7* below demonstrate sediment and nitrogen loading changes between the scenarios and the "base" or current-condition scenarios.

Figure 6: Sediment loading at the Little Cannon outlet between 2005 and 2011. (Figure provided by LimnoTech.)

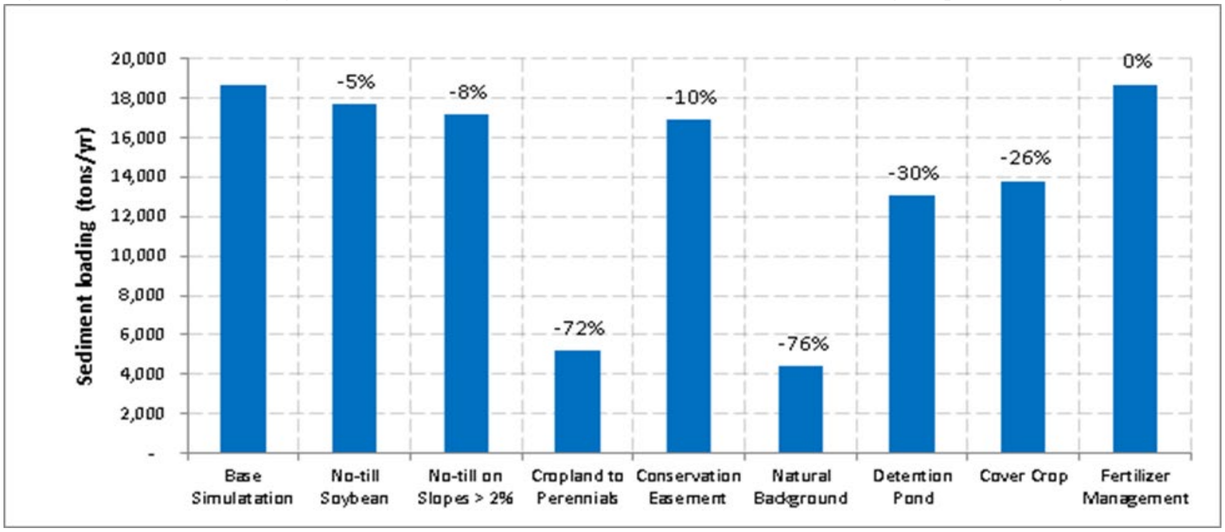
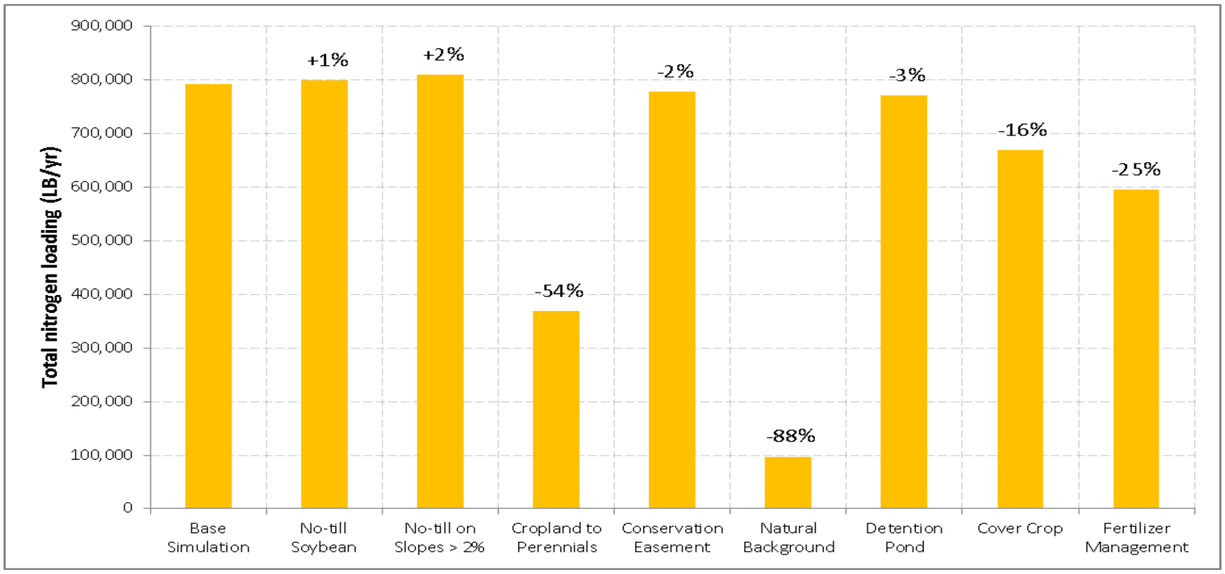


Figure 7: Nitrogen loading at the Little Cannon outlet between 2005 and 2011. (Figure provided by LimnoTech.)



Appendix G: Methodology for TNC Protection Prioritization.

Habitat Quality:

These layers were selected to rate HUC12 subwatersheds based on the presence and abundance of features likely to be a focus of multi-benefit protection efforts.

MBS Biodiversity Significance:

- A raster was created scoring cells of "Outstanding" biodiversity significance 4 points, "High" 3 points, "moderate" 2 points, and "Below" 1 point. All other areas were "NoData" or 0 points. The zonal mean for each HUC12 subwatershed was calculated, and scores were standardized to 10 points by dividing each subwatershed by the max score and multiplying by 10.

Public Ownership:

- Total area of public and conservation land in each subwatershed was calculated. Scores were standardized to 10 points.

Stream Quality Thresholds:

- Monitoring stations reporting values within the MPCA's confidence interval of relevant water quality thresholds were given the following points:
    - Above threshold, but within CI: 10 Points
    - Below threshold, and within ½ of the CI: 4 points
    - More than ½ the CI below threshold, within one CI: 2 points

Perennial Cover in Critical Areas:

- Overlapped NLCD 2011 land cover data and the EBI Water Quality layer to pick out areas scoring over 60 in the EBI data for their impact on water quality that were mapped as having perennial landcover in the NLCD data. The total area in each HUC12 was calculated and standardized to 10 points.

EBI Habitat Quality Layer:

- The zonal mean of each subwatershed was calculated for the EBI Habitat Quality layer. Subwatersheds were then classified into quintiles, with the top quintile receiving 10 points, the 2nd highest 8 points, the third highest 6, etc.

Conversion Risk:

Layers measuring the risk of conversion from perennial cover to row crops, as well as risk of more intensive development were created by Kristin Blann, aquatic ecologist with The Nature Conservancy. Both layers are raster data on a 1 to 100 scale. The zonal mean for each subwatershed was standardized to a 10-point scale.

Watershed Health Assessment Framework (WHAF):

A subset of the layers available from the WHAF was also included in the analysis (all scores standardized to 10 points for each HUC12 for each of the main categories below):

- Hydrology index
    - Perennial cover index (2011)
    - Impervious cover index (2011)
    - Storage, straightened-meandering stream ratio index
- Biology metrics
    - Aquatic invertebrate IBI
    - F-IBI
    - Mussel score
- Connectivity index
    - Riparian connectivity
    - Aquatic connectivity
- WQ Metric
    - Non-point sources: phosphorous risk
    - Wastewater treatment plants
    - Superfund sites
    - Septic systems
    - Potential contaminants
    - AUs

Combined Scores:

Final scores for each subwatershed were calculated by taking the sum of the average component score within each scoring category (Protection Value, Conversion Risk, and WHAF Metrics). Since each component within the categories had a max score of 10, this resulted in combined scores for each HUC12 having a max of 30. Each subwatershed was then ranked by percentile. The map shows those subwatersheds that scored in the top 4 deciles (60^{th} percentile and above).

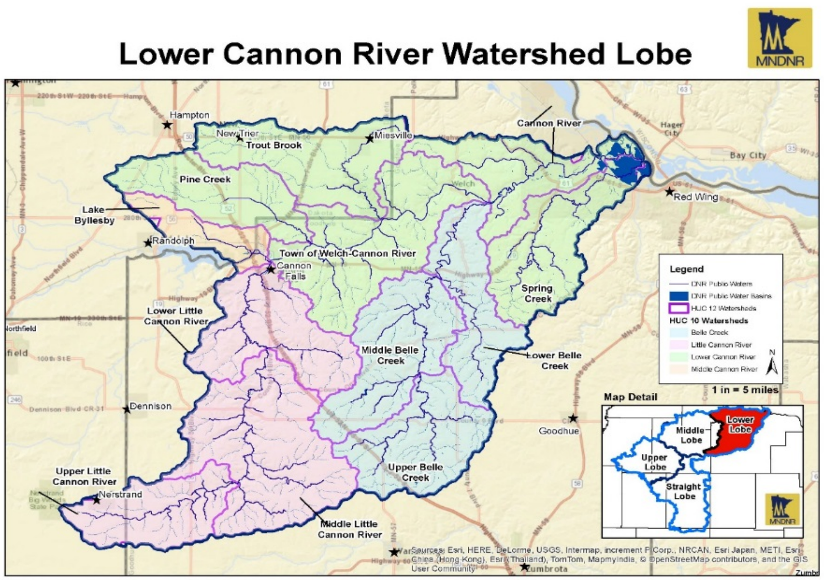
Appendix H: DNR Summary of strategies and priorities for Lower Cannon lobe.

DNR Watershed Priorities for the Lower Cannon River Watershed Lobe

This document was prepared by efforts led by the Department of Natural Resources (DNR) Division of Ecological and Water Resources. Region 3 staff from DNR Divisions (Fisheries, Wildlife, Parks and Trails and Ecological and Water Resources) were engaged in several meetings to develop watershed priorities for the Cannon River Watershed. The meetings focused on gathering input from staff based upon professional judgement from their combined experience and local knowledge from working within the watershed.

The information gathered is presented as a table organized by the 10-digit hydrologic unit code (HUC) number and associated name, along with the appropriate 12-digit HUC subwatershed name(s). Priorities identified during this process varied from protection, restoration, regulatory (protection and/or restoration), and technical guidance and/or assistance) types of strategies and are presented in no particular order.

While every attempt was made to provide information for the entire Cannon River Watershed at the 10-digit HUC scale, some subwatersheds priorities at the HUC 12 scale were left blank. Blank cells should not be interpreted as 'not important', rather, they should be viewed as 'more information needs to be collected' to determine specific priorities. Conversely, cells where strategies are identified should not be viewed as inclusive, rather priority strategies identified represent the opinions of the Region 3 staff.



LOWER CANNON RIVER WATERSHED LOBE

Priority: strategy represented by cell color.
Protection Strategy
Restoration Strategy
Regulatory Strategy (protection and/or restoration strategy)
Technical Guidance and/or Assistance Protection and/or Restoration Strategy

10 digit HUC (Name & No.)	12 digit HUC (Name & No.)	Trout Stream Designation (Name & Kittle No.)	Water Quality Condition: Impaired Stream (MPCA 2014 Draft) Impairment Type; (Use); Reach Description	Strategies				
Belle Creek (0704000208)	**Upper Belle Creek** (070400020801)	None	**E.coli, Turbidity** (AQR and AQL) Headwaters to Hwy 19	Provide technical guidance to SWCDs, and the MDA for making recommendation on target areas to promote the Minnesota Agricultural Water Quality Certification Program				
	Middle Belle Creek (070400020802)	None	**E.coli, Turbidity** (AQR and AQL) Headwaters to Hwy 19	Follow **Minnesota's Forest Management Guidelines** when managing DNR owned Forestry lands. Practices employed to reduce erosion include special provisions for filter strips, riparian management zones (RMZs), timing of acitivies to minimize soil compaction and disturbance and erosion control. More information can be found at: http://mn.gov/frc/forest-management-guidelines.html	**Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features Provide technical guidance to SWCDs, and the MDA for making recommendation on target areas to promote the Minnesota Agricultural Water Quality Certification Program			
	Lower Belle Creek (070400020803)	None	**E. coli, Turbidity** (AQR and AQL) Hwy 19 to Cannon River **E. coli** (AQR) Unnamed Cr to Belle Creek	Preserve the **High Conservation Value Forest (HCVF)** designation of the Vermillion Bottoms & Lower Cannon River Area by: •maintaining native forest cover in floodplain forest plant communities; •maintaining large patches of older forest; •managing for floodplain forest tree regeneration by controlling reed canary grass when necessary; •maintaining or enhance size and health of SGCN bird populations with adequate forest cover, vertical structure, & snags; ensure rare reptiles have habitat for nesting, feeding, & travel	Follow **Minnesota's Forest Management Guidelines** when managing DNR owned Forestry lands. Practices employed to reduce erosion include special provisions for filter strips, riparian management zones (RMZs), timing of acitivies to minimize soil compaction and disturbance and erosion control. More information can be found at: http://mn.gov/frc/forest-management-guidelines.html	Restore high quality habitat on the **Cannon River Turtle Preserve SNA**	**Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features Provide technical guidance to SWCDs, and the MDA for making recommendation on target areas to promote the Minnesota Agricultural Water Quality Certification Program	**Minnesota's Wildlife Action Plan (MN WAP):** Focus conservation efforts within the high to medium scored priority zones of the Wildlife Action Network (WAN). Projects and practices implemented here will protect rare, declining, or vulnerable to decline nongame wildlife species, including Species in Greatest Conservation Need (SGCN); protect and restore perennial vegetation for clean water; promote biological diversity and ecosystem resilience.
Little Cannon River (0704000207)	**Upper Little Cannon River** (070400020701)	**Little Cannon River** (M-048-012)	**E. coli, Nitrate, Turbidity** (AQR, DW, AQL) T110 R18W S10, west line to T111 TR18W S13, east line	**Protection strategies for recovered tributaries and headwater stream segments:** Enforce buffer rule, avoid ditch cleanouts, increase perennial cover and replace/modify road crossings that are either barriers to aquatic movement or sediment transport.	Continue to maintain and restore **AMA easements**, increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Expand the **DNR observation well monitoring network** to increase knowledge of sustainable yields Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. This information will help set a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection	**Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features	**Protection strategies for unstable[1] tributaries and headwater stream segments:** In-stream restoration following natural channel design principals where the channel has significantly incised and has remained in an unstable[1] state for more than 10-20? years and shows only minor signs of recovery on its own (use the stream succession scenarios). In-stream restorations must be sequenced beginning with upstream segments and before progressing downstream. Restoration should address the underlying cause of excess sediment, which in the upper reaches of these catchments tends to be systemic in nature due to historic landuse change altering the hydrology resulting in destabilizing channels. Riparian vegetation has mostly recovered since and the current channels are in various states of recovery/non-recovery. Recommend replace/modify road crossings that are either barriers to aquatic or sediment transport. [1]unable to carry the water and sediment of its watershed without maintaining its dimension, pattern and profile through time and is either aggrading or degrading

LOWER CANNON RIVER WATERSHED LOBE

Priority: strategy represented by cell color.
Protection Strategy
Restoration Strategy
Regulatory Strategy (protection and/or restoration strategy)
Technical Guidance and/or Assistance Protection and/or Restoration Strategy

10 digit HUC (Name & No.)	**12 digit HUC** (Name & No.)	**Trout Stream Designation** (Name & Kittle No.)	**Water Quality Condition: Impaired Stream (MPCA 2014 Draft)** Impairment Type; (Use); Reach Description	**Strategies**				
Little Cannon River (0704000207)	**Middle Little Cannon River** (070400020702)	**Little Cannon River** (M-048-012)	**E. coli, Nitrate, Turbidity** (AQR, DW, AQL) T110 R18W S10, west line to T111 TR18W S13, east line **E. coli, M-IBI, Turbidity** (AQR and AQL) T111 R17W S18, west line to Cannon River	**SNA Program Ecological Evaluation Site:** **Little Cannon Woods (600 acres)** One of the most important maple basswood forests in Goodhue County due to large intact size of old growth forest and species/habitat diversity. The site contains the only documented occurrence of talus slopes and black ash seeps in the Little Cannon River Watershed. Subject to development pressure and selective logging. Recommend protecting the site via fee title acquisition as a Scientific and Natural Area (SNA); highest priority is to protect the Leon 20 Woods over the Urland Church Woods-two MCBS sites that comprise the Little Cannon Woods EE site. **Calcareous Fen** Protect the Holden 1 West high quality calcareous fen **Protection strategies for recovered tributaries and headwater stream segments:** Enforce buffer rule, avoid ditch cleanouts, increase perennial cover and replace/modify road crossings that are either barriers to aquatic movement or sediment transport.	Increase **water storage** for flood attentuation. Focus on historic wetland areas. Avoid structures on-channel when on a perennial flowing channel	Continue to maintain and restore **AMA easements**, increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Expand the **DNR observation well monitoring network** to increase knowledge of sustainable yields Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. Information will establish a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features	**Protection strategies for unstable[1] tributaries and headwater stream segments:** In-stream restoration following natural channel design principals where the channel has significantly incised and has remained in an unstable[1] state for more than 10-20? years and shows only minor signs of recovery on its own (use the stream succession scenarios). In-stream restorations must be sequenced begining with upstream segments and before progressing downstream. Restoration should address the underlying cause of excess sediment, which in the upper reaches of these catchments tends to be systemic in nature due to historic landuse change altering the hydrology resulting in destabilizing channels. Riparian vegetation has mostly recovered since and the current channels are in various states of recovery/non-recovery. Recommend replace/modify road crossings that are either barriers to aquatic or sediment transport. [1]unable to carry the water and sediment of its watershed without maintaining its dimension, pattern and profile through time and is either aggrading or degrading
	Lower Little Cannon River (070400020703)	None	**E. coli, M-IBI, Turbidity** (AQR and AQL) T111 R17W S18, west line to Cannon River **E. coli, M-IBI, Turbidity** (AQR and AQL) Unnamed Cr to Little Cannon River	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Expand the **DNR observation well monitoring network** to increase the understanding of groundwater quantity **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features				

LOWER CANNON RIVER WATERSHED LOBE

Priority: strategy represented by cell color.
Protection Strategy
Restoration Strategy
Regulatory Strategy (protection and/or restoration strategy)
Technical Guidance and/or Assistance Protection and/or Restoration Strategy

10 digit HUC (Name & No.)	**12 digit HUC** (Name & No.)	**Trout Stream Designation** (Name & Kittle No.)	**Water Quality Condition: Impaired Stream (MPCA 2014 Draft)** Impairment Type; (Use); Reach Description	**Strategies**				
Lower Cannon River (070400209)	**Cannon River** (070400020905)	None	**E.coli, PCBF** (AQR and AQC) Belle Cr to split near mouth **PCBF, Turbidity** (AQC and AQL) North Branch of split to Vermillion River	Preserve the **High Conservation Value Forest (HCVF)** designation of the Vermillion Bottoms & Lower Cannon River Area by: •maintaining native forest cover in floodplain forest plant communities; •maintaining large patches of older forest; •managing for floodplain forest tree regeneration by controlling reed canary grass when necessary; •maintaining or enhance size and health of SGCN bird populations with adequate forest cover, vertical structure, & snags; ensure rare reptiles have habitat for nesting, feeding, & travel	**SNA Program Ecological Evaluation Site:** **Wood Turtle Flats (360 acres)** Protect the existing habitat within the floodplain forest (streamside habitat) of the lower Cannon River near Red Wind to support a population of the state threatened wood turtle (Clemys insculpta). **Calcareous Fens** Protect the Red Wing 21 high quality calcareous fen	Restore high quality habitat on the **Cannon River Turtle Preserve SNA**	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws **Expand the** DNR observation well monitoring network **to increase knowledge of sustainable yields** **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features	**State Wildlife Action Plan (SWAP):** Protect high quality terrestrial and aquatic habitat and their connections among public and private conservations lands as identified by the State Wildlife Action Plan (SWAP). Approaches include acquisition, restorations, technical guidance monitoring and collection of new data.
	Pine Creek (070400020901)	**Pine Creek** (M-048-011)	**Nitrate** (DW) T113 R18W S26, west line to Cannon R	Continue to maintain and restore **AMA easements**, increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Expand the **DNR observation well monitoring network** to increase knowledge of sustainable yields Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. This information will help set a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features	**SNA Program Ecological Evaluation Site:** **River Terrace Prairie (80 acres)** Only known occurrence of a large gravel prairie in Goodhue County. Restore surrounding croplands to native prairie vegetation and recommend protecting the site as a Scientific and Natural Area (SNA).	**Minnesota's Wildlife Action Plan (MN WAP):** Focus conservation efforts within the high to medium scored priority zones of the Wildlife Action Network (WAN) to protect rare, declining, or vulnerable to decline nongame wildlife species, including Species in Greatest Conservation Need (SGCN). Protection and restoration activities targeting nongame species within the WAN will result in multiple environmental benefits. Benefits include increased perennial vegetation for habitat enhancement and for clean water (improved water quality) increase biological diversity and ecosystem resilience. Provide technical guidance to SWCDs, and the MDA for making recommendation on target areas to promote the Minnesota Agricultural Water Quality Certification Program	Provide technical guidance to SWCDs, and the MDA for making recommendation on target areas to promote the Minnesota Agricultural Water Quality Certification Program
	Spring Creek (070400020904)	**Spring Creek** (M-047)	**E. coli, Turbidity** (AQR and AQL) T112 R15W S18, west line to T113 R15W S34, north line **Turbidity** (AQL) T113 R15W S27, south line to Spring Creek Lk	**SNA Program Ecological Evaluation Site:** **Red Wing Bluffs (100 acres)** Recommend protecting the bedrock bluff prairie site through acquisition to resist development pressure as Red Wing expands. Follow **Minnesota's Forest Management Guidelines** when managing DNR owned Forestry lands. Practices employed to reduce erosion include special provisions for filter strips, riparian management zones (RMZs), timing of acitivies to minimize soil compaction and disturbance and erosion control. More information can be found at: http://mn.gov/frc/forest-management-guidelines.html	**John Peter Hoffman Spring Brook Valley WMA** - manage bluffs to maintain forest communities and uplands to have a mix native grasses and agricultural crops for farmland wildlife. Continue timber harvest and prescribed fire as needed for management	Continue to maintain and restore **AMA easements** on **Spring Creek AMA**. Increase AMA easements along designated trout streams where appropriate and/or implement stream buffers		

LOWER CANNON RIVER WATERSHED LOBE

Priority: strategy represented by cell color.
Protection Strategy
Restoration Strategy
Regulatory Strategy (protection and/or restoration strategy)
Technical Guidance and/or Assistance Protection and/or Restoration Strategy

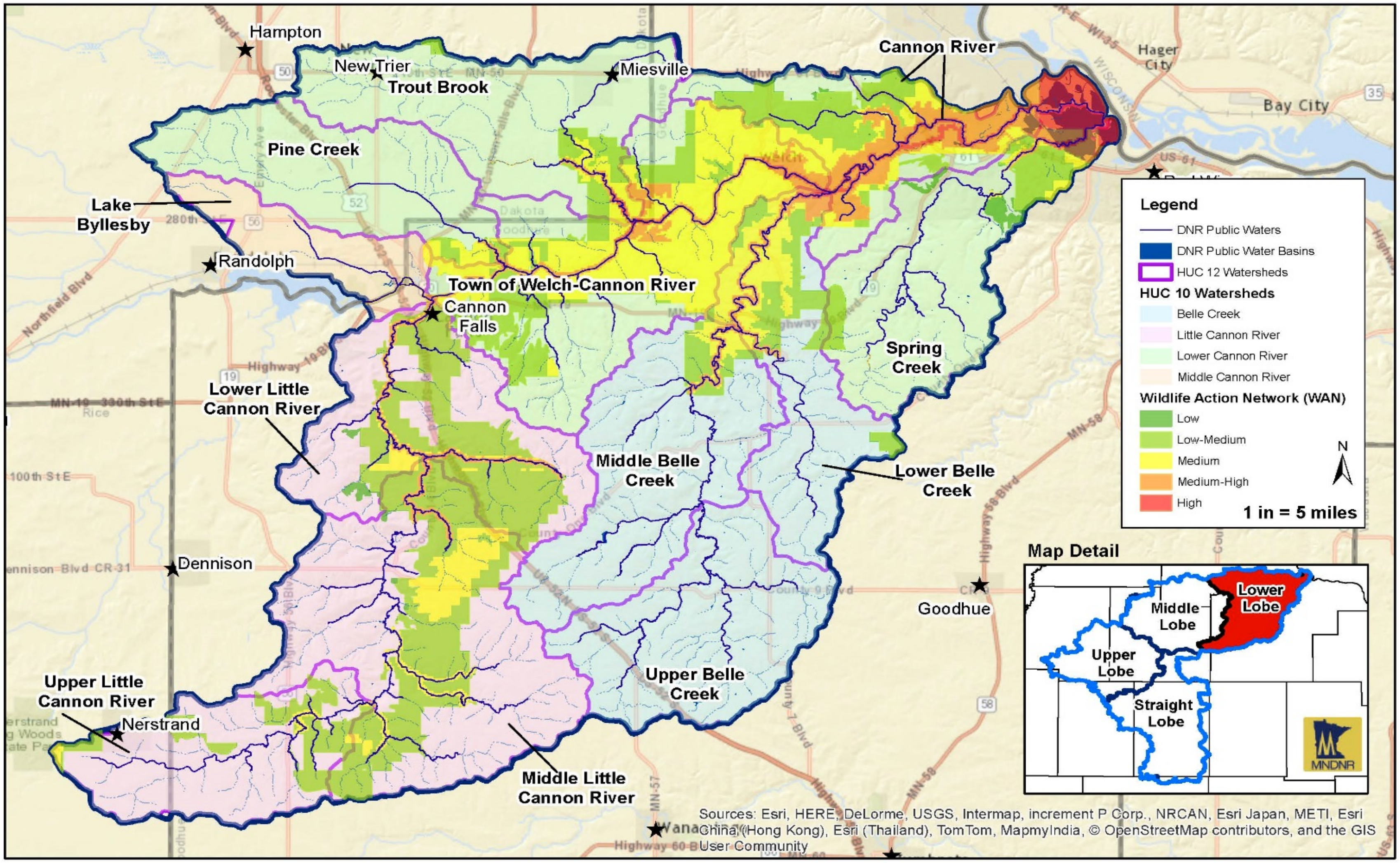
10 digit HUC (Name & No.)	**12 digit HUC** (Name & No.)	**Trout Stream Designation** (Name & Kittle No.)	**Water Quality Condition: Impaired Stream (MPCA 2014 Draft)** Impairment Type; (Use); Reach Description	**Strategies**				
Lower Cannon River (0704000209)	**Town of Welch-Cannon River** (070400020903)	**Confluence of Trout Brook** (M-048-007)	**PCBF** (AQC) Little Cannon River to Pine Cr **FC, PCBF, Turbidity** (ACR, AQC, AQL) Pine Cr to Belle Cr	Follow **Minnesota's Forest Management Guidelines** when managing DNR owned Forestry lands. Practices employed to reduce erosion include special provisions for filter strips, riparian management zones (RMZs), timing of acitivies to minimize soil compaction and disturbance and erosion control. More information can be found at: http://mn.gov/frc/forest-management-guidelines.html	**Tangential WMA** - manage WMA for upland forest habitat that includes northern hardwood and mesic oak forest. Look for opportunities to expand WMA boundaries where appropriate	Continue to maintain and restore **AMA easements**, increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. This information will help set a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection	**Minnesota's Wildlife Action Plan (MN WAP):** Focus conservation efforts within the high to medium scored priority zones of the Wildlife Action Network (WAN) to protect rare, declining, or vulnerable to decline nongame wildlife species, including Species in Greatest Conservation Need (SGCN). Protection and restoration activities that targets nongame species within the WAN will result in multiple environmental benefits. Benefits include increased perennial vegetation for habitat enhancement and for clean water (improved water quality) increase biological diversity and ecosystem resilience.
	Trout Brook (070400020902)	**Trout Brook** (M-048-007)	**M-IBI** (AQL) T113 R17W S27, west line to Unnamed Cr and Unnamed Cr to unnamed cr **Nitrate and Turbidity** (DW and AQL) Unnamed Cr to Cannon River (trout stream portion) (AQL)	Continue to maintain and restore **AMA easements**, increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws Expand the **DNR observation well monitoring network** to increase knowledge of sustainable yields Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. This information will help set a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features	Continue to support the **Fisheries Long-Term Monitoring (LTM)** site on Trout Brook to increase the understanding of cyclic trout populations, watershed health and aquatic resources of SE MN. Strategies include: • Collect base flow discharge measurements • Perform annual DNR fish assessments • Perform DNR aquatic invertebrate assessments during odd calendar years • Build working relationships with MPCA and other agencies to expand the LTM project where possible **Minnesota's Wildlife Action Plan (MN WAP):** Focus conservation efforts within the high to medium scored priority zones of the Wildlife Action Network (WAN) to protect rare, declining, or vulnerable to decline nongame wildlife species, including Species in Greatest Conservation Need (SGCN). Protection and restoration activities that targets nongame species within the WAN will result in multiple environmental benefits. Benefits include increased perennial vegetation for habitat enhancement and for clean water (improved water quality) increase biological diversity and ecosystem resilience.		

LOWER CANNON RIVER WATERSHED LOBE

Priority: strategy represented by cell color.
Protection Strategy
Restoration Strategy
Regulatory Strategy (protection and/or restoration strategy)
Technical Guidance and/or Assistance Protection and/or Restoration Strategy

10 digit HUC (Name & No.)	**12 digit HUC** (Name & No.)	**Trout Stream Designation** (Name & Kittle No.)	**Water Quality Condition: Impaired Stream (MPCA 2014 Draft)** Impairment Type; (Use); Reach Description	**Strategies**				
Middle Cannon River (0704000206)	**Lake Byllesby** (070400020605)	**None**	**M-IBI, PCBF** (AQL and AQC) Byllesby Dam to Little Cannon River	Continue to maintain and restore **AMA easements** on **Gemini AMA**. Increase AMA easements along designated trout streams where appropriate and/or implement stream buffers	**Water Appropriation:** Ensure all water users appropriating 10,000 gal/day or 10 Million/gal/year are in compliance with existing laws **Expand the** DNR observation well monitoring network **to increase knowledge of sustainable yields** Protect the **base flow of trout streams** by focused groundwater level monitoring, aquifer testing and application of water appropriation analysis where needed. This information will help set a diversion limit of no more than 10% of the August median base flow to preserve the seasonal variability of the natural hydrology under all but the most extreme drought conditions. **Education and Outreach:** Encourage groundwater users in high use areas to conserve water, and to use agricultural best management practices that further reduce water use, such as infiltration of rain water, buffer strip implementation or wetland protection **Karst Features:** Perform springshed mapping and dye tracing studies to better understand the surface water and groundwater interaction Provide **technical guidance to NRCS/SWCD offices** for interpreting springshed mapping results and make recommendations for implementing BMPs to protect karst features			

Lower Cannon River Watershed Lobe
Minnesota Wildlife Action Plan
Wildlife Action Network (WAN) Prioritization



Appendix I: Summary of stressors in the CRW

(• = stressor, ○ = inconclusive stressor, blank = not a stressor, C = contributing to a stressor).

10 Digit HUC	AUID	Reach	Biological Impairment	Class	Stressors										
					Temperature	Nitrate	Phosphorus	DO	TSS	Habitat	Fish Passage	Flow Alteration*	Ammonia	Chloride	pH
Chub Creek	528	Chub Creek	Fish and Macroinvertebrates	2B		○	•	•	•	•					
Little Cannon	526	Little Cannon River	Macroinvertebrates	2B		•	○		•	•					
Little Cannon	589	Little Cannon River	Fish and Macroinvertebrates	2A	•	•	○	○	•	•	•				
Little Cannon	590	Butler Creek	Macroinvertebrates	2B		○	○		•	○					
Little Cannon	639	Trib to Little Cannon River	Macroinvertebrates	2B		•	○		○	•					
Little Cannon	670	Trib to Little Cannon River	Macroinvertebrates	2B	○	•	○	○	○	○					
Prairie Creek	504	Prairie Creek	Macroinvertebrates	2C		•	○		•	•					
Prairie Creek	512	Unnamed Creek	Macroinvertebrates	2B		•	○	○	•	•					
Prairie Creek	587	Unnamed Creek	Macroinvertebrates	2B		•	○		○	•					
Prairie Creek	723	Trib to Prairie Creek	Macroinvertebrates	2B	○	•	○	○	○	•					
Straight River	503	Straight River	Macroinvertebrates	2B		•	○		•	○			○		
Straight River	515	Straight River	Macroinvertebrates	2B		•	○		•	○					
Straight River	536	Straight River	Macroinvertebrates	2B		•	○	○	•	•					
Straight River	547	Medford Creek	Fish and Macroinvertebrates	2B		•	○	○	○	•	○				
Straight River	731	Unnamed Creek	Macroinvertebrates	2B		•	○	○	○	○					
Straight River	732	Unnamed Creek to Unnamed Creek	Macroinvertebrates	2B		•	○		○	○					
Lower Cannon	580	Trib to Trout Brook	Macroinvertebrates	2A		•	○	○	○	•					
Lower Cannon	573	Trout Brook	Macroinvertebrates	2A		•	○	○	○	•					
Middle Cannon	582	Cannon River	Macroinvertebrates	2B		○	○		○	○					
Middle Cannon	507	Cannon River	Macroinvertebrates	2B		○	○		○	○					
Middle Cannon	509	Cannon River	Fish and Macroinvertebrates	2B		•	•		•	○	•				
Middle Cannon	539	Cannon River	Macroinvertebrates	2B		○	○			○					
Middle Cannon	591	Spring Creek	Macroinvertebrates	2B	○	•	○		○	•					

10 Digit HUC	AUID	Reach	Biological Impairment	Class	Stressors										
					Temperature	Nitrate	Phosphorus	DO	TSS	Habitat	Fish Passage	Flow Alteration*	Ammonia	Chloride	pH
Middle Cannon	557	Unnamed – Rice Creek (Spring Brook)	Macroinvertebrates	2A		•	○		○	•					
Middle Cannon	555	Unnamed Ditch - Heath Creek	Fish and Macroinvertebrates	2B		○	○	○	○	•	○			•	
Middle Cannon	531	Heath Creek	Fish and Macroinvertebrates	2B			•	•	○	•					
Upper Cannon	542	Cannon River	Macroinvertebrates	2B	C	○	•	•		•		C			○
Upper Cannon	577	Devils Creek	Macroinvertebrates	2B		○	○	•	○	○					
Upper Cannon	576	Mackenzie Creek	Macroinvertebrates	2B		•			○	•					
Upper Cannon	705	Trib to Cannon River (Dixon)	Fish	2B		○	○	○	○	•	○	•			
Upper Cannon	638	Trib to Cannon River	Macroinvertebrates	2B			•	•		•		○			
Upper Cannon	560	Waterville Creek	Fish and Macroinvertebrates	2B		•	○		○	•					
Upper Cannon	706	Whitewater Creek	Macroinvertebrates	2B		•	○	○	○	•					○

***For the most part, flow alteration was not looked at on an individual AUID basis, but was examined on the larger watershed scale (8 digit HUC). See Section 3 in the CRW Stressor Identification Report for more information on flow alteration in the CRW.**