Cannon River Watershed (07040002)
Groundwater Restoration and Protection Strategies Report

September 2017

MINNESOTA

Cannon River Watershed (07040002) Groundwater Restoration and Protection Strategies Report (GRAPS)

Minnesota Department of Health
Source Water Protection Unit
PO Box 64975,
St. Paul, MN 55164-0975
(651) 201-4695
carrie.raber@state.mn.us
www.health.state.mn.us

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Contributors

The following agencies dedicated staff time and resources toward the development of the Cannon River Watershed GRAPS report:

- Minnesota Board of Water and Soil Resources (BWSR)
- Minnesota Department of Agriculture (MDA)
- Minnesota Department of Health (MDH)
- Minnesota Department of Natural Resources (DNR)
- Minnesota Pollution Control Agency (MPCA)
- Metropolitan Council (Met Council)

Photo Credit: The photo on the front page is from the Minnesota Pollution Control Agency and is available at Cannon River (https://www.pca.state.mn.us/water/watersheds/cannon-river).

Summary

Groundwater is an important resource for the communities, businesses, and individuals that live in the area that is part of the Cannon River Watershed (CRW) One Watershed One Plan (1W1P) planning effort.[1] Groundwater accounts for over 85 percent of the water pumped to meet agricultural, industrial, drinking water, and other water-use needs. In addition, groundwater accounts for 100 percent of the region's drinking water. As such, it is important to make sure that adequate supplies of high quality groundwater remain available for residents and businesses of the region as well as for some of the region's natural resources.

Groundwater resources can be put at risk both from overuse and from the introduction of pollutants. These issues may be amplified in areas of the CRW where Karst is prevalent. Karst is a geologic feature that allows a direct, very rapid exchange between surface water and groundwater and significantly increases groundwater contamination risk from surface pollutants. The counties of Rice, Dakota, and Goodhue have extensive karst regions and, as such, special considerations are necessary to prevent these areas from becoming pathways for contaminants to enter aquifers used as a drinking water source. Naturally occurring arsenic and radium and pollutants from various human activities impact the region's groundwater and drinking water supplies.

The CRW GRAPS was designed to help prioritize and target local efforts to restore and protect groundwater resources in the CRW. Representatives from BWSR, MDA, MDH, DNR, MPCA, and Met Council researched, compiled existing state and regional data, and developed maps to establish a baseline understanding of groundwater conditions and associated resource management concerns for the CRW. The team highlighted strategies and supporting actions that can be applied at a county-, sub-watershed-, or watershed-level to help restore and protect groundwater.

The report identifies a number of areas in the CRW where groundwater/drinking water resources currently have concentrations of pollutants that are a public health concern, as well as land use activities that have the potential to cause pollution if they are not appropriately managed. Key highlights include:

- Nitrate contamination in wells is primarily located in areas with high pollution sensitivity and karst geology.
- Arsenic has been detected in groundwater in a variety of locations, concentrated through the center of the watershed.
- Pesticides have been detected in groundwater at both MDA monitoring wells in Goodhue County.
- Animal feedlots, stormwater infiltration practices, and subsurface sewage treatment systems (SSTS, also known as septic systems) are located throughout the watershed and can lead to groundwater contamination if improperly installed or maintained.
- Active and leaky tank sites are located throughout the watershed, with the greatest concentrations in larger communities.

[1] The Cannon River Watershed is located primarily in the counties of Rice, Steele, Goodhue, Dakota, Le Sueur, and Waseca, while small portions of Blue Earth, Freeborn, and Scott dot the perimeter. For this report, the boundary of the CRW was expanded to include the sub-watersheds of the Vermillion River and the Big River – Mississippi River to match the 1W1P planning boundaries

- A closed landfill (Dakhue Landfill) with a known groundwater contamination plume is located in southeast Dakota County.

This report also includes an assessment of the availability of groundwater and evaluates whether groundwater levels have declined because of pumping. Groundwater quantity is a concern if groundwater pumping outpaces groundwater recharge and if withdrawals adversely affect groundwater-dependent natural resources. The availability of groundwater within the CRW varies according to the underlying geology; generally, groundwater availability is high from deeper bedrock layers that are prevalent throughout the watershed. Trends in groundwater levels could only be evaluated at a few locations in the CRW, but additional monitoring wells have recently been installed.

The Cannon River GRAPS highlights nine categories of strategies (in the bulleted list below) to address the groundwater/drinking water issues and concerns that occur in the CRW. The report also suggests specific actions that individuals, local government, and partners can take to implement the listed strategies. The specific actions are paired with which counties and sub-watersheds (HUC-10) should be prioritized as a way to help target local actions.

- **Conservation Easements:** Maintain and expand the amount of land protected from being converted to high intensity uses, such as row crop agriculture.
- **Contaminant Planning and Management:** Use land use planning, ordinances, and collaboration with state regulatory agencies to protect groundwater and drinking water supplies from contaminant releases.
- **Cropland Management:** Encourage the implementation of voluntary practices to manage resource concerns while minimizing environmental loss.
- **Education and Outreach:** Educate landowners, private well users, and other stakeholders about how their actions affect groundwater and what they can do to conserve, restore, and protect groundwater.
- **Integrated Pest Management:** Implement a pest management approach that incorporates the many aspects of plant health care/crop protection in ways that mitigate harmful environmental impacts and protect human health.
- **Irrigation Water Management:** Control the volume, frequency, and application rate of irrigation water to sustain groundwater.
- **Land Use Planning and Management:** Use city or county government planning and regulations along with land management goals that implement best management practices (BMP), conserve water, and educate stakeholders to protect groundwater levels, quality, and contributions to groundwater dependent features.
- **Nutrient Management:** Assure that application of crop fertilizer or manure uses the right source, right rate, right time, and right place.
- **SSTS Management:** Monitor, maintain, and/or upgrade SSTS to assure proper operation and treatment.

This report should be used in conjunction with the WRAPs report, which focuses on surface water issues and needs, to ensure that both groundwater and surface water are effectively addressed during the 1W1P planning process.

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Introduction

What Is the GRAPS Report?

The State of Minnesota adopted a watershed approach to address the state's 81 major watersheds.[2] Major watersheds are denoted by an eight-digit hydrologic unit code (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 watershed restoration and protection (Figure 1).

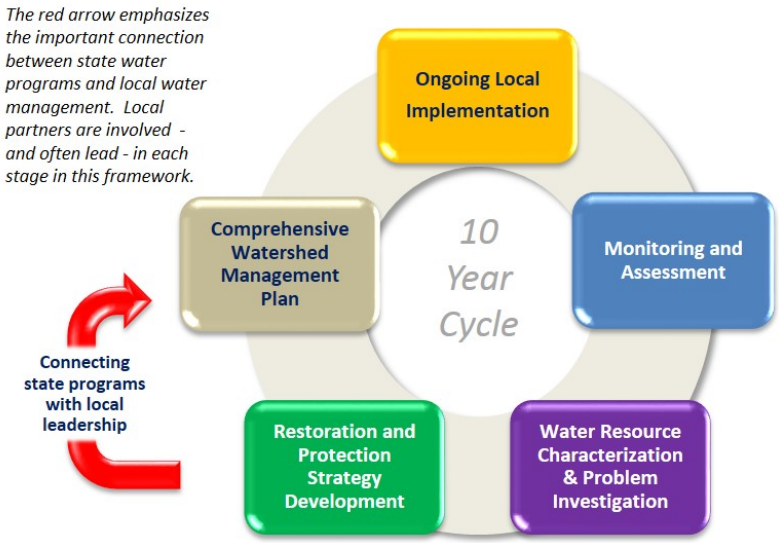

Figure 1: Watershed Approach Framework

Groundwater Restoration and Protection Strategies (GRAPS) reports are designed to help prioritize and target local efforts to restore and protect groundwater resources as part of local water planning. While groundwater is not broken into watersheds like surface water, several state agencies have worked together to compile information and strategies for groundwater below surface water watersheds. A GRAPS report uses existing state data and information about groundwater and land-use practices that affect groundwater in the watershed to identify key groundwater quality and quantity concerns. The report also suggests targeted strategies and actions to restore and protect the groundwater. GRAPS reports are meant to be used in conjunction with Watershed Restoration and Protection Strategies (WRAPS) reports in the development of local watershed management plans. WRAPS inform how to restore and protect surface water, and GRAPS inform how to restore and protect groundwater in the same geographical area.

[2] You can learn more about the Watershed Approach at Watershed approach to restoring and protecting water quality (https://www.pca.state.mn.us/water/watershed-approach-restoring-and-protecting-water-quality).

WRAPS focus on restoration, which is initiated through an intensive monitoring effort to determine if a surface water is meeting its designated use. WRAPS identify actions and the rate of adoption needed to restore water quality. GRAPS, on the other hand, is largely protection-based—identifying actions to maintain groundwater quality and quantity. However, if contaminants exist or overuse is suspected, the strategies and actions identified to address the issue, can result in restoration as well as protection. In most cases, it is very difficult determine the rate of best management practice (BMP) adoption needed to restore groundwater and is therefore not a part of GRAPS.

How to Use this Report

This report is a resource and tool for developing local water management plans. The report is divided into five parts to accommodate different needs and information partners and agencies may seek. This report is not necessarily designed to be read cover to cover. Rather, you should flip to the parts that sound most helpful. If you are accessing this document electronically, you can click on hyperlinks throughout the report to move to different parts of the report and/or access webpages (all hyperlinks are in blue font). Please note, the CRW boundary for the GRAPS report reflects the One Watershed One Plan (1W1P) planning boundary, which includes the entire CRW plus the sub-watersheds of the Vermillion River and the Big River – Mississippi River on the northeastern edge of the watershed. When referencing the CRW in this report it is referring to the 1W1P Cannon River Watershed Planning Boundary (CRWPB).

The report is divided into the following parts:

1. **CRW Overview**: This section provides a brief overview of the watershed and groundwater in the CRW.

2. **CRW Groundwater Issues and Concerns**: This section highlights the main groundwater quality and quantity concerns, where each concern is most prevalent within the watershed, and general ways to address the concern.

3. **CRW Strategies and Actions to Protect and Restore Groundwater**: This section provides tips for prioritizing and targeting restoration and protection strategies, makes suggestions about what strategies and actions would be most appropriate in which counties and sub-watersheds, describes the suggested strategies, and provides information about existing programs and resources for each strategy.

4. **Making Sense of the Regulatory Environment:** This section provides an overview of the roles State agencies play in managing groundwater and drinking water.

5. **Appendices**

CRW Overview

This report provides a brief overview of land use, geology, hydrogeology, pollution sensitivity, wellhead protection planning and drinking water, and water use and groundwater withdrawals affecting the CRW groundwater quality and quantity. You can find more detailed information about the CRW and groundwater through the following resources:

- MPCA **Cannon River Watershed Overview** (https://www.pca.state.mn.us/water/watersheds/cannon-river).
- MPCA **Cannon River Watershed Restoration and Protection Strategies Report** (https://www.pca.state.mn.us/sites/default/files/wq-ws4-23a.pdf).

The CRW spans 940,543 acres along the eastern edge of Minnesota, just south of the Twin Cities. The watershed drains approximately 1,460 square miles through two main channels, the Cannon and Straight Rivers, to the Mississippi River at Red Wing. The CRW spans a portion of nine counties. The six counties with the largest land area in the watershed include Rice, Steele, Goodhue, Dakota, Le Sueur, and Waseca, while small portions of Blue Earth, Freeborn, and Scott dot the perimeter. Major cities include Owatonna, Faribault, Northfield, Waseca, and Cannon Falls. The northern part of the watershed falls within the Twin Cities Metropolitan Council authority and is centered on fourteen communities, including Castle Rock Township, Miesville, Sciota Township, Eureka Township, Greenvale Township, Douglas Township, Randolph, Randolph Township, Elko New Market, Northfield, New Market Township, Waterford Township, New Trier, and Hampton Township.

All 130,325 people living in the watershed depend groundwater as a drinking water source. Approximately 70 percent use community public water supply systems. The remaining 30 percent get their water from private wells.

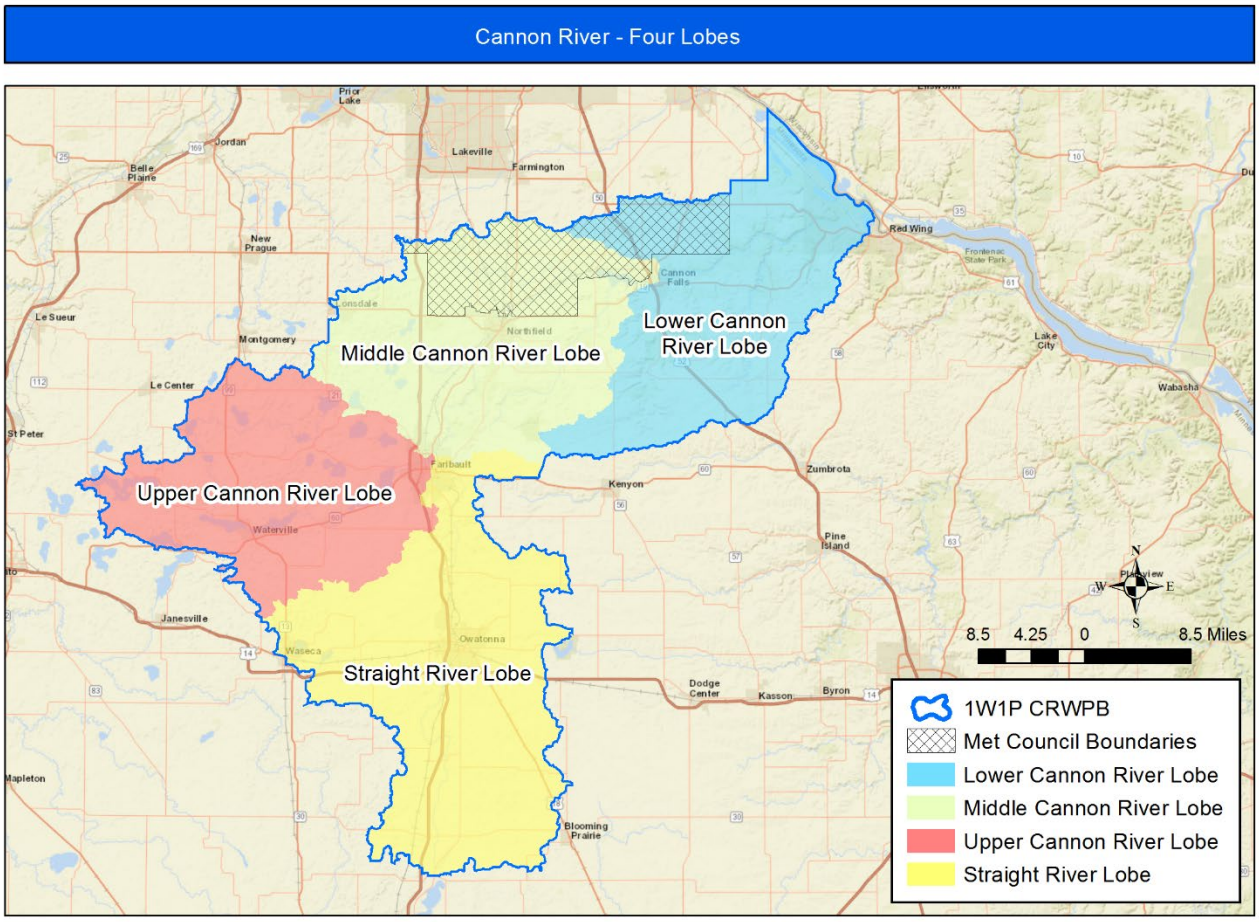

Figure 2: Four lobes of the Cannon River Watershed Planning Boundary

Land Use

The CRW is a mixture of agriculture, forest, prairie/shrubs, developed land, and open waters (Figure 3). Cultivated cropland, pasture and forage account for approximately 77 percent of the watershed's land use. Cropland is mainly growing corn and soybeans. Six percent of the CRW is covered in open waters, including 90 lakes and 107 wetlands of ten acres or more in size (MPCA, Cannon River WRAPS). The remaining 17 percent of land cover is split between forest and developed land. Historically, the CRW was prairie and deciduous woodland. The four watershed lobes highlight land use differences between each region (Figure 2).

- **Straight River** is characterized by agricultural production, both row crop and animal livestock. Owatonna and Waseca are the largest communities and account for the greatest permitted water use in the region.
- **Upper Cannon River** has the greatest number of lakes and wetlands in the CRW. Morristown and Waterville are the largest communities and are the biggest water users in the region. There is also a high concentration of private well users that live on the lakes and river systems.
- **Middle Cannon River** is more urbanized as you get closer to the Twin Cities metropolitan area. The cities of Northfield and Faribault are two of the largest water users; however, agricultural

irrigation is widespread in the eastern portion of the Middle Cannon River. The upper part of the region (portions of Scott and Dakota counties) are under the authority of the Metropolitan Council and are required to forecast population growth through 2040. Most of the communities anticipate slow or even declining growth in the coming years, with the exception of Elko New Market who forecasts their population almost tripling in size, growing from 4,110 people in 2010 to 11,900 by 2040.

- **Lower Cannon River** includes more of the forested land in the watershed. It also has a large concentration of irrigated cropland around Cannon Falls, accounting for the greatest water use outside of the public water supply wells for Cannon Falls and Red Wing. The portion of Dakota County in this region is under the authority of the Metropolitan Council. Population within Dakota County for the Lower Cannon River is expected to remain stable through 2040.

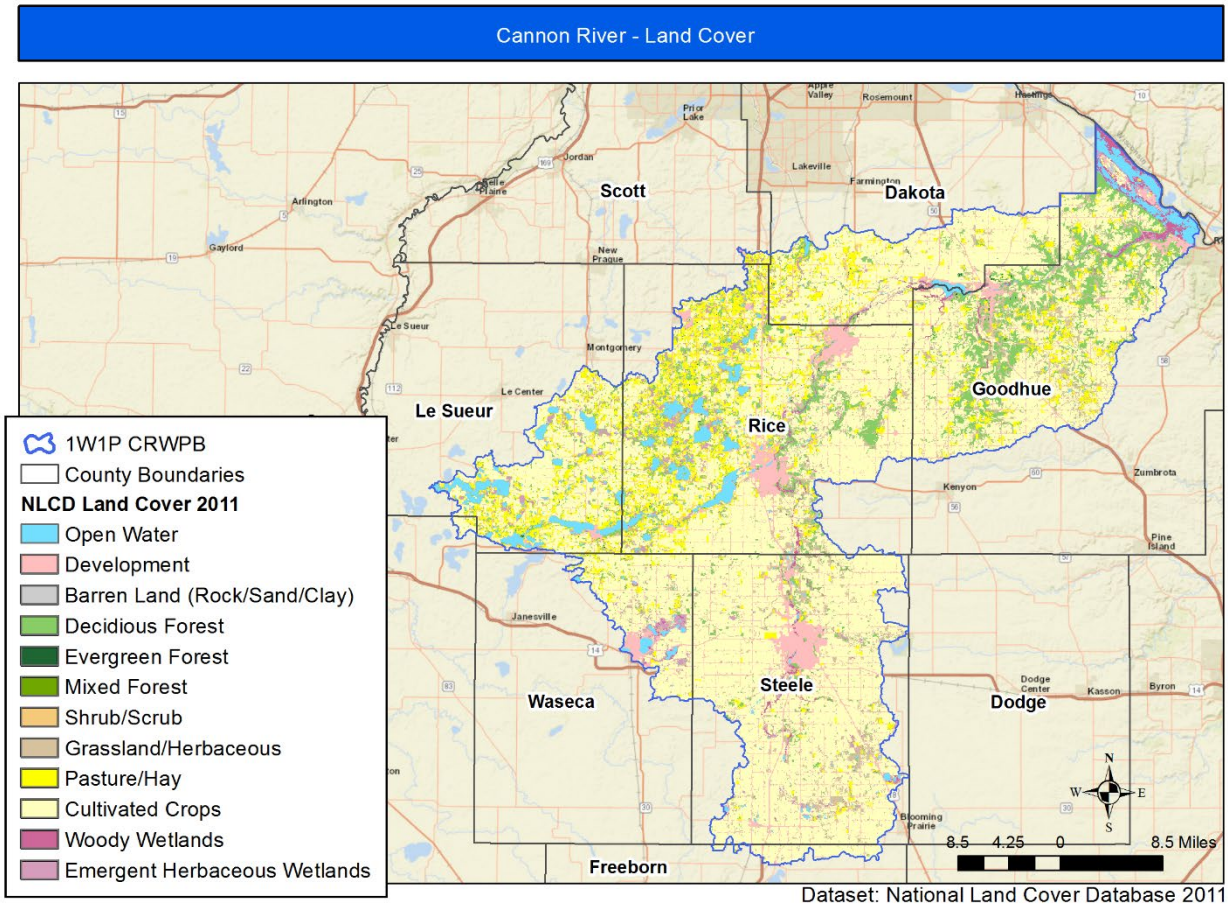

Figure 3: Cannon River Watershed Planning Boundary- Land Cover

Geology and Hydrogeology

The availability of groundwater within the CRW varies according to the underlying geology. Surficial geologic materials in the upland areas of the CRW are clay-rich till and glacial-fluvial sediments that are little used as a source of groundwater due to their low productivity. Sandy alluvium occurs along the major drainages and is a common source of water for domestic supply and some agricultural irrigation.

The greatest groundwater production in the CRW is from deeper sedimentary bedrock layers that are consistently encountered throughout the watershed. Figure 4 depicts a generalized map of aquifers in the watershed. Figure 5 is a geologic cross-section of the CRW.

The relative geologic age of the bedrock layers increases from the southwest to northeast. In the southern region of the watershed (Area 1 on Figure 4), in Steele County and parts of Waseca, Rice, and Goodhue counties, the uppermost bedrock is the Galena Group and Platteville and Glenwood Formations composed of carbonate rock and shale. These units overly older bedrock layers that have been exposed in the central-northern part of the CRW (Area 2). In Area 2, the uppermost bedrock is the St. Peter Sandstone and the Prairie du Chien Group, composed of dolostone and sandstone. Along the lower reaches of the CRW, to the northeast (Area 3), there is a thick sequence of bedrock units composed primarily of sandstone and shale: Jordan Sandstone, St. Lawrence and Lone Rock Formations, Wonewoc Sandstone, Eau Claire Formation, and Mt. Simon Sandstone. The most heavily used bedrock units in the CRW, for both drinking water and irrigation, are the St. Peter Sandstone, Prairie du Chien Group, and the Jordan Sandstone; these are component layers of the regional St. Peter-Prairie du Chien-Jordan Aquifer system. The preferential use of this aquifer is the result of both its widespread occurrence and high productivity. Figure 6 documents drinking water wells in each of the major aquifers.

Karst geology is an issue of concern affecting mainly the northern and northeastern parts of CRW. Karst conditions include features such as sinkholes, caves, sinking streams, and springs. Dissolution of water-soluble carbonate rocks (such as limestone and dolostone) create these features. Dissolution starts an erosive process and creates conduits for rapid groundwater flow within the rock mass. Areas with karst conditions are more likely to have rapid exchange between surface water and groundwater. This rapid exchange increases the risk of surface contaminants polluting groundwater (Adams, Barry, Green, et. al, 2016). (Figure 7).

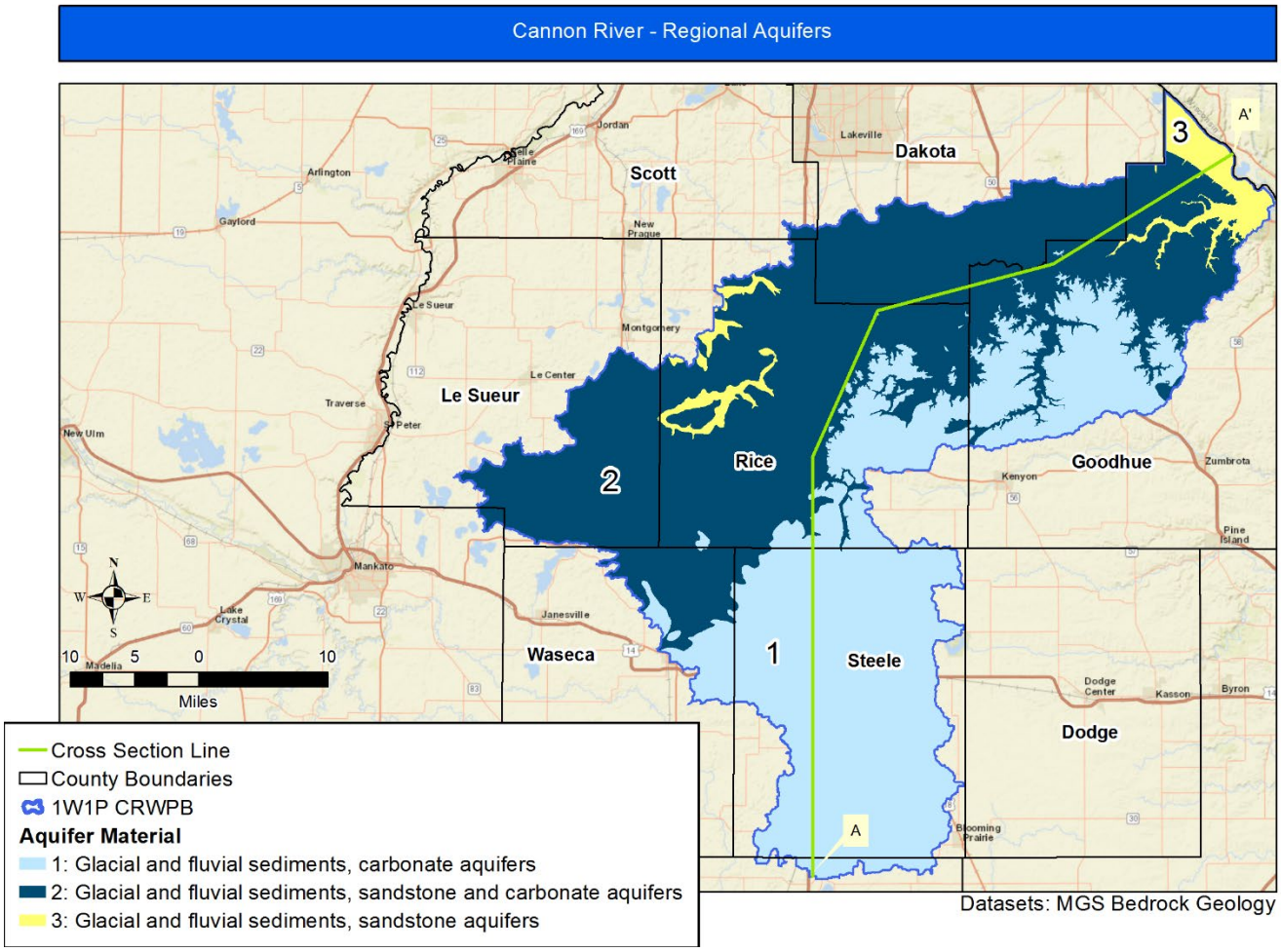

Figure 4: Cannon River Watershed Planning Boundary-Regional Aquifers

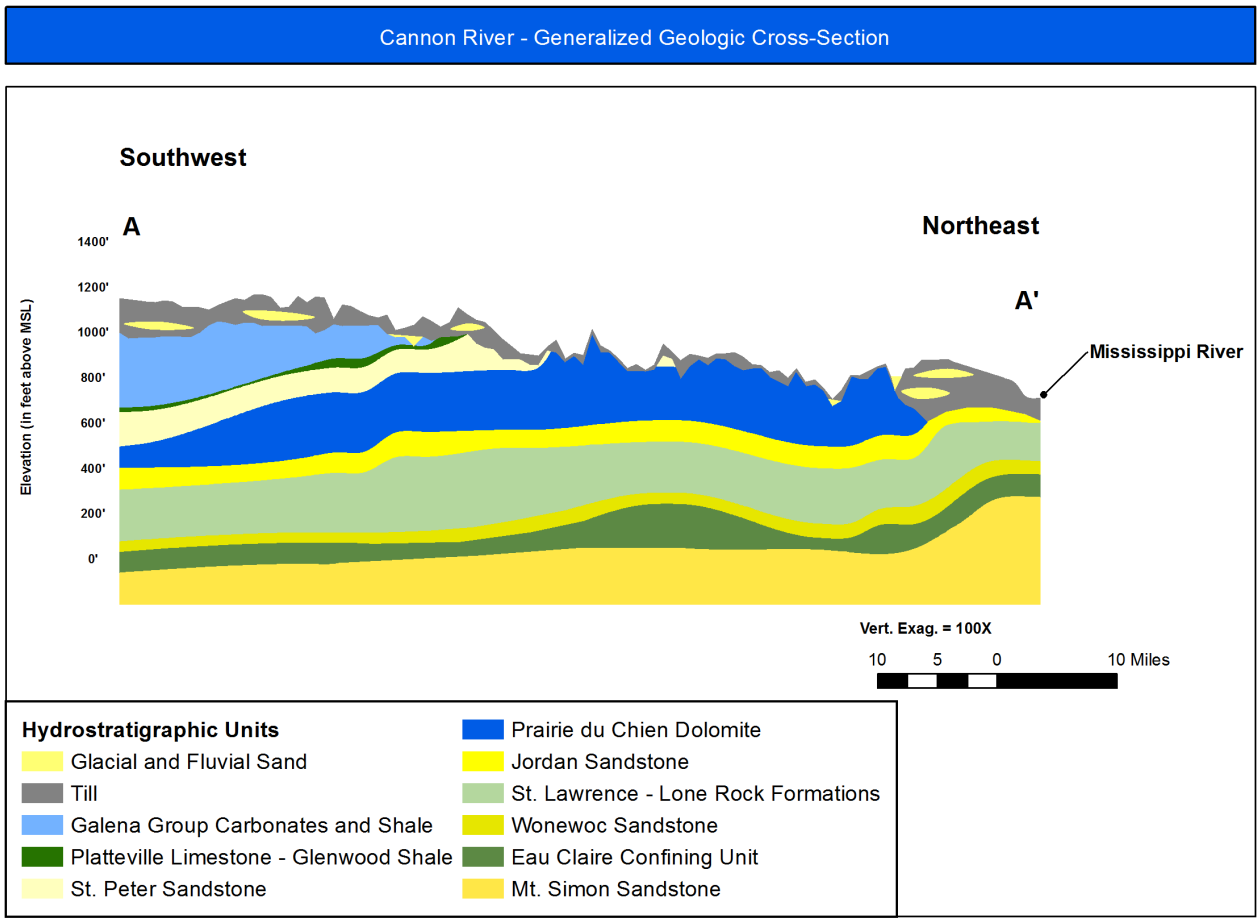

Figure 5: Cannon River Watershed Planning Boundary-Generalized Geologic Cross-Section

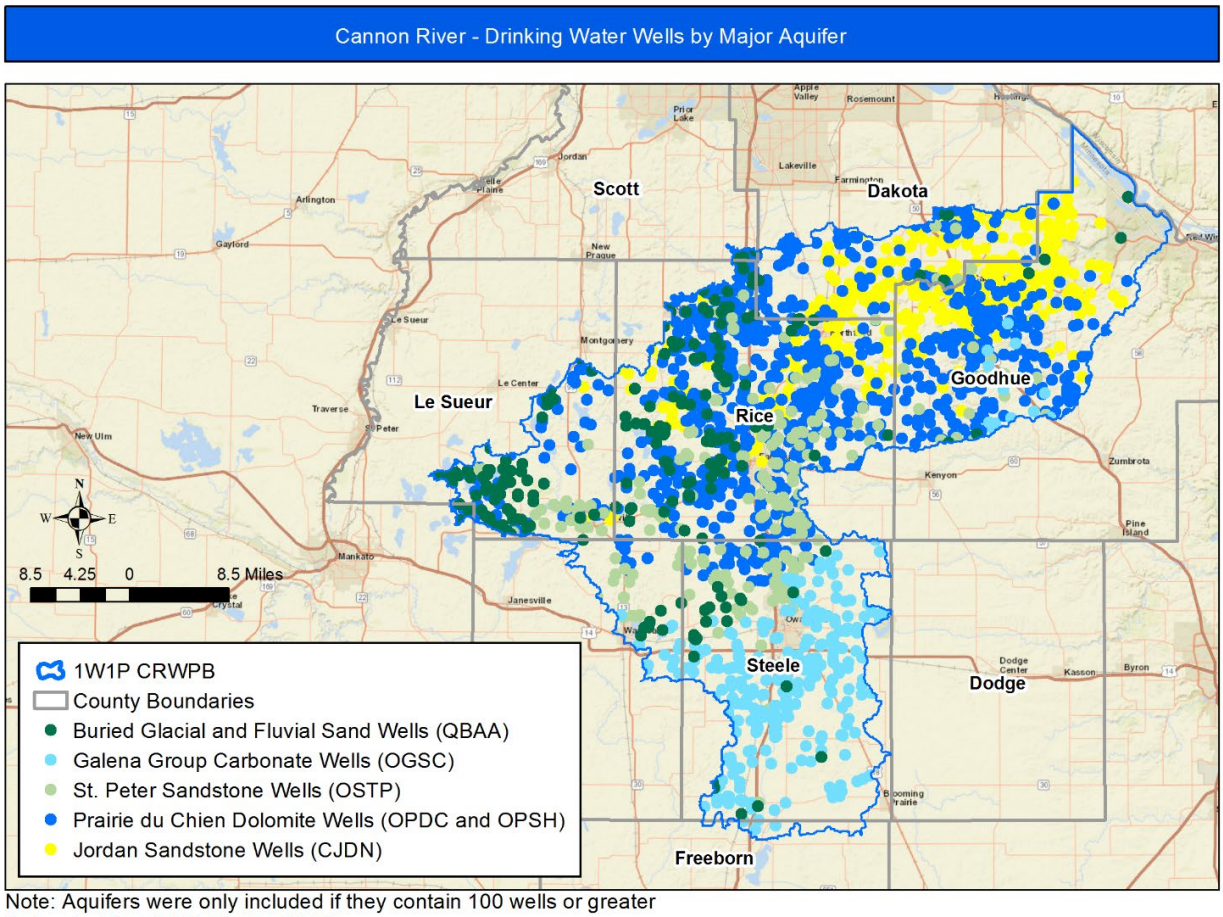

Figure 6: Drinking water wells in the Cannon River Watershed Planning Boundary by aquifer

Pollution Sensitivity

Understanding pollution sensitivity is important for prioritizing and targeting implementation efforts. Pollution sensitivity (also known as aquifer vulnerability or geologic sensitivity) refers to the time it takes recharge and contaminants at the ground surface to reach the underlying aquifer.

It is important to understand the target aquifer when assessing pollution sensitivity. A drinking water aquifer may be deeper and more geologically protected than the water table aquifer in a given area, or it may not be. Figure 7 depicts the pollution sensitivity of near-surface materials developed by the DNR. This dataset only takes into account the top ten feet of soil and geologic material when assigning a sensitivity rating. This figure shows that a significant amount of karst material is present in the northeastern portion of the watershed, and down through minor portions of the rest of the watershed. Karst is considered to be very highly sensitive to pollution. The remaining areas of the watershed are generally given a rating of “low” to “very low”. More information on this dataset can be found at Minnesota Hydrogeology Atlas (MHA) (www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-ns.html).

The pollution sensitivity of deeper aquifer materials depicted in Figure 10 was created by calculating the geologic sensitivity at individual wells in the watershed and then inferring between them to create a smooth layer. The wells used to make this figure vary in depth, but overall provide a picture of the geologic sensitivity of aquifers below the water table. This method was used because there is no available statewide dataset depicting pollution sensitivity, or vulnerability, of buried aquifers. Figure 10 shows that large areas of karst bedrock are present in the northeastern portion of the watershed and smaller areas through the rest of the watershed. Areas with well-developed karst landforms are considered to be very highly sensitive to pollution. This is similarly depicted in Figure 7. This high sensitivity is due, in part, to both the presence of karst landforms overlying the aquifers, and the lack of substantial clay units. Figure 10 also shows "high" to "very high" sensitivity to pollution in the southwestern border of the watershed boundary in Le Sueur and Waseca counties. These ratings are not necessarily due to the presence of karst bedrock, but primarily the lack of protective clay layers above the aquifer material. The remaining parts of the watershed have ratings of "low" to "moderate". More information on the geologic sensitivity calculations used to make this figure is included in the appendix section of this report as Figure 39 and Figure 40.

It is also important to understand how recharge travel time ratings (Figure 8 and Figure 9) for surficial water table aquifers differ from those used for deeper buried aquifers (Table 1). These two types of aquifers follow two different sets of recharge travel times that correspond to sensitivity ratings. For example, a pollution sensitivity rating of 'moderate' for surficial materials reflects vertical travel times on the order of weeks (Figure 8); whereas, for deeper aquifers more commonly used for drinking water, a rating of 'moderate' reflects travel times of years to decades (Figure 9). This difference stems from the fact that surficial materials are reached more quickly by infiltrating water and contaminants than deeper buried aquifers. Deeper aquifers often have protective clay layers that make travel time significantly longer. As noted above, this distinction is important when determining the potential impact of various contaminants on surficial materials and drinking water aquifers.

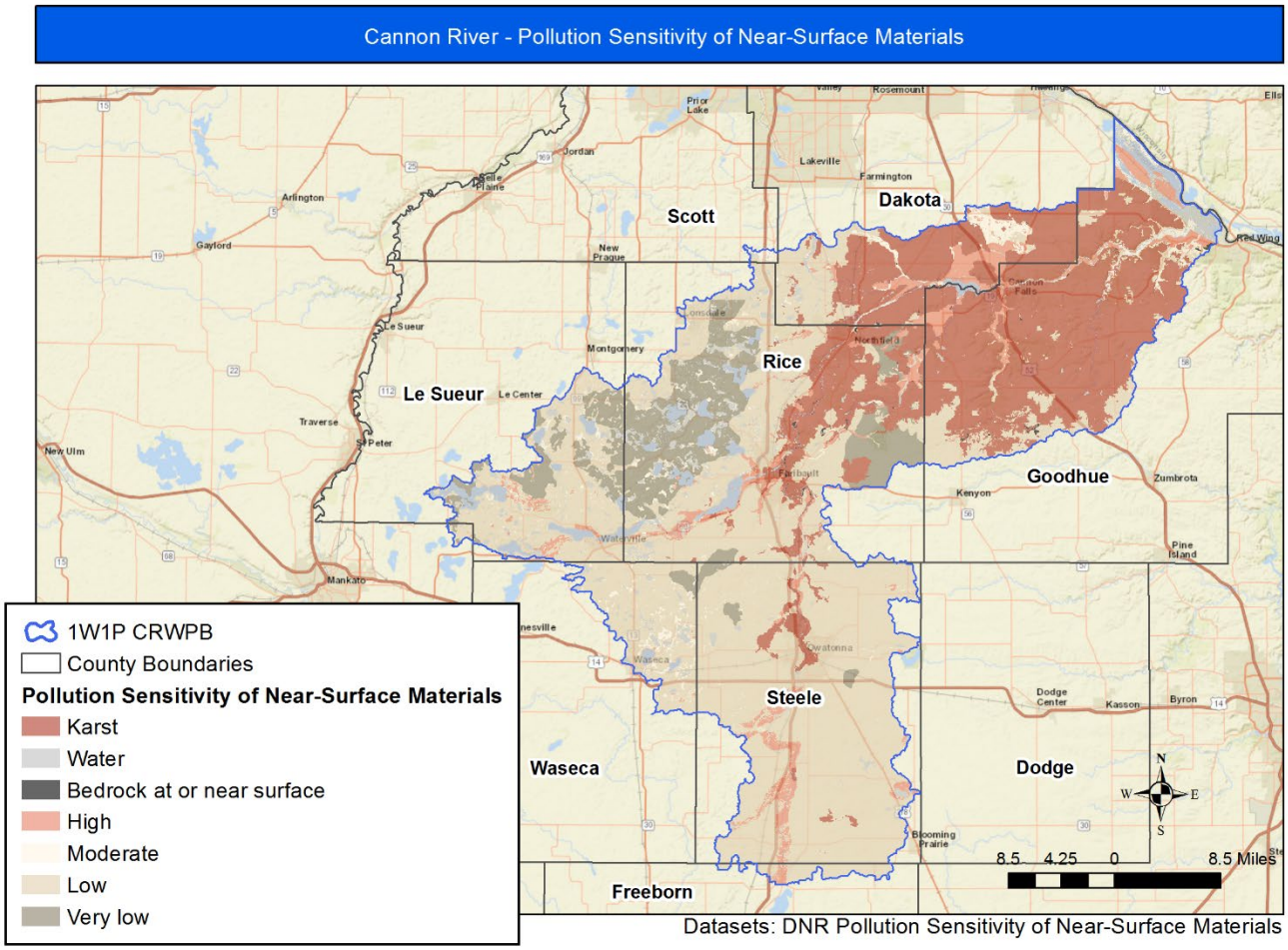

Figure 7: Cannon River Watershed-Pollution Sensitivity of Near-Surface Materials

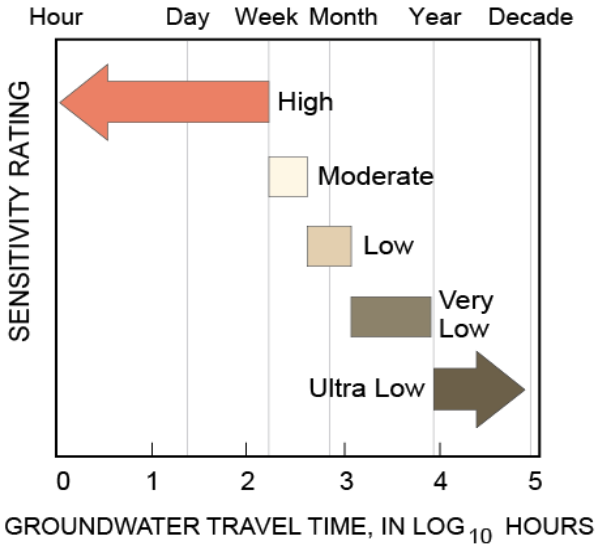

Figure 8: Recharge Travel Time for Near-Surface Materials

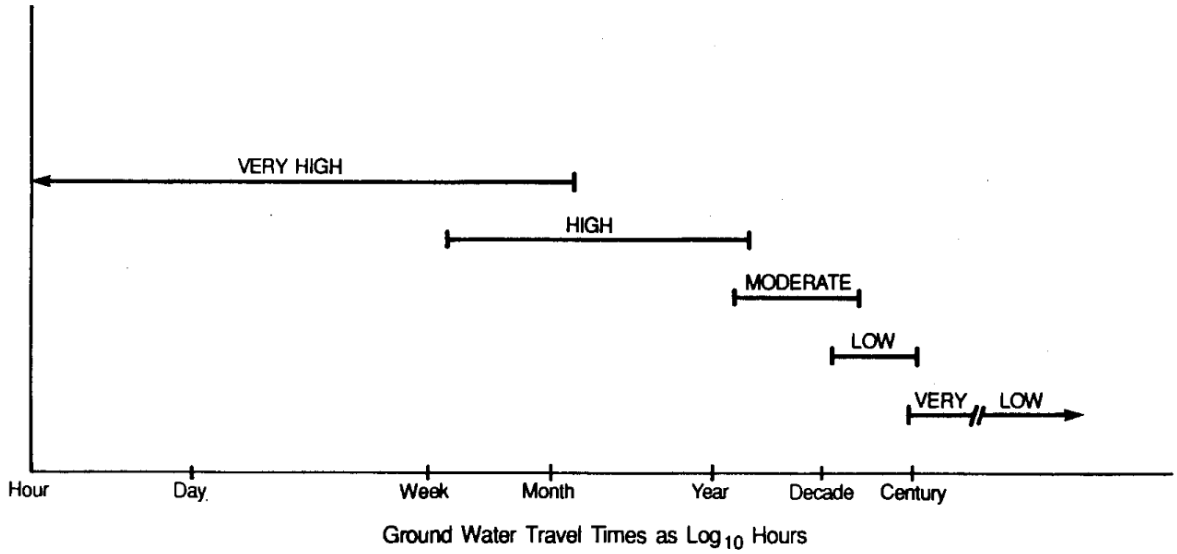

Figure III-1. Geologic sensitivity ratings and ground water travel times.

Figure 9: Recharge Travel Time for Buried Aquifers

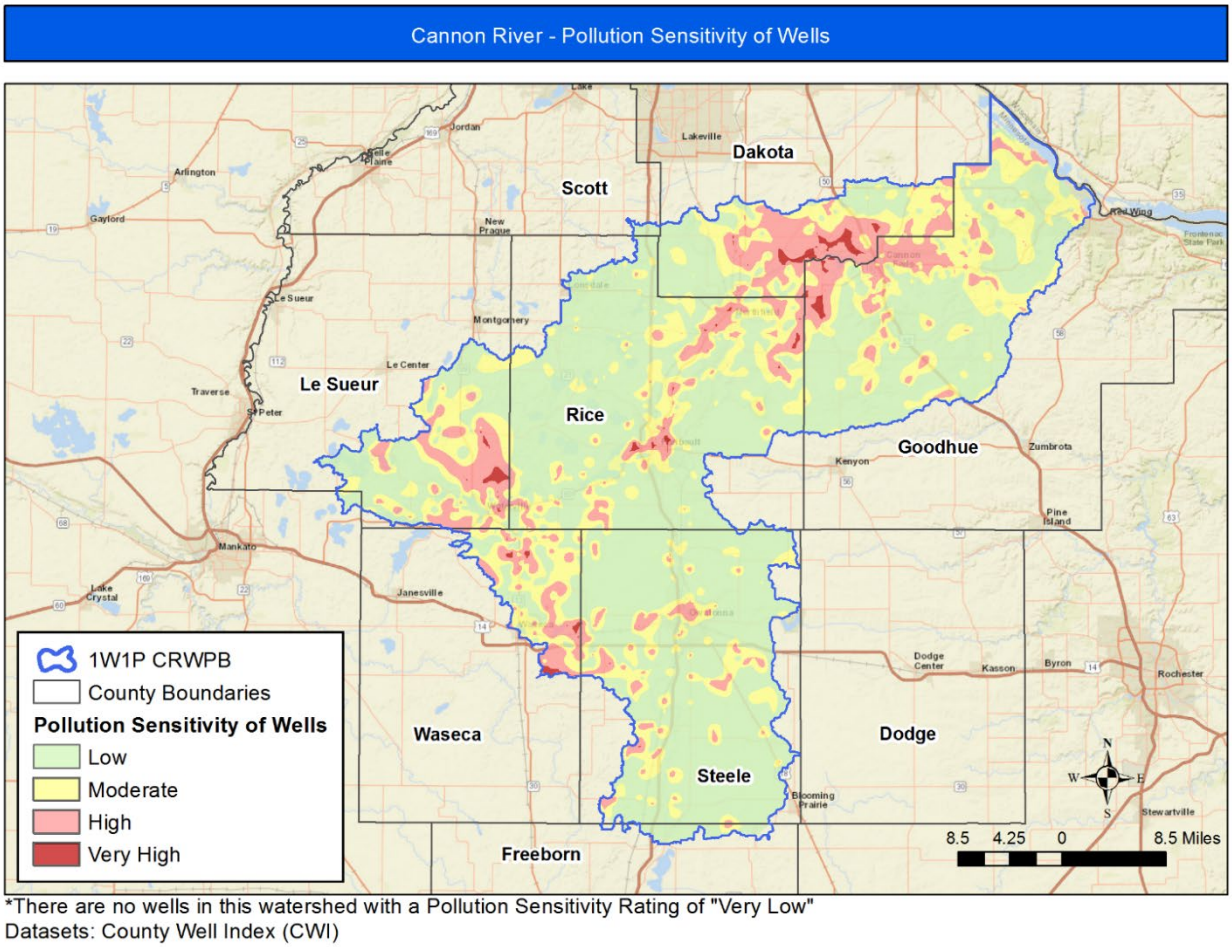

Figure 10: Cannon River Watershed Planning Boundary-Geologic Sensitivity of Wells

Table 1: Sensitivity rating and the associated recharge travel times for surficial and buried aquifers.

Pollution Sensitivity Rating	Aquifer Recharge Time Period[3] for Surficial Aquifers	Aquifer Recharge Time Period for Buried Aquifers
High	**Time Period: hours to a week**	**Time Period: days to months**
Moderate	**Time Period: a week to weeks**	**Time Period: years up to one or two decades**
Low	**Time Period: weeks to a year**	**Time Period: several decades to a century**

[3] Aquifer recharge time periods refer to the time it takes aquifers to receive recharge from the land surface. Aquifer recharge rate informed by the Geologic Sensitivity Project Workgroup, 1991.

Wellhead Protection Planning and Drinking Water Supply Management Areas

Wellhead protection planning is the program whereby public water systems examine land uses in the recharge area for their wells and develop strategies for land use management. The strategies are based on the geologic vulnerability and are appropriate for safeguarding drinking water supplies. Both community and nontransient noncommunity public water suppliers are required to prepare Wellhead Protection Plans. As part of this effort, the recharge area that contributes water to the public water supply well(s) is delineated based on physical and chemical characteristics of the aquifer being used. These areas, known as wellhead protection areas (WHPAs), provide an assessment of the aquifer vulnerability (sensitivity) of the public water supply wells. Once the WHPA is established, a Drinking Water Supply Management Area (DWSMA) is created to provide planning boundaries on the land surface for management of the resource. Learn more about the MDH Source Water Protection Program at Source Water Protection (www.health.state.mn.us/divs/eh/water/swp/).

The word **'sensitivity'** is used to describe groundwater generally throughout the state. **'Vulnerability'** is the term used for wellhead protection planning to protect public sources of drinking water. While there are minor differences between how these words are developed as described above, the words are essentially the same for the purposes of planning and management.

Aquifers and wells used for public water supplies vary widely. Some are very shallow and unprotected and can be easily contaminated by activities at the ground surface. Others are deeper or more protected by geologic materials; these tend to exhibit a low vulnerability to overlying land uses. Guided by the vulnerability of the public water systems' wells and the aquifer they draw from, the scope and breadth of management activities within wellhead protection areas and the associated drinking water supply management areas varies.

Eighteen of the 30 community public water supply systems within the CRW are in the wellhead protection planning process or are implementing their plans. Of the twelve systems with approved plans, eight are considered to be not vulnerable to contamination from the land surface with all others exhibiting moderate and high vulnerability. Figure 11 shows the state of wellhead protection planning for the community public water supplies in the watershed. Figure 12 shows the vulnerability of the DWSMAs that have been delineated to date in the CRW.

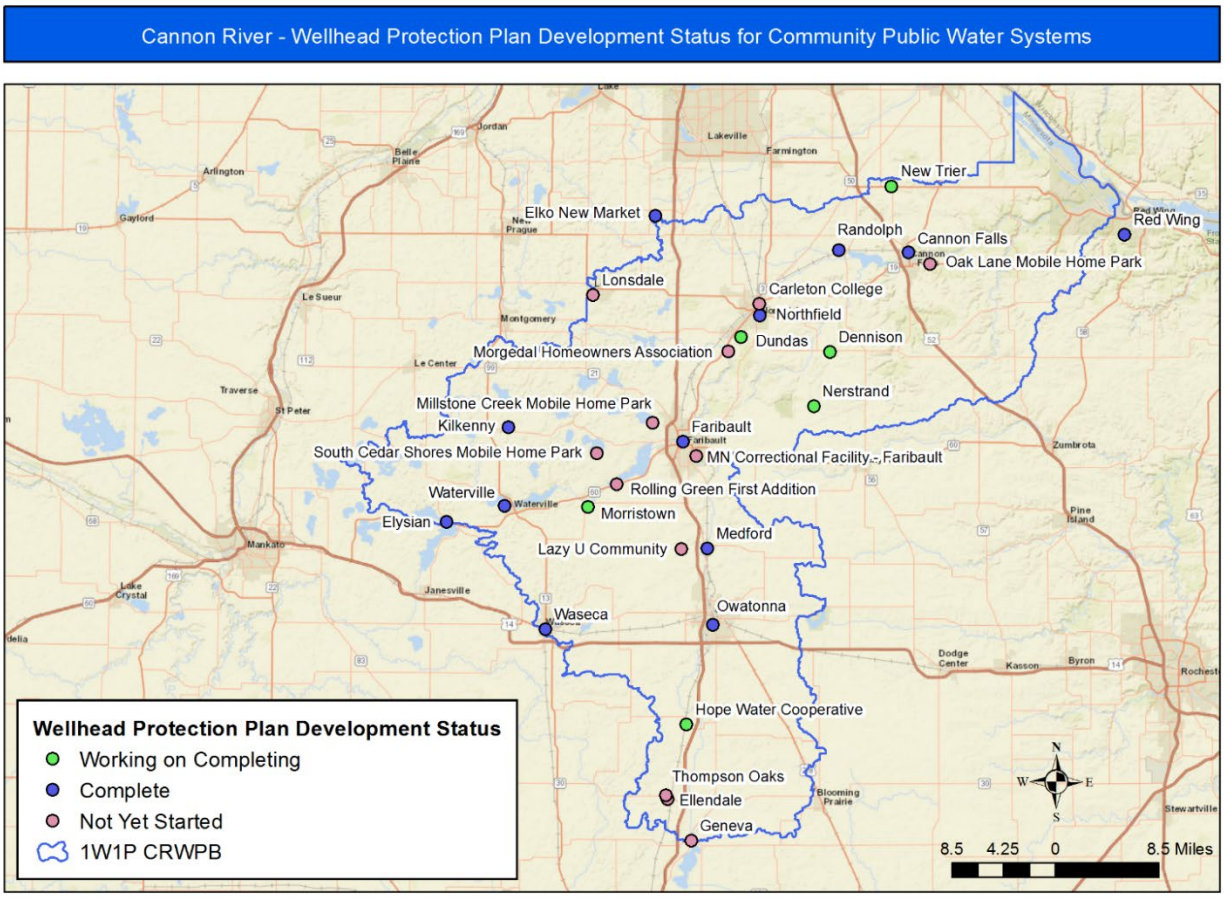

Figure 11: Cannon River Watershed Planning Boundary-Wellhead Protection Plan Development Status for Community Public Water Systems

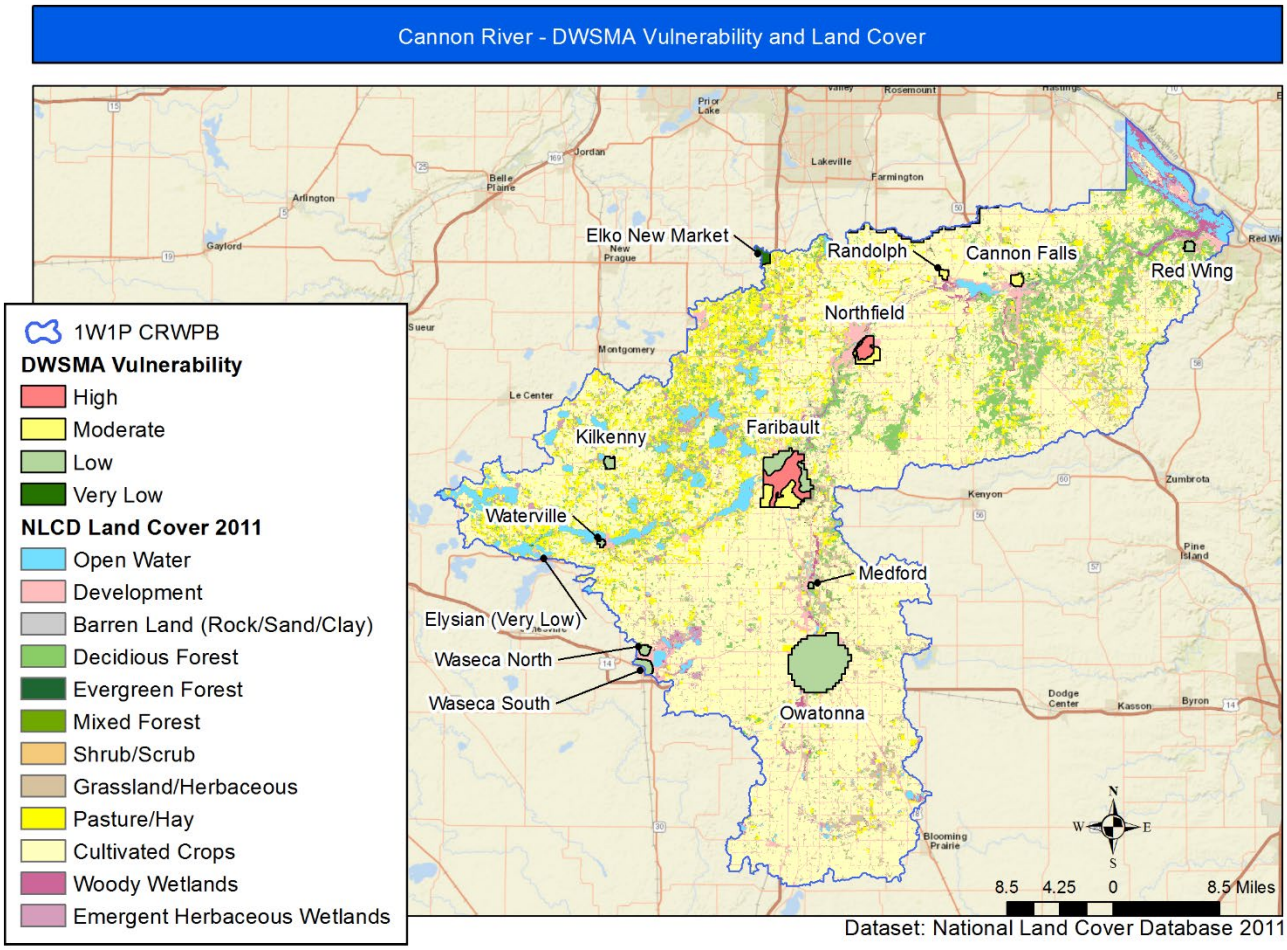

Figure 12: Cannon River Watershed Planning Boundary-Vulnerability of Drinking Water Supply Management Areas and Land Cover

Groundwater Use

Groundwater accounts for more than 85 percent of the water appropriated in the CRW. Groundwater has been the primary source for water use for the watershed for many years. As populations grow and land use practices evolve, there is a growing demand for water within the CRW. Figure 13 shows that permitted groundwater use has steadily increased in the CRW since 1988. There is limited surface water used in the CRW; surface water has experienced small increases since 1988.

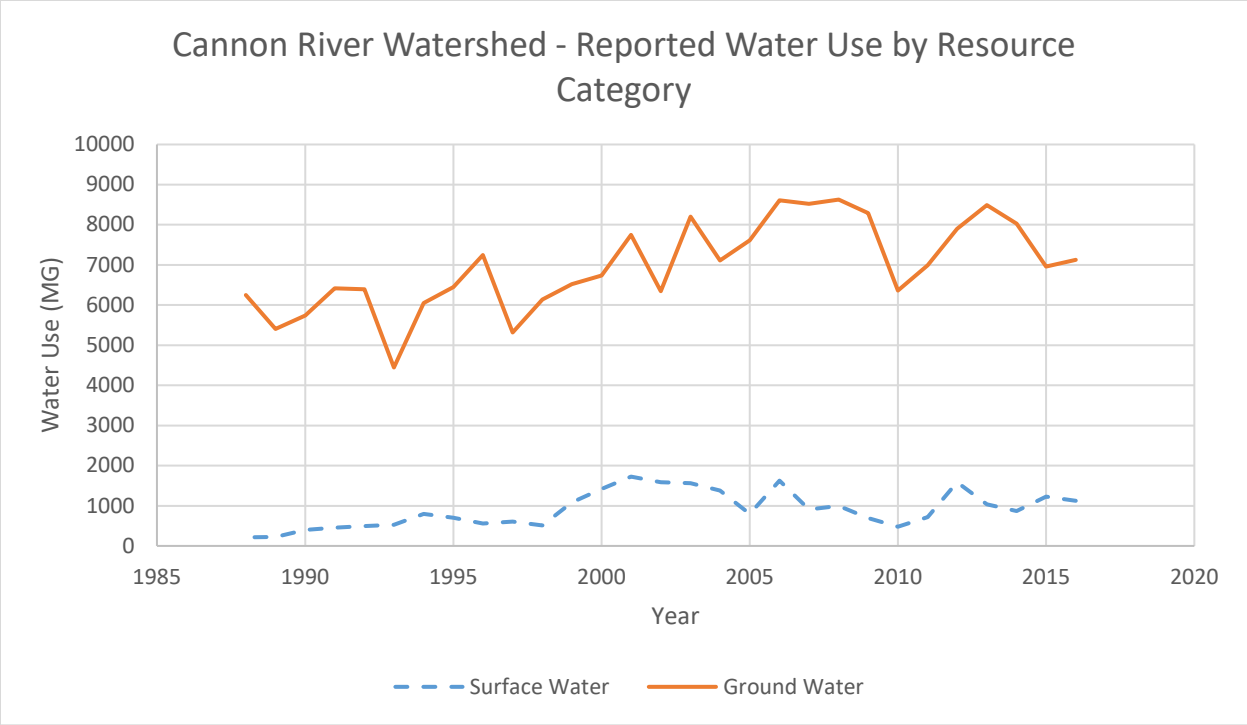

Figure 13: Groundwater vs. Surface Water Use

More than 93 percent of reported groundwater use in the CRW is derived from bedrock aquifers (Figure 14). The surficial sand (water table) and buried sand and gravel (confined) aquifers account for less than five percent of reported groundwater use.

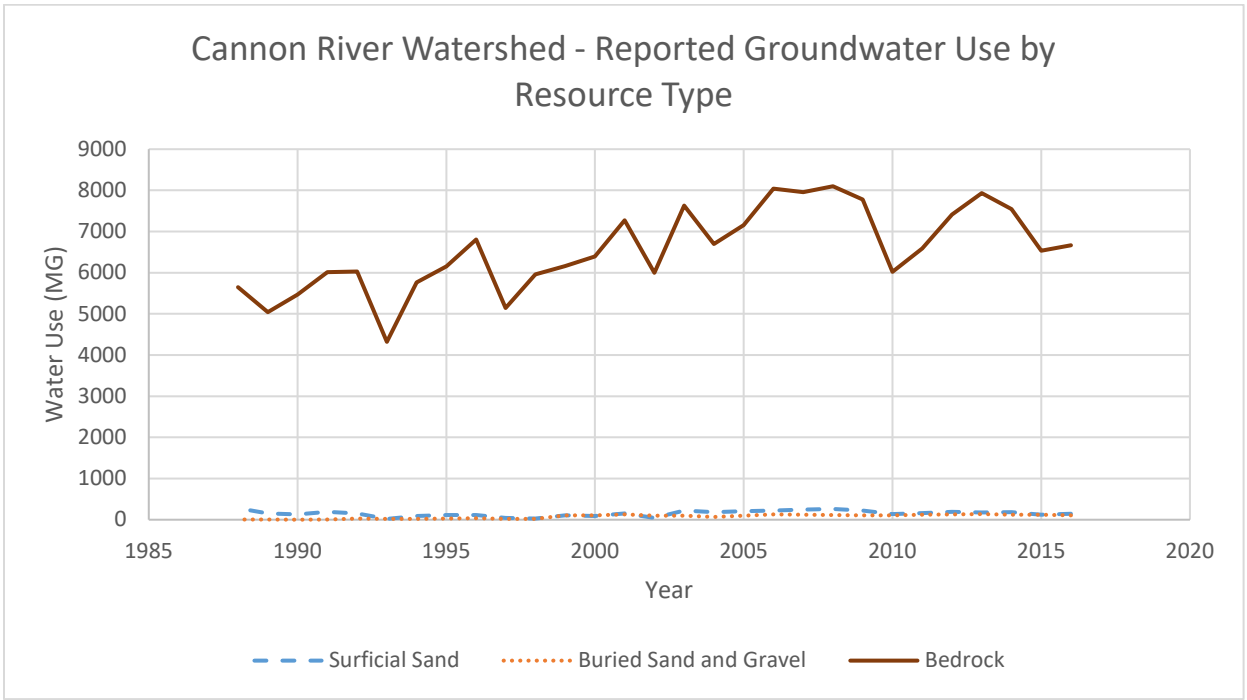

Figure 14: Reported Groundwater Use by Resource Type

There are many types and uses of permitted wells in the CRW. Beyond drinking water supplies for public water supply systems, wells are used for irrigation, animal feeding, industrial and commercial purposes, power generation, and other specialized needs. Public water supplies and agricultural irrigation are the two largest uses of water in the CRW, accounting for more than 90 percent of reported water use. The amount of water permitted for public water supplies and irrigation has increased since 1988 (Figure 15). Domestic use does not require a water use permit; therefore, no data on use is available.

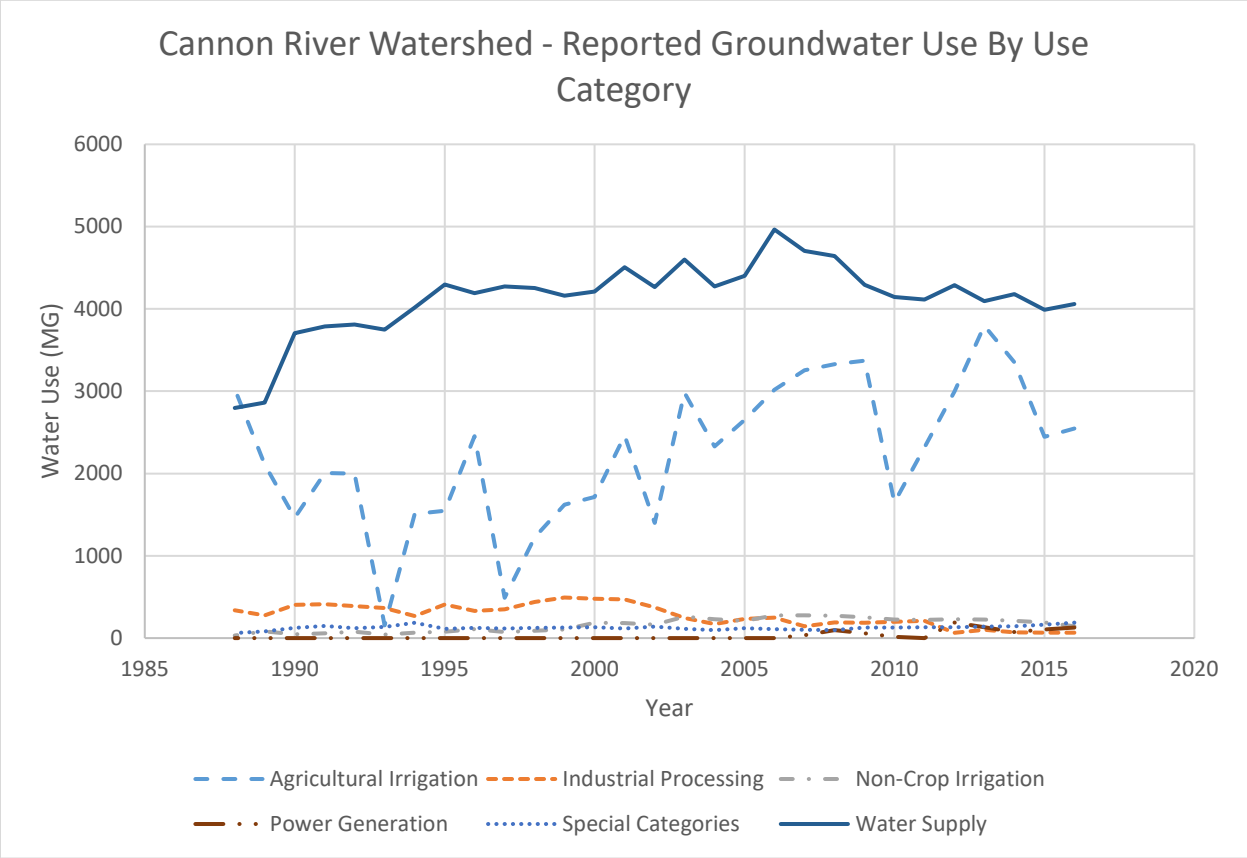

Figure 15: Groundwater Use by Use Category

Groundwater Withdrawals

A water-use appropriation permit from the DNR is required for all water appropriators (surface or groundwater) withdrawing more than 10,000 gallons of water per day or one million gallons per year. This provides the DNR with the ability to assess and regulate which aquifers are being used and for what purpose. One condition of the appropriation permit is to report actual water use; the DNR has records of reported water use from 1988 to the present.

Table 2 provides data from the Minnesota DNR Permitting and Reporting System (MPARS). Most groundwater is used for water supply. Agricultural irrigation is also a large water user, but is a seasonal use. Other uses account for less than ten percent of reported water use.

Table 2: Reported 2016 water use from DNR groundwater permit holders.

Aquifer	Water Supply	Agricultural Irrigation	Industrial Processing	Non-crop Irrigation	Power Generation	Special Categories	Total (MGY)	Total (percent)[4]
Surficial Sand (Water Table)	--[5]	142	--	--	--	--	142	2
Buried Sand and Gravel (Confined)	53	8	--	11	--	36	108	1.5
Bedrock	3995	2238	59	120	128	124	6664	93.5
Unknown	12	158	6	13		28	217	3
Total (MGY[6])	4060	2546	65	144	128	188	7131	
Total (percent)	56.9	35.7	0.9	2	1.8	2.6		

[4] Percentages may not total to 100 due to rounding.

[5] Dashes indicate no use in those categories.

[6] Million gallons per year.

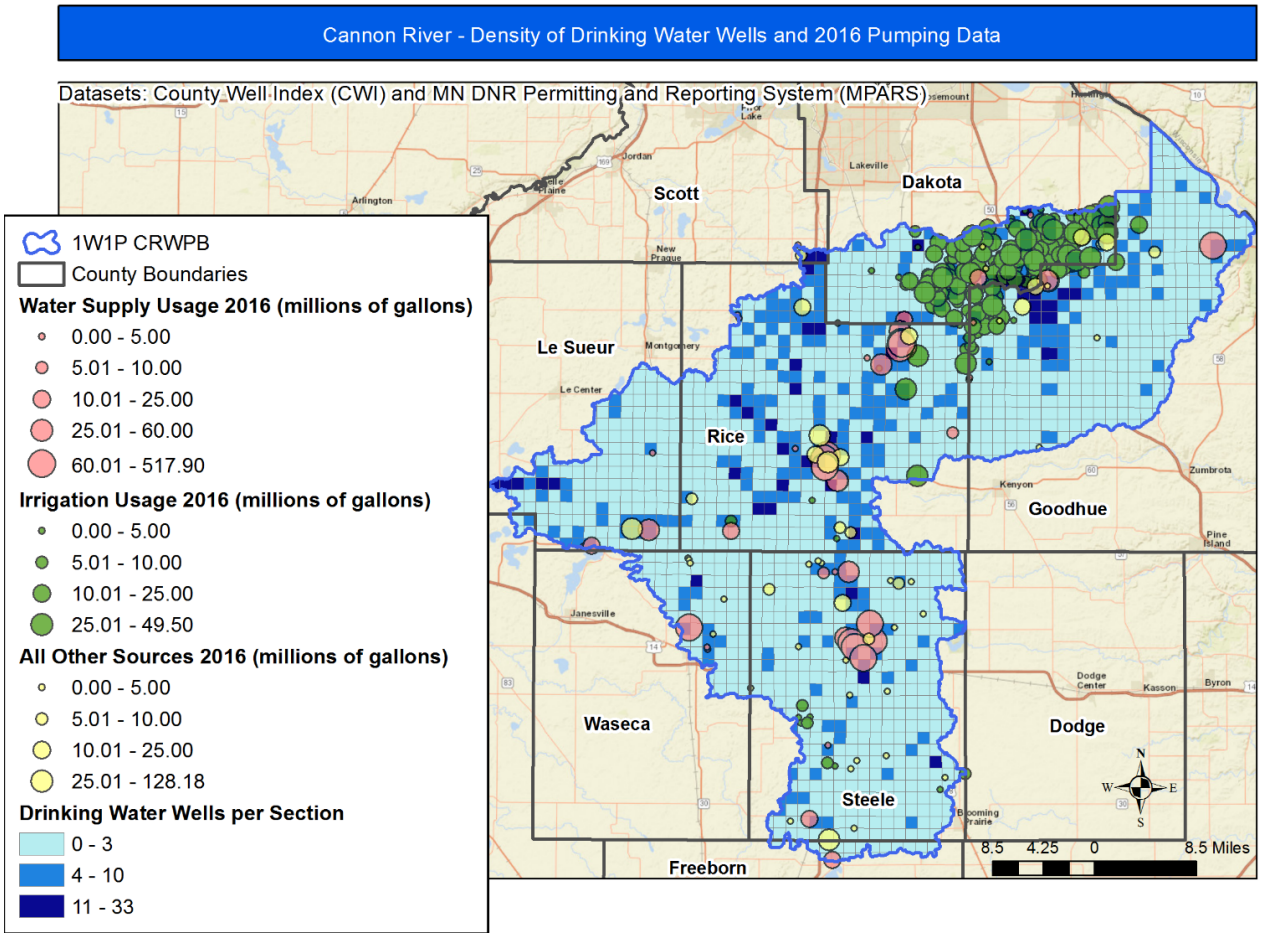

Figure 16: Cannon River Watershed Planning Boundary-Well and Pumping Data

Figure 16 illustrates both well density and water use data in the CRW. This figure contains a grid that depicts the number of wells in each six-mile by six-mile section of the watershed. Deeper colors correspond to a higher concentration of wells. Well density varies across the watershed. All well types were included in this analysis.

Circles represent water use data. The three colors of circles correspond to water use permits issued for public water supply, irrigation, and all remaining sources of water use. The size of the symbol indicates how many millions of gallons were reported as pumped in 2016.

CRW Groundwater Issues and Concerns

This section of the report describes the key groundwater quality and quantity issues for the CRW. The descriptions of each issue include an overview of the issue, where the issue is most prevalent, and references a few key approaches to address the issue. The CRW Strategies and Actions to Protect and Restore Groundwater section provides a more detailed list of actions to address CRW groundwater issues and concerns.

Groundwater Quality Issues and Concerns

Naturally occurring minerals and human-made contaminants affect CRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate, arsenic, radium, and pesticides have been detected in wells sampled in the CRW. This section provides context and data about these contaminants and their occurrence in the watershed. It also provides information about feedlots, subsurface sewage treatment systems, contaminated sites, and household hazardous waste in the watershed that may affect groundwater quality.

All public water systems in the watershed strive to meet Safe Drinking Water Act (SDWA) requirements for the quality of water served to their customers. However, some public water systems have water quality issues in their untreated source water that requires either blending or treatment to meet SDWA standards.

Nitrate

Nitrate is a compound that occurs naturally and has many human-made sources. When nitrate levels are above 3 milligrams per liter (mg/L)[7] in groundwater, human activity is the likely cause (Mueller and Helsel, 1996). Human-induced sources of nitrate include animal manure, fertilizers used on agricultural crops, failing SSTS, fertilizers used at residences and commercially, and nitrous oxides from the combustion of coal and gas.

Nitrate is one of the most common contaminants of groundwater in Minnesota and is a public health concern where it is found in groundwater used for drinking water. The SDWA standard for nitrate in drinking water is 10 mg/L. Approximately two percent of the 1,230 samples taken from wells within the watershed had levels of nitrate at or above the SDWA standard. This dataset includes newly constructed wells, private wells, and other drinking water supply wells sampled by MDH. Table 3 shows nitrate test results for samples taken from these wells. Sampling of newly constructed wells for nitrate began in 1974. Many older wells, pre-well code, are not included in this dataset.

[7] One milligram per liter is the same as 1 part per million (ppm).

Table 3: Summary of nitrate results in drinking water wells of the Cannon River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum Nitrate-N concentration (mg/L)	Maximum Nitrate-N concentration (mg/L)	Median Nitrate-N concentration (mg/L)	Nitrate-N samples at or above 3 mg/L (%)	Nitrate-N, samples at or above 10 mg/L (%)
< 50	85	0.025	48	0.5	45.9	27.1
50 - 99	44	0	7.15	0.1	11.4	0.2
100 - 149	109	0	9.2	0.09	0.9	0.1
150 - 199	190	0	5.1	0.17	1.1	0.2
>= 200	802	0	7.32	0.34	1.4	0.0
Total	1230	0	48	0.27	4.7	1.9

Where Is Nitrate in the CRW?

Higher levels of nitrate are present in areas where there are both human-caused sources of nitrate and high pollution sensitivity. This pattern is consistent with MDA findings in their Township Testing Program (TTP). The following images help identify where and at what levels nitrate is detected in the watershed:

- Figure 17 compares nitrate levels in wells in the CRW with the pollution sensitivity of the area. The map shows that there is a correlation between areas with high pollution sensitivity and nitrate detections above 3 mg/L. In other instances, the absence of elevated nitrate concentrations may be a function of low-impact land use near the well or the presence of favorable geochemical conditions in the aquifer. Nitrate requires relatively oxidizing conditions to persist in groundwater, and the presence of locally reducing conditions can remove nitrate. The dataset used to create this figure is the same as that used in Table 3. These nitrate samples were taken from newly constructed wells, private wells, and other drinking water supply wells sampled by MDH.
- Figure 18 shows the TTP schedule and the percentage of nitrate detected in sampling conducted in the CRW. MDA identified townships where groundwater is vulnerable and row crop agriculture is present as the focus of the testing program. Their results show that more than ten percent of wells sampled to date in eight townships, all in Dakota County, had levels of nitrate over the SDWA standard. This percentage would have been higher if the 15 percent of wells found to be unsuitable had not been removed from the final well dataset. The unsuitable wells include hand-dug wells, wells that did not meet well code construction requirements, or other factors that may have influenced nitrate sample results. Future sampling will include townships in Goodhue, Rice, Steele, Waseca, and the southern tip of the watershed in Freeborn County. Learn more about the TTP at Township (Nitrate) Testing Program (www.mda.state.mn.us/townshiptesting).

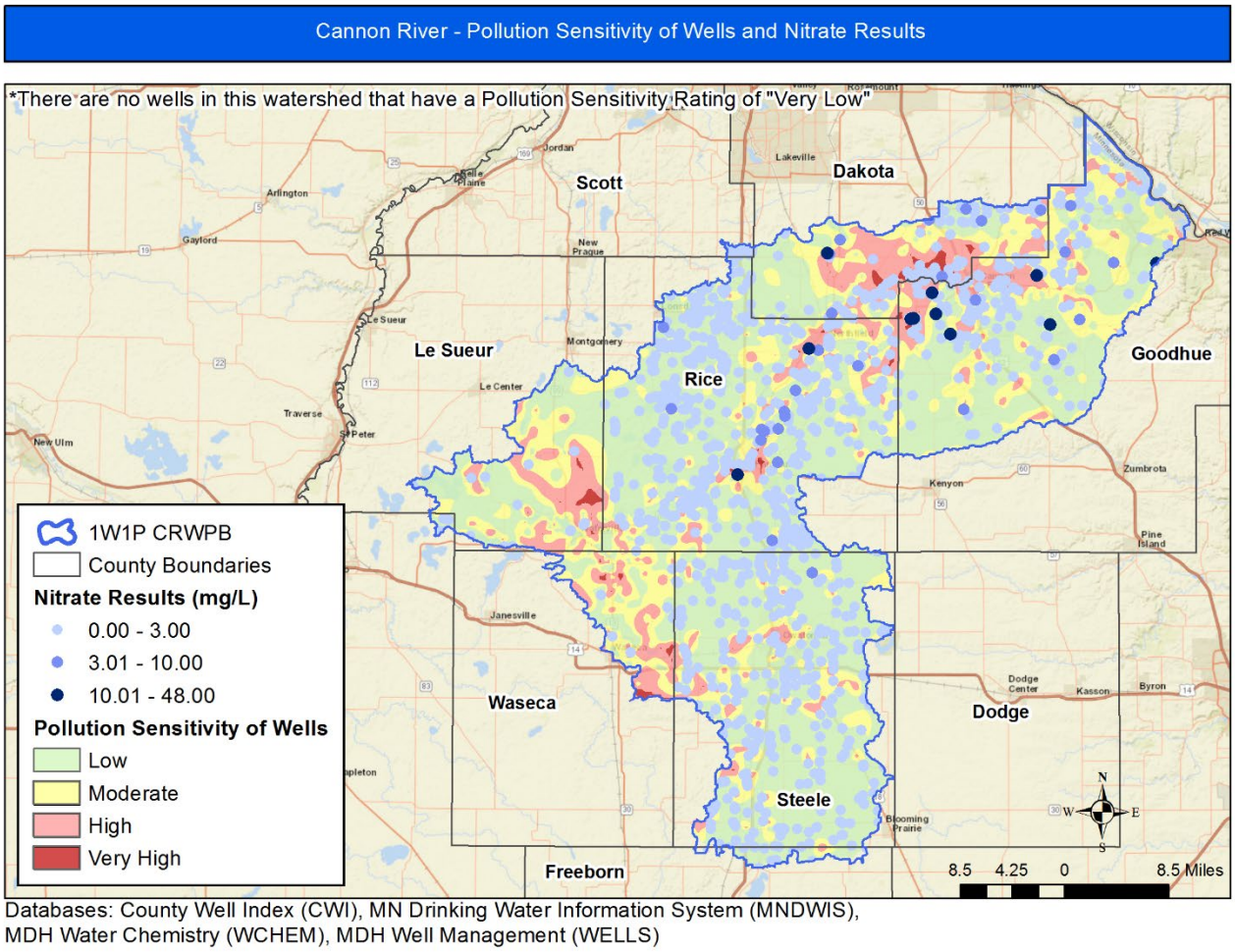

Figure 17: Cannon River Watershed Planning Boundary-Nitrate Results and Pollution Sensitivity of Wells

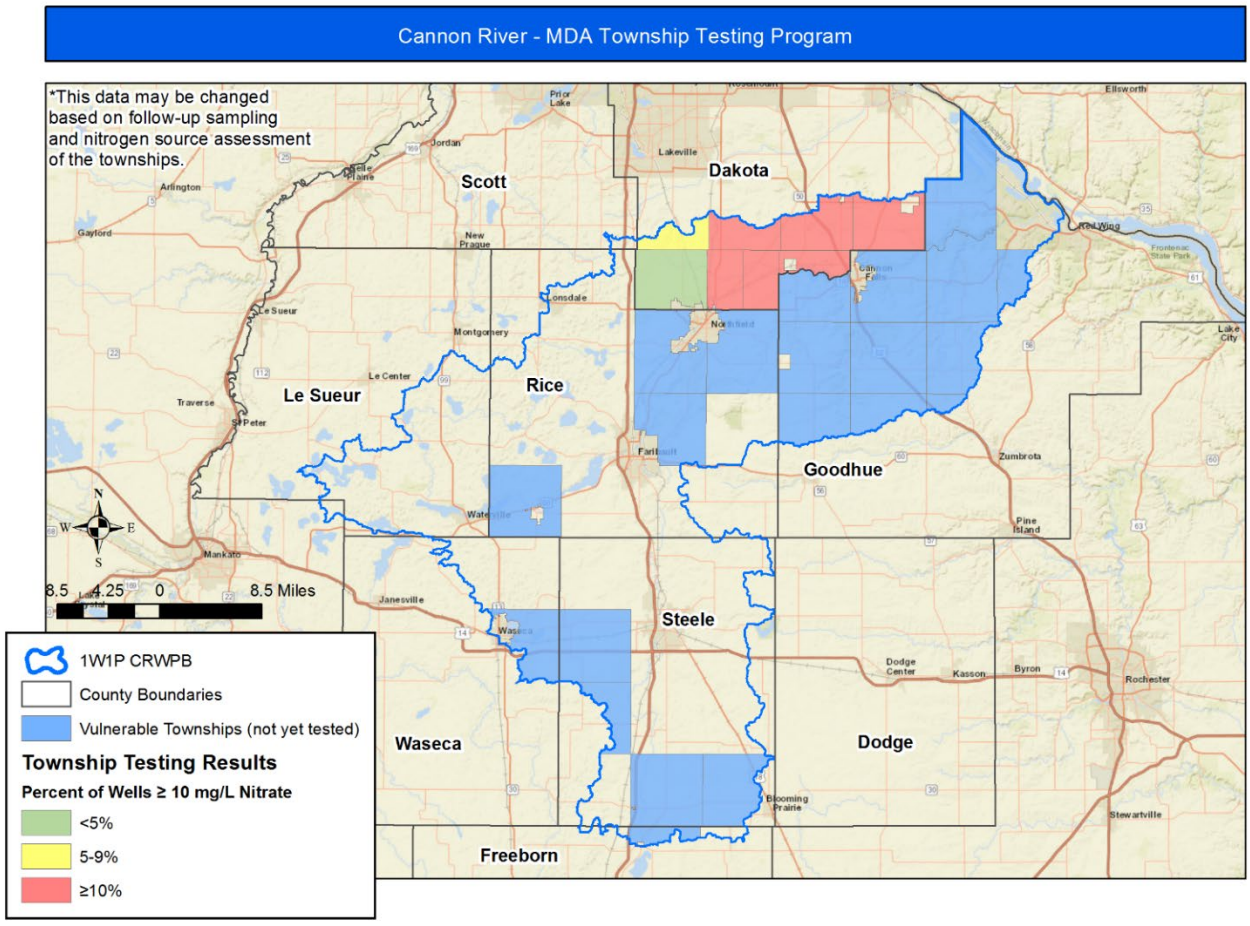

Figure 18: Cannon River Watershed Planning Boundary-MDA Township Testing Program

How to Address Nitrate in Groundwater

General approaches to reduce the amount of nitrate that may enter groundwater include:

- Providing educational opportunities on the 4R nutrient management concept (right source, right rate, right time, and right place)
- Employing nutrient BMPs and cropping systems that scavenge nutrients
- Leveraging the work of existing programs focused on nutrient management
- Developing incentives and providing technical assistance for adopting nutrient BMPs
- Providing educational opportunities about turf BMPs
- Assuring SSTS are constructed properly and encourage regular maintenance of the systems
- Prioritizing feedlot inspections and the proper application of manure in areas at greatest risk to contamination in delegated feedlot counties
- Employing land use controls that safeguard public health through regulations and ordinance development
- Implementing conservation easements through programs such as the Conservation Reserve Program (CRP) and Reinvest in Minnesota (RIM) in vulnerable wellhead protection areas and areas with private wells.

Table 7 provides a more comprehensive list of specific actions counties and sub-watersheds in CRW can take to restore and protect groundwater quality related to nitrate.

Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or lessening the damage of any pest and may be a chemical substance or a biological agent. Consuming water with different types of pesticides in it can cause a variety of health problems. MDA monitors for 'common detection pesticides' as a part of the MDA Pesticide Management Plan (www.mda.state.mn.us/protecting/waterprotection/pmp.aspx). Common detection pesticides are pesticides frequently used in row crop production and include acetochlor, alachlor, atrazine, metolachlor, and metribuzin.

Where Are Pesticides in the CRW?

MDA uses two monitoring wells in the northeastern region of the CRW to monitor for common detection pesticides. The monitoring wells are in the northeastern region because of the karst geology and row crop agriculture increasing the potential for pesticides or pesticide degradates to get into groundwater. Figure 19 displays the number of common detection pesticides recorded at each monitoring location in the CRW in 2016. Samples ranging from two to four common detection pesticides were detected at the monitoring wells. No detections exceeded any human health-based drinking water standards or reference values. MDA's monitoring wells only give information about pesticides at those specific locations. Pesticide sampling of private wells is included as part of the TTP, which is currently underway and will provide more information on the presence of pesticides in other locations in the watershed.

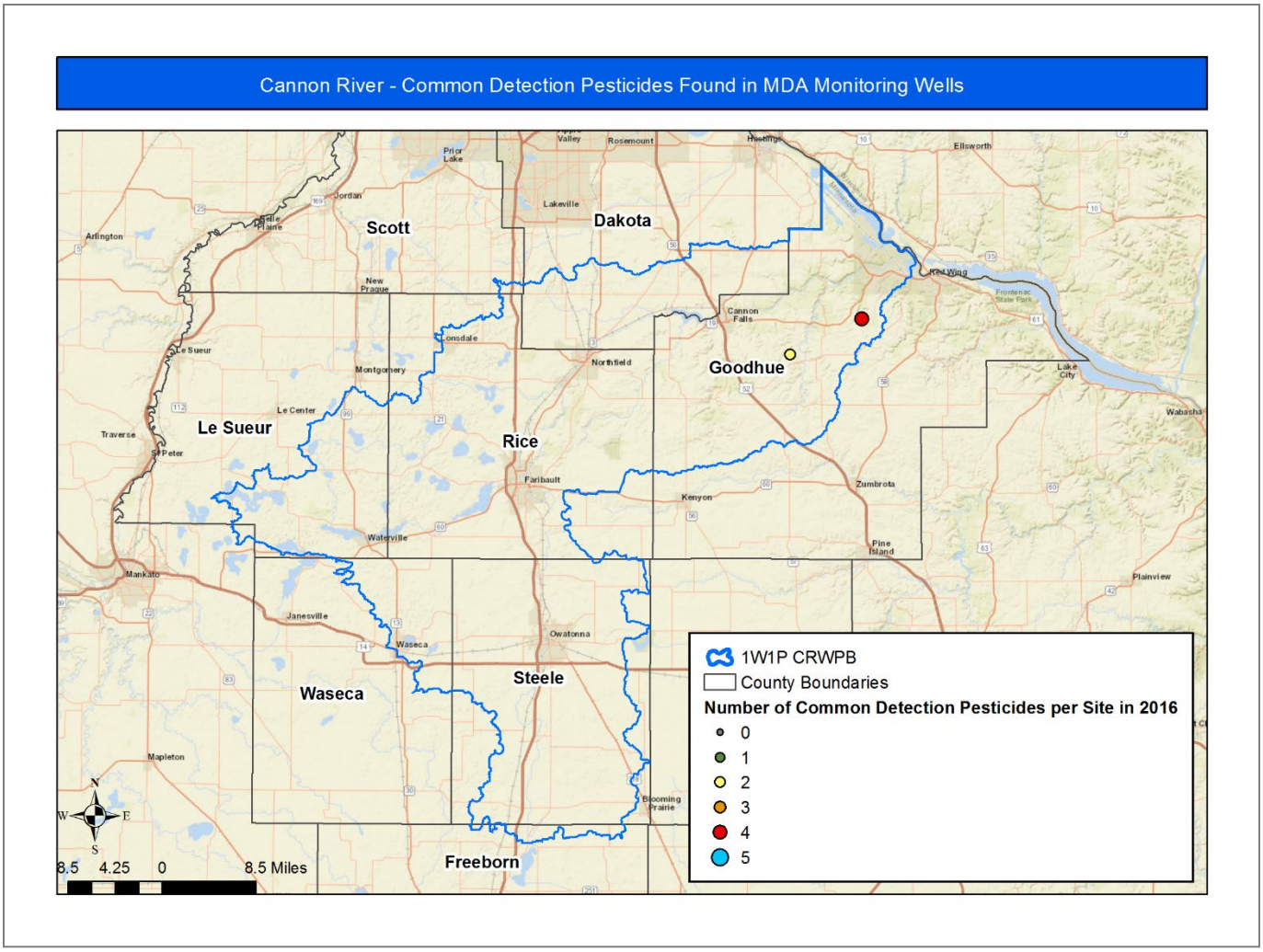

Figure 19: Cannon River Watershed Planning Boundary-Common Detection Pesticides Found in MDA Monitoring Wells

How to Address Pesticides in Groundwater

General approaches to reduce the amount of pesticides that may enter groundwater include:

- Providing educational opportunities about pesticide and insecticide BMPs for both agricultural lands and residential/commercial lawns (turf)
- Increasing the adoption of water quality BMPs for pesticides and insecticides

Table 7 provides a more comprehensive list of specific actions the counties and sub-watersheds in CRW can take to restore and protect groundwater quality related to pesticides.

Pharmaceuticals

The presence of pharmaceuticals in water is of increasing concern because they may cause harm to humans and aquatic life. Pharmaceuticals enter rivers, lakes, and groundwater when human waste, animal waste, or discarded medications move from stormwater systems, sewer systems, or septic tanks into water. Wastewater and drinking water treatment may not completely remove pharmaceuticals. As a result, these chemicals can be found in drinking water sources.

How to Protect Groundwater from Pharmaceutical Contamination

Do not flush old or unwanted prescription or over the counter medications down the toilet or drain and do not put them in the trash. There are more than 240 medication collection boxes located at law enforcement facilities and pharmacies in Minnesota. These collection sites do not charge for disposal. You can use the Earth 911 website to identify collection sites by zip code, Locations that take medications (search.earth911.com/?what=Medications&where=MN). If a disposal site is not available, follow the MPCA guidance to minimize risk to the environment, Medication Disposal Guidance (https://www.pca.state.mn.us/living-green/managing-unwanted-medications).

Arsenic

Approximately five percent of the 250 arsenic samples taken from wells in the CRW have levels of arsenic higher than the SDWA standard of 10 micrograms per liter (µg/L)[8]. Arsenic occurs naturally in rocks and soil across Minnesota and can dissolve into groundwater. Consuming water with low levels of arsenic over a long time is associated with diabetes and increased risk of cancers of the bladder, lungs, liver, and other organs. The SDWA standard for arsenic in drinking water is 10 (µg/L); however, drinking water with arsenic at levels lower than the SDWA standard over many years can still increase the risk of cancer. The EPA has set a goal of 0 µg/L for arsenic in drinking water because there is no safe level of arsenic in drinking water.

Since 2008, the state of Minnesota has required that water from new water supply wells be tested for arsenic. Table 4 outlines the number of well water samples tested for arsenic in the CRW by MDH and shows the percentage of samples with arsenic levels over the SDWA standard. This dataset includes newly constructed wells (installed after 2008), domestic wells, and other drinking water supply wells. It is important to remember that arsenic concentrations can be drastically different from nearly identical wells installed on adjoining properties.

Table 4: Summary of arsenic (As) concentrations in wells of the Cannon River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum As concentration (µg/L)	Maximum As concentration (µg/L)	Median As concentration (µg/L)	As samples at or above 5 µg/L (%)	As samples at or above 10 µg/L (%)
< 50	6	0.0005	5.1	0.002655	16.7	0
50 - 99	14	1	22.8	1.85	21.4	14.3
100 - 149	34	0.00131	20.3	1.55	17.6	8.8
150 - 199	37	0.00281	13.5	1.1	21.6	8.1
>= 200	159	0.0005	27.5	1	10.1	2.5

[8] One microgram per liter is the same as 1 part per billion (ppb).

Depth Completed Range (feet)	Total samples (n)	Minimum As concentration (µg/L)	Maximum As concentration (µg/L)	Median As concentration (µg/L)	As samples at or above 5 µg/L (%)	As samples at or above 10 µg/L (%)
Total	250	0.0005	27.5	1	23.2	4.8

Where Is Arsenic in the CRW?

Arsenic is most prevalent in the Quaternary Buried Artesian Aquifers (lenses of sand and gravel enclosed within clay-rich sediments). Elevated levels are likely related to local geochemical conditions that allow for mobilization of the metal. These geochemical conditions tend to be moderately reducing and are often associated with the contact between sand and gravel aquifers and adjacent clay-rich sediments (Erickson and Barnes, 2004 and 2005). Figure 20 shows that arsenic is found in the center portion of the watershed, extending from north to south. The dataset used to create Figure 20 is the same that is displayed in Table 4. These samples were taken from newly constructed wells, domestic wells, and other drinking water supply wells sampled by MDH.

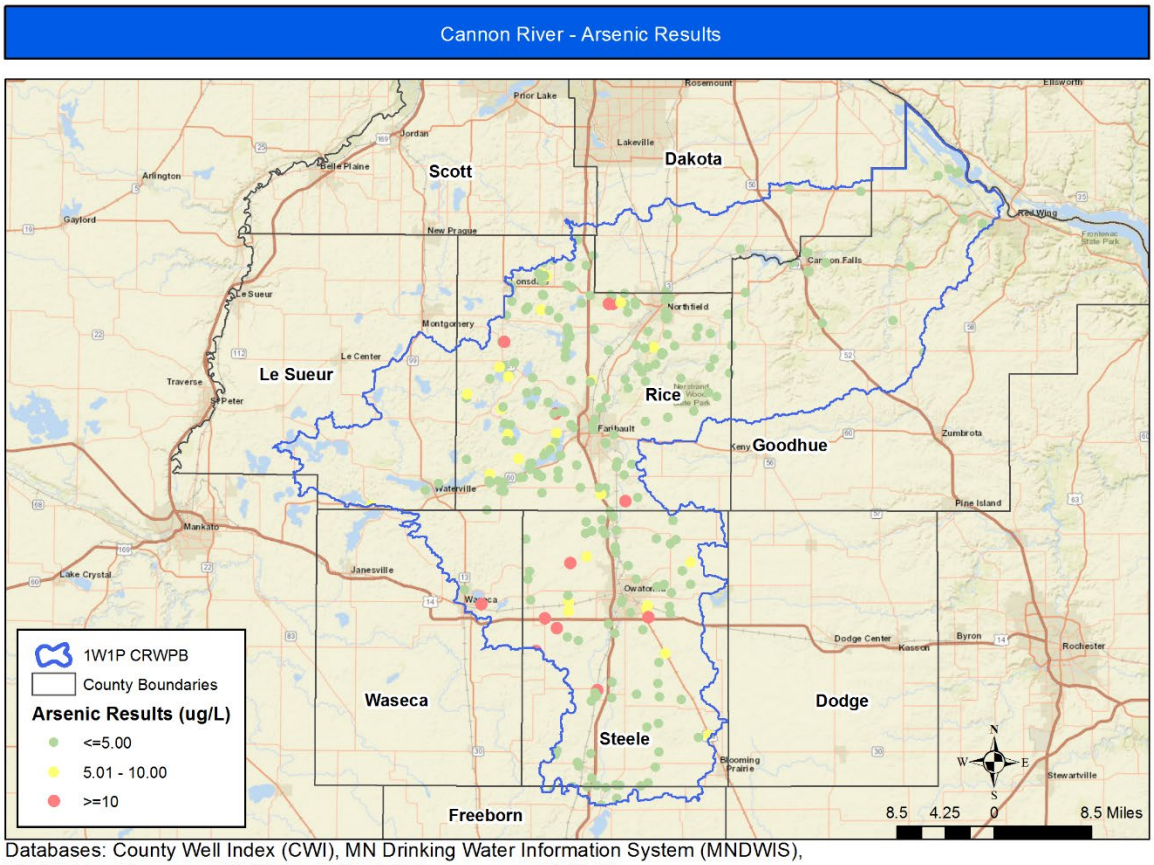

Figure 20: Cannon River Watershed Planning Boundary-Arsenic Results

How to Address Arsenic in Groundwater

Unlike nitrate and pesticides, human activity rarely causes arsenic in groundwater, except for local releases of insecticides or wood preservatives into the environment. Therefore, few actions can reduce the amount of arsenic in groundwater. Implementation efforts should focus on making private well users aware of the health risks, encouraging them to test their water for arsenic, and providing them with treatment options to keep their drinking water safe when arsenic is present.

Radionuclides

Elevated concentrations of naturally occurring radioactive radium have been detected in some groundwater in the CRW. In certain areas of the CRW, the levels at which these chemicals are found cause them to be considered drinking water contaminants. The exact source of these compounds is not entirely clear. They may originate in the clay-rich glacial sediments or may be part of the original mineral composition of the Galena Group. What is known is that their presence in the groundwater is related to reducing geochemical conditions and the very slow rate of groundwater flow in these bedrock layers.

Where are Radionuclides in the CRW?

Elevated concentrations of naturally occurring radioactive radium occur in the bedrock Galena Group and St. Peter Sandstone aquifers in the southernmost parts of the Straight River drainage.

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in CRW groundwater. Therefore, actions cannot really reduce the amount of radionuclides present in groundwater. Implementation efforts should focus being aware that radionuclides may be found in groundwater. The factors that contribute to the presence of radionuclides in CRW groundwater are not well understood at this point. If private well users are concerned about radionuclides in their well, they can pay to have the water tested through an accredited laboratory. Learn more at Radionuclides (Radium) in Drinking Water (www.health.state.mn.us/divs/eh/water/contaminants/radionuclides.html).

Ambient Groundwater Monitoring

The Minnesota Pollution Control Agency's Ambient Groundwater Monitoring Program monitors trends in statewide groundwater quality by sampling for a comprehensive suite of over 100 chemicals including nutrients, metals, anions and cations, and volatile organic compounds. The Ambient Groundwater Network currently consists of approximately 260 sites that represent a mix of deeper domestic wells and shallow monitoring wells in non-agricultural regions across the state. The primary focus areas are shallow aquifers that underlie urban areas, due to the higher tendency of vulnerability to pollution. The wells are predominately located in sand and gravel and Prairie du Chien-Jordan aquifers, and are sampled annually. In addition to the annual ambient groundwater samples, MPCA staff collect 40 contaminants of emerging concern (CECs) samples that are analyzed for over 130 analytes, such as pharmaceuticals, personal care products and fire retardants.

There are three ambient groundwater monitoring wells within the Cannon River Watershed, Figure 21. All detections were within the primary or secondary maximum contaminant levels (MCLs), with the exception of manganese in one of the monitoring wells, which exceeded the MCL.

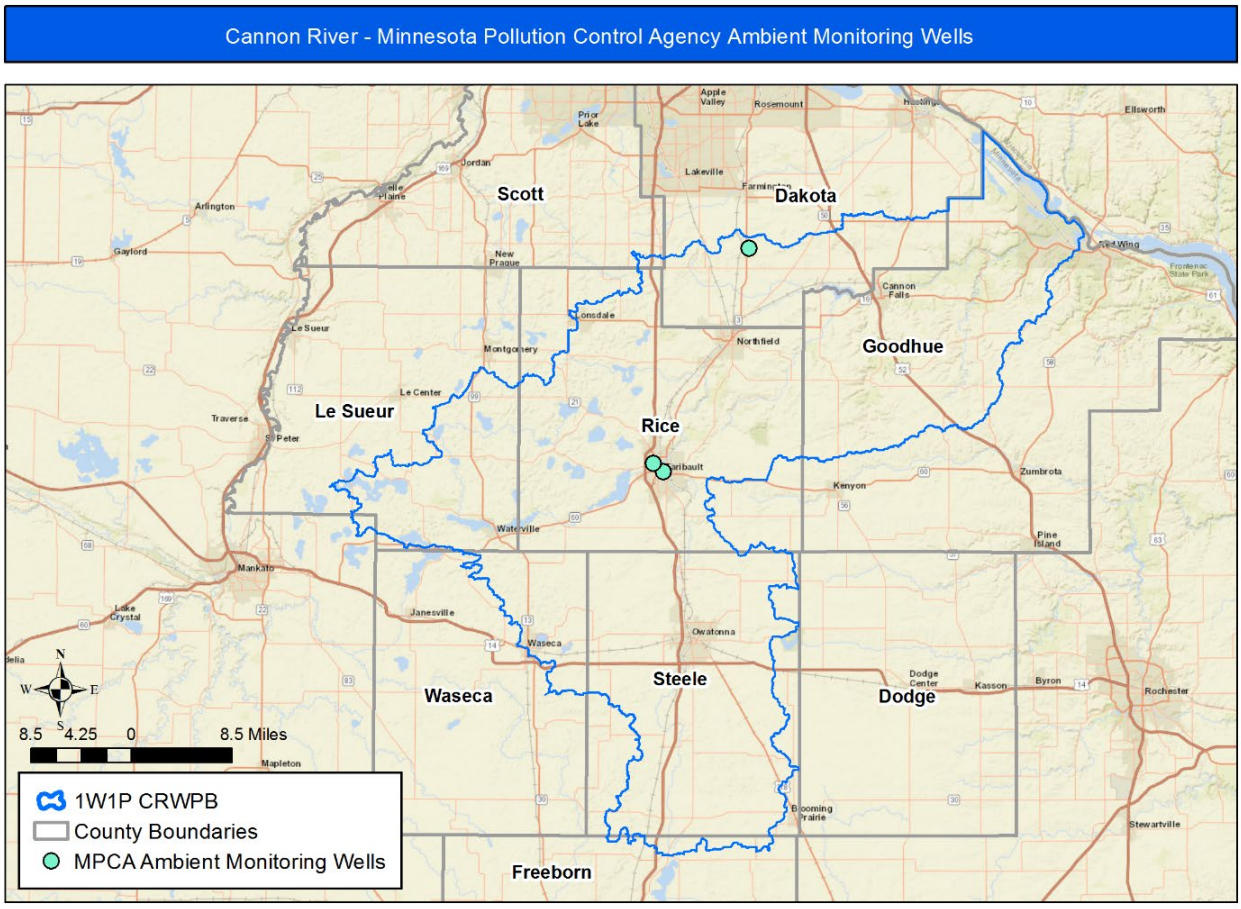

Figure 21: MPCA Ambient Monitoring Wells in the Cannon River Watershed Planning Boundary

Potential Contaminant Sources

Some land use practices make it easier for contaminants to get into groundwater. Key land uses that could be contaminant sources in the CRW are described below.

Animal Feedlots

MPCA regulates the land application and storage of manure generated from animal feedlots in accordance with Minnesota Rule Chapter 7020. The MPCA Feedlots Program (https://www.pca.state.mn.us/quick-links/feedlots) requires that the land application and storage of manure be conducted in a manner that prevents nitrate contamination to both groundwater and surface water. Animal manure contains significant quantities of nitrogen and pathogens. Improper manure management, especially in places with high pollution sensitivity (including karst geology), can lead to contamination of groundwater.

MDA hosts an interactive map that provides information on local ordinances regulating animal agriculture in Minnesota's counties. The information includes the most common areas of regulations, such as setbacks and separation distances, conditional use permits, feedlot size limitations, and

minimum acreage requirements. For more information, visit the [Local Ordinances Regulating Livestock - Web Mapping](www.mda.state.mn.us/animals/livestock/local-livestock-ordinances.aspx).

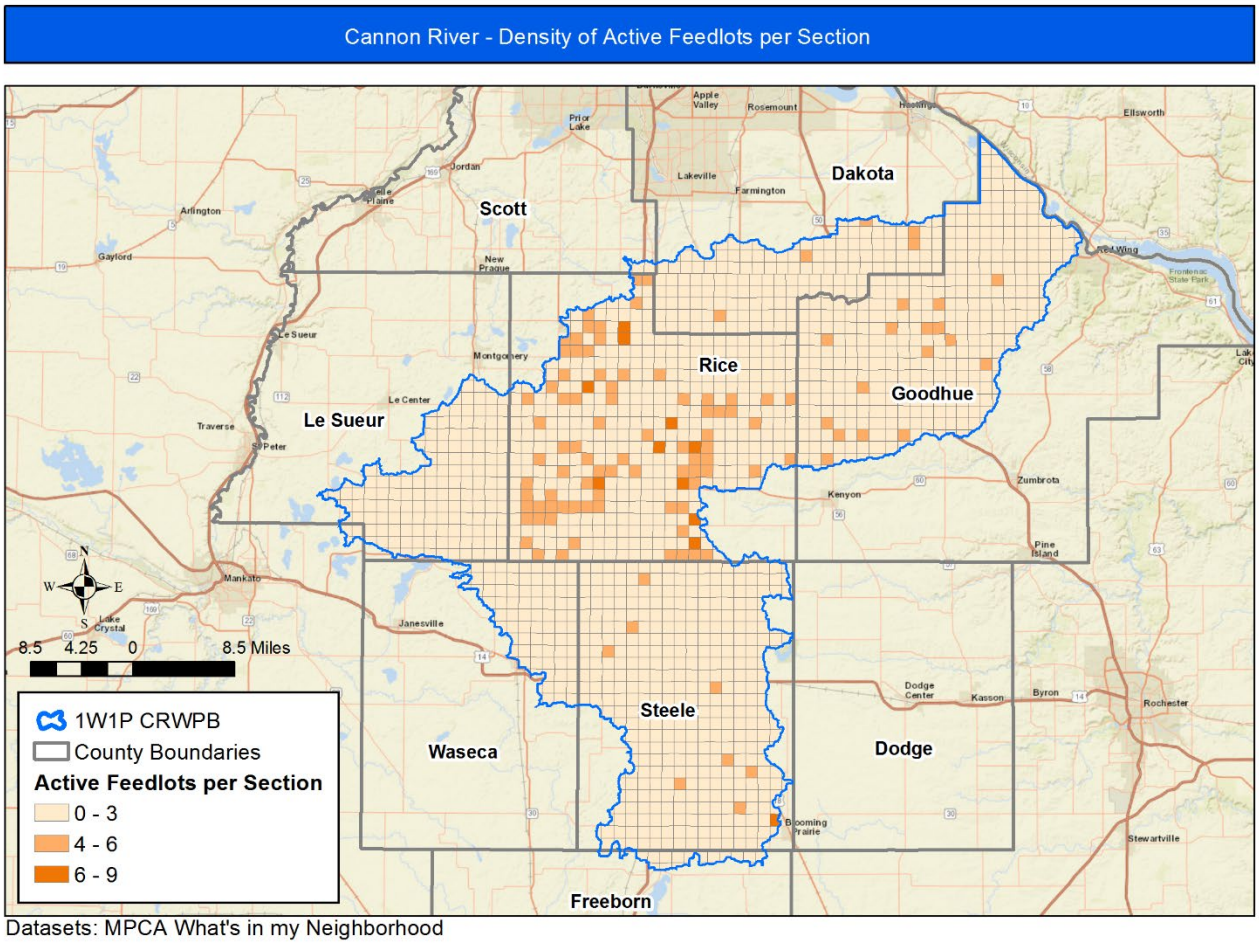

Figure 22: Cannon River Watershed Planning Boundary-Active Feedlots

Where Are Animal Feedlots in Cannon River Watershed?

The CRW has 2,075 registered feedlots. The watershed has a diverse animal agriculture industry, being a top livestock producing region for turkeys, milk cows, cattle, and hogs. Minnesota Rule 7020 allows the MPCA to transfer or 'delegate' regulatory authority and administration of certain parts of the feedlot program to a county. A delegated county regulates feedlots with less than 1,000 animal units; MPCA regulates anything above that threshold. County feedlot programs have responsibility for implementing state feedlot regulations including: registration, permitting, inspections, education/assistance, and complaint follow-up. Table 5 outlines the number of registered feedlots for each county within the watershed and whether that county has been delegated the authority to administer the feedlot program locally.

Table 5: Number of registered feedlots and the delegated counties.

County	Number of Registered Feedlots per County	Delegated?
Dakota	168	No
Scott	2	No
Le Sueur	100	Yes
Rice	1003	Yes
Goodhue	374	Yes
Waseca	59	Yes
Steele	360	Yes
Blue Earth	1	Yes
Freeborn	8	Yes

How to Protect Groundwater from Contamination

Manure management plans, feedlot inspections, permitting, technical assistance, and record keeping are all used to manage nitrogen impacts to water quality. Because of the large number of registered feedlots within the watershed, especially in Rice County, it is important to prioritize activities in the most groundwater sensitive areas first. Table 7 provides a more comprehensive list of specific actions partners in CRW can do to protect groundwater from nitrate and pathogen contamination.

Subsurface Sewage Treatment Systems (SSTS)

Of the approximately 450,000 SSTS (commonly called septic systems) across the state, slightly over 100,000 of them are estimated to be failing. As more time passes, additional systems are likely to fail. Failing SSTS can pollute both surface and groundwater. A failing system is one that does not provide adequate separation between the bottom of the drainfield and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients, and some chemicals. SSTS infiltrate treated sewage into the ground, ultimately traveling to groundwater.

Where Are SSTS in the CRW?

SSTS are found in the nine counties in the CRW. There are no existing statewide data sets identifying where failing SSTS are located. However, state regulations require each county to adopt a local SSTS ordinance and that eminent health threat or failing systems be replaced and brought up to current standards. Even with a required ordinance, some counties still have identified gaps in their SSTS program, ranging from lack of record on treatment system age, type or function, known unsewered communities, and lack of a point of sale requirement trigging an inspection through a property sale.

How to Protect Groundwater from SSTS Contamination

SSTS must be properly sited, designed, constructed, and maintained to minimize the potential for disease transmission and contamination of groundwater. Each county carries out permitting, inspections, and operation of the SSTS program locally. Table 7 provides a more comprehensive list of specific actions CRW can do to assure SSTS do not contaminate groundwater. You can find more information about building and maintaining SSTS at Subsurface Sewage Treatment Systems (https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems).

Contaminated Sites

The MPCA identifies 323 active tank and 23 leak sites and one closed landfills in the CRW. These types of contaminated sites, also referred to as point sources, have the potential to contaminate groundwater with a variety of chemicals.

Where Are Contaminated Sites in Cannon River Watershed?

Figure 23, maps active tank or leak sites compared to pollution sensitivity of aquifers tapped by drinking water wells in the CRW. **Figure 24** provides a map of the closed landfills in the CRW. The following sites also provide maps to help identify contaminated sites.

- **What's in My Neighborhood** (https://www.pca.state.mn.us/data/whats-my-neighborhood)**:** This app identifies potential contamination sites for water quality, feedlots, hazardous waste, investigation and clean up, air quality, and solid waste.
- **Landfill Cleanup Act Participants** (mpca.maps.arcgis.com/apps/Solutions/s2.html?appid=6470bb44bd83497993da5836333d1cb3) : This site has an interactive map that shows closed landfills and the corresponding groundwater plumes and groundwater areas of concern.

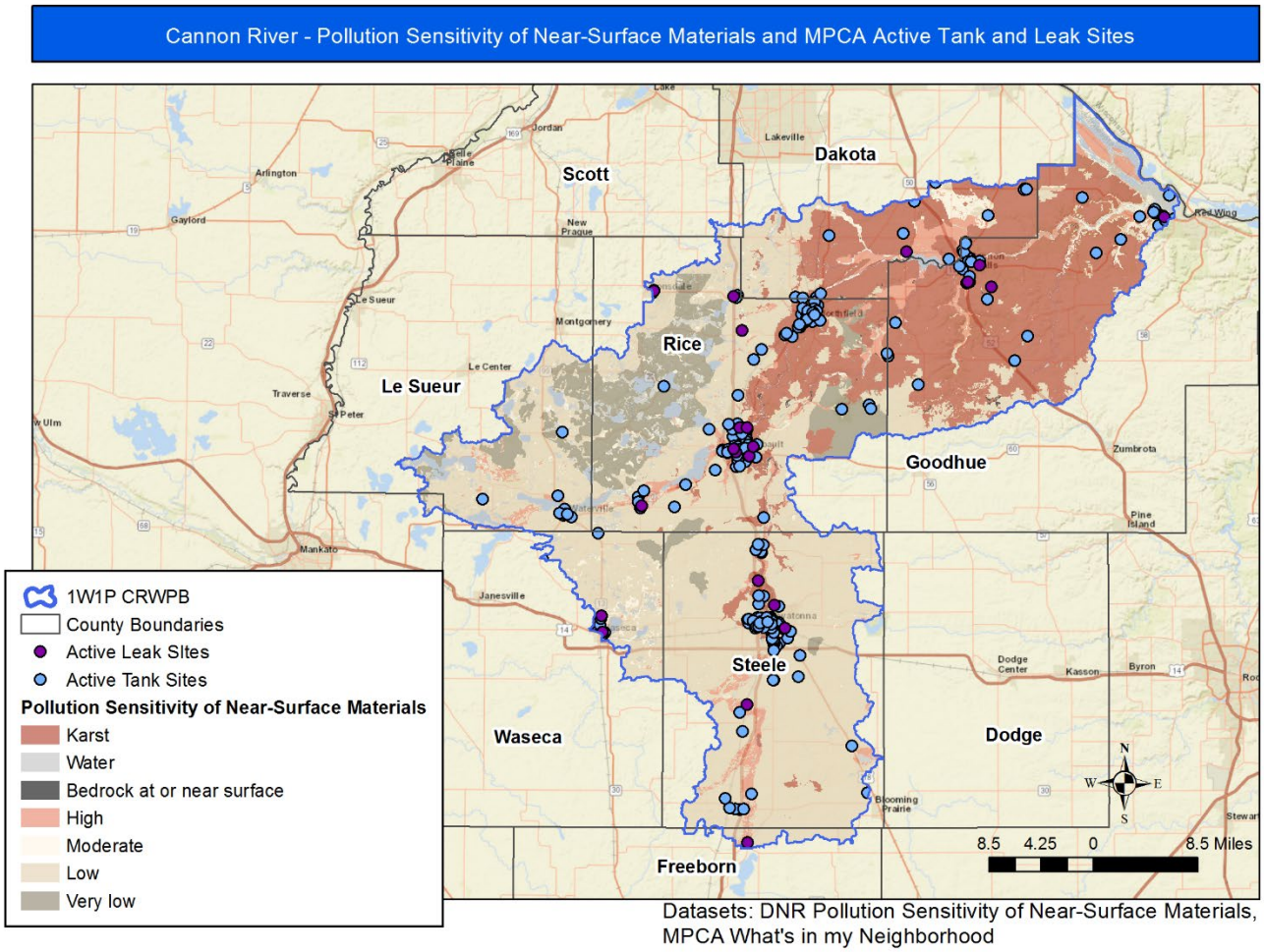

Figure 23: Cannon River Watershed Planning Boundary-MPCA Active Tank and Leak Sites and Pollution Sensitivity of Near-Surface Materials

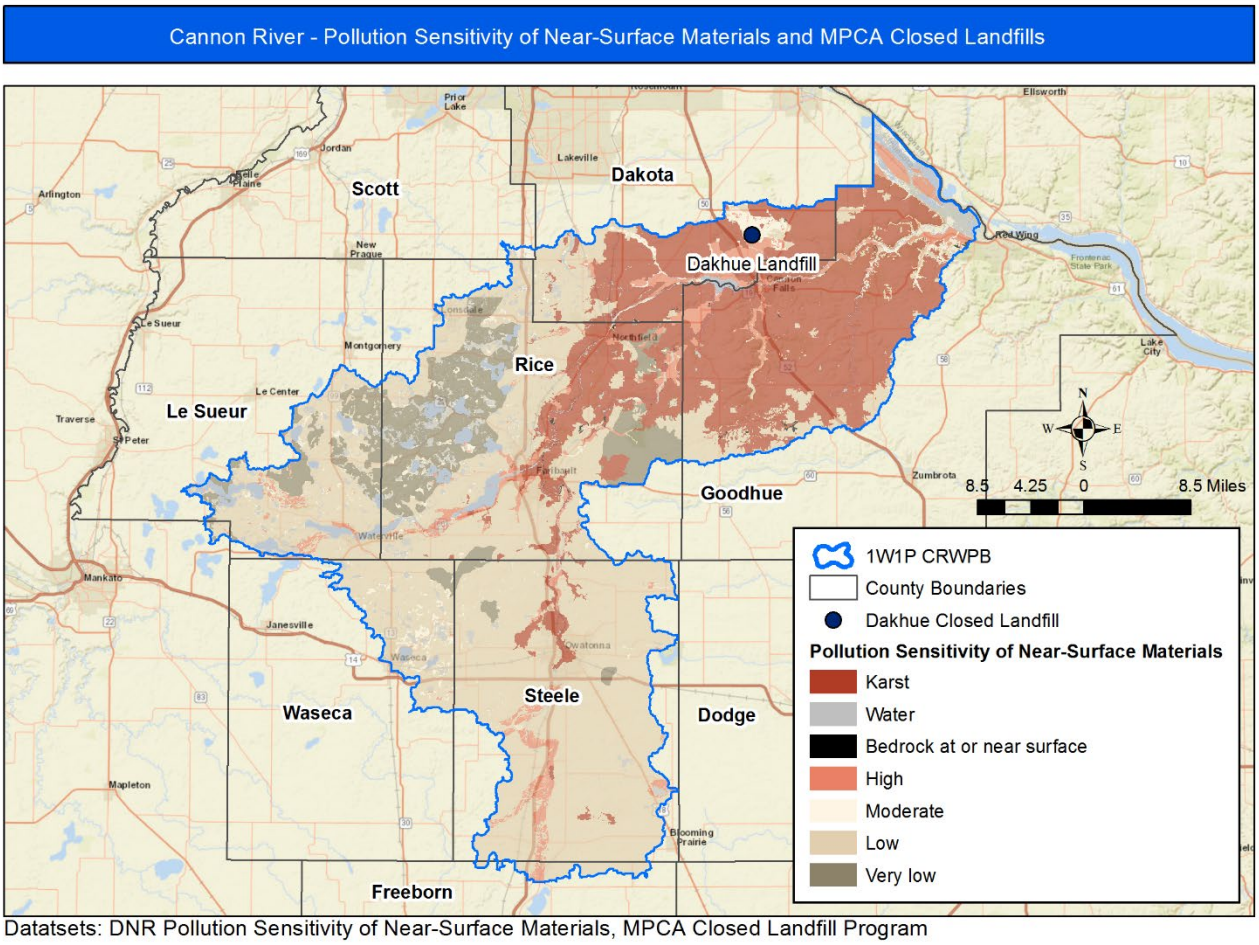

Figure 24: Cannon River Watershed Planning Boundary-MPCA Closed Landfills

How to Protect Groundwater from Contaminated Sites

Contaminated sites should be identified before making or changing any land use plans, zoning maps, and/or ordinances. Table 7 provides a more comprehensive list of specific actions CRW can do to assure contamination sites do not further contaminate groundwater.

Stormwater

The MPCA Stormwater Program (https://www.pca.state.mn.us/water/stormwater) regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems (MS4s), construction activities, and industrial facilities, mainly through the administration of the National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Program. The CRW has six cities, one township, two counties, and the MN Department of Transportation that have MS4 permits requiring the treatment and management of stormwater runoff.

The management of stormwater runoff is increasingly reliant on the infiltration of stormwater into the soil to control the volume of runoff. A number of stormwater practices concentrate runoff and force

infiltration into the soil where it can recharge groundwater aquifers. The impacts of these practices on groundwater quality have not been thoroughly evaluated.

Active karst regions require additional oversight to limit the development of a sinkhole below a stormwater BMP. As such, the Construction Stormwater Permit prohibits infiltration of stormwater runoff "within 1,000 feet up-gradient or 100 feet down-gradient of active karst features unless allowed by a local unit of government with a current MS4 permit". The Minnesota Stormwater Manual provides additional guidance for karst geology, MN Stormwater Manual/karst (https://stormwater.pca.state.mn.us/index.php/Karst).

How to Manage Potential Stormwater Infiltration Risk

Caution should be observed when infiltrating stormwater, especially in areas with vulnerable drinking water sources. Use the MDH Stormwater Guidance for Sites in Drinking Water Supply Management Areas (https://stormwater.pca.state.mn.us/images/d/d3/Flow_Chart_-_MDH_Stormwater_Guidance_for_Sites_in_Drinking_Water_Supply_Management_Areas.pdf) to better understand when infiltration is appropriate in wellhead protection areas. Additional caution should be practiced in karst geology. Use the recommendations for karst geology (https://stormwater.pca.state.mn.us/index.php/Karst) developed as part of the stormwater manual to safely manage stormwater runoff. This guidance has been incorporated as part of the updated stormwater permit and is available in Minnesota's Stormwater Manual (https://www.pca.state.mn.us/water/minnesotas-stormwater-manual). Table 7 provides a more comprehensive list of additional actions CRW can take to prevent stormwater infiltration from contaminating groundwater.

Household Hazardous Waste

Many household products you use to clean your home, maintain your yard, and control animals and insects contain hazardous materials. When these products are disposed of improperly, it may lead to groundwater contamination.

Minnesota's household hazardous waste (HHW) program is a partnership with the MPCA and the counties. Together they provide education, storage and disposal, as well as maintain a network of regional, local, and mobile facilities to collect HHW statewide. In addition, many counties offer temporary collection sites, including one-day events. The MPCA has a searchable database to find HHW collection sites for your county, Household Hazardous Waste Collection Sites (https://www.pca.state.mn.us/living-green/find-your-household-hazardous-waste-collection-site).

Similar to the partnership for HHW, the MDA collaborates with counties to provide a means to safely dispose of unwanted and unusable pesticides through the Waste Pesticide Collection Program. Through this program, pesticide users in every county around the state have opportunities to dispose of unwanted agricultural pesticides through county HHW facilities, their mobile events or by attending MDA schedule events. Participants can drop off up to 300 pounds free of charge. MDA manages a waste pesticide collection schedule to learn about partnerships and scheduled events, MDA Waste Pesticide Collection Schedule (www.mda.state.mn.us/chemicals/spills/wastepesticides/schedule.aspx).

How to Protect Groundwater from Household Hazardous Waste Contamination

Promote HHW and the pesticide collection program availability to residents and evaluate opportunities to expand services to increase participation. Table 7 provides a more comprehensive list of specific actions CRW can do to assure contamination sites do not contaminate groundwater.

Groundwater Quantity Issues and Concerns

The availability of groundwater is currently not a concern throughout the CRW. There is sufficient water available to meet the commercial, industrial, drinking water, and agricultural needs from one or more aquifers depending on the users' location. This situation could change in the future if demand for groundwater increases and/or changes in precipitation patterns or human activities result in less groundwater recharge.

An analysis of groundwater levels in wells with at least 20 years of measurements identified only one well with a downward trend that appeared to be due to human activity. However, there are only five monitoring wells in the CRW that could be included in that assessment. For most areas in the watershed, long-term changes in aquifer levels/groundwater quantity could not be evaluated. In recent years, additional monitoring wells have been installed that will allow a more in-depth evaluation of how groundwater levels/groundwater quantity is changing in the future.

Groundwater levels naturally have seasonal fluctuations and annual variability. Climate and weather typically drive minor variability. Human activities (primarily water withdrawals and land use change) have a much larger influence on water levels. Activities on land can affect groundwater levels by reducing infiltration (groundwater recharge); these activities include tiling, changes in vegetation, increased areas of impervious surface, and changing surface water or stormwater flow.

To understand whether there is groundwater quantity concerns in the CRW, water level monitoring data from local wells is essential. Depending on the location, hydrogeology, intensity of use, and other factors, water level changes may have little impact on the groundwater resource or other natural features. In other places, pumping wells or changing land use can significantly affect water levels. These changes result in well interference; less water available for withdrawal; less streamflow; and lower water levels in wetlands, fens, or lakes. Lower water levels in wetlands, fens, or lakes can impact aquatic and terrestrial communities. Even if other wells or natural features are not immediately impacted, a downward trend in groundwater levels can indicate an unsustainable use and should be addressed.

Groundwater Level Monitoring

The DNR maintains a statewide groundwater level monitoring program using observation wells for the purpose of assessing the status of groundwater resources. The network provides valuable information to determine long-term trends, interpret impacts of pumping and climate, plan for water conservation, evaluate water use conflicts, and inform other water management decisions.

Multiple decades of data are necessary when assessing whether groundwater levels have changed. The DNR observation wells have a large range of length of record. A few wells have water-level records extending back twenty or more years. But, many of the observation wells were recently installed within the past year or two. The water level records from newer wells will be of great use in the future, but are not used in this report. The locations of DNR observation wells, their year of installation, and the

location of well nests (where wells completed at different depths in different aquifers are located near each other) are shown in Figure 26.

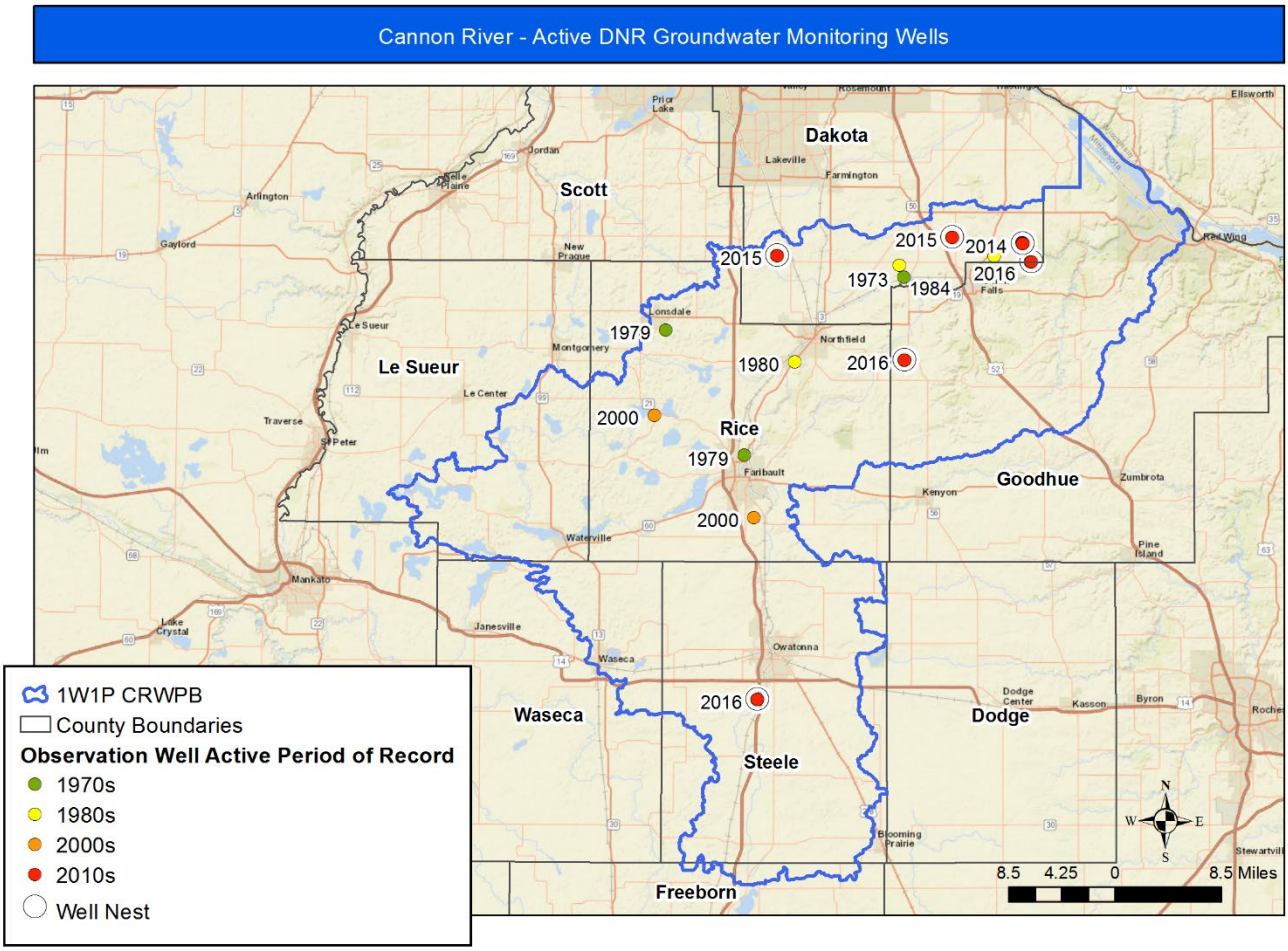

Figure 25: Cannon River Watershed Planning Boundary- Location of Active DNR Groundwater Monitoring Wells

Five observation wells with greater than twenty years of record were analyzed for water level trend by the Mann-Kendall non-parametric statistical method. One well is completed in the surficial sand (water table) aquifer, three wells are completed in the Prairie du Chien aquifer, and one well is completed in the Jordan aquifer. (Most statistical methods assume a normal data distribution. Because hydrologic data typically do not have a normal distribution, non-parametric statistics are required). The trends were calculated using one data point per year: the lowest annual water level reading. The trends are meant to show a general direction of water levels over time and are shown in Figure 26. The Mann-Kendall method can indicate an upward trend, a downward trend, or no trend. All calculated trends from observation wells in the CRW were either no trend or downward trend. A downward trend can result from changes in precipitation and groundwater recharge, increases in nearby pumping, or both. The following figures are hydrographs showing water elevation over time for these five wells: Figure 27, Figure 28, and Figure 29.

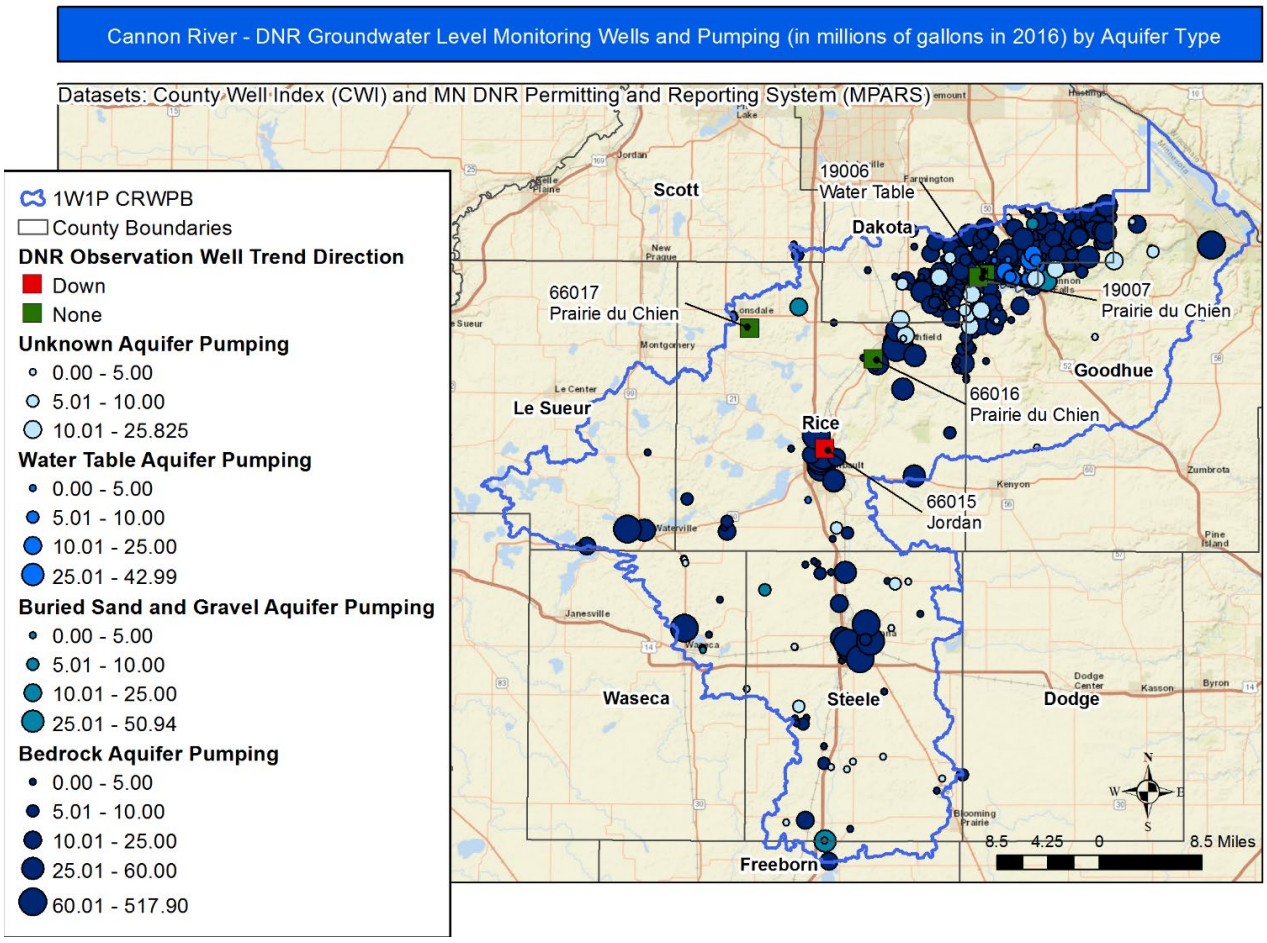

Figure 26: Cannon River Watershed Planning Boundary-Location of Long-Term DNR Groundwater Level Monitoring Wells

Jordan aquifer observation well 66015 has a statistical downward trend. Figure 27 shows the hydrograph (water elevation versus time) of observation well 66015 and pumping volumes from the nearest permitted pumping wells. The early part of the hydrograph, from 1979 to 1996 shows small water-level fluctuations that are probably related to precipitation patterns. For example, the dip in the hydrograph from 1988 to 1992 is a result of 1988 drought; the water level remained low until sufficient precipitation brought the levels up in 1992. There is a downward trend starting in 1997 that is due to a new nearby City of Faribault well drilled about 5000 feet from observation well 66015 and started pumping in 1997. Another new City of Faribault well was drilled and started pumping in 2006, this one about 3100 feet from observation well 66015. Both the distance from large-volume pumping wells and the total volume pumped affect the hydrograph for well 66015. The pattern seen in observation well 66015 matches the general rule that water levels in observation well declines in inverse proportion to the distance between the well and the pumping location and increases in direct proportion to the volume pumped.

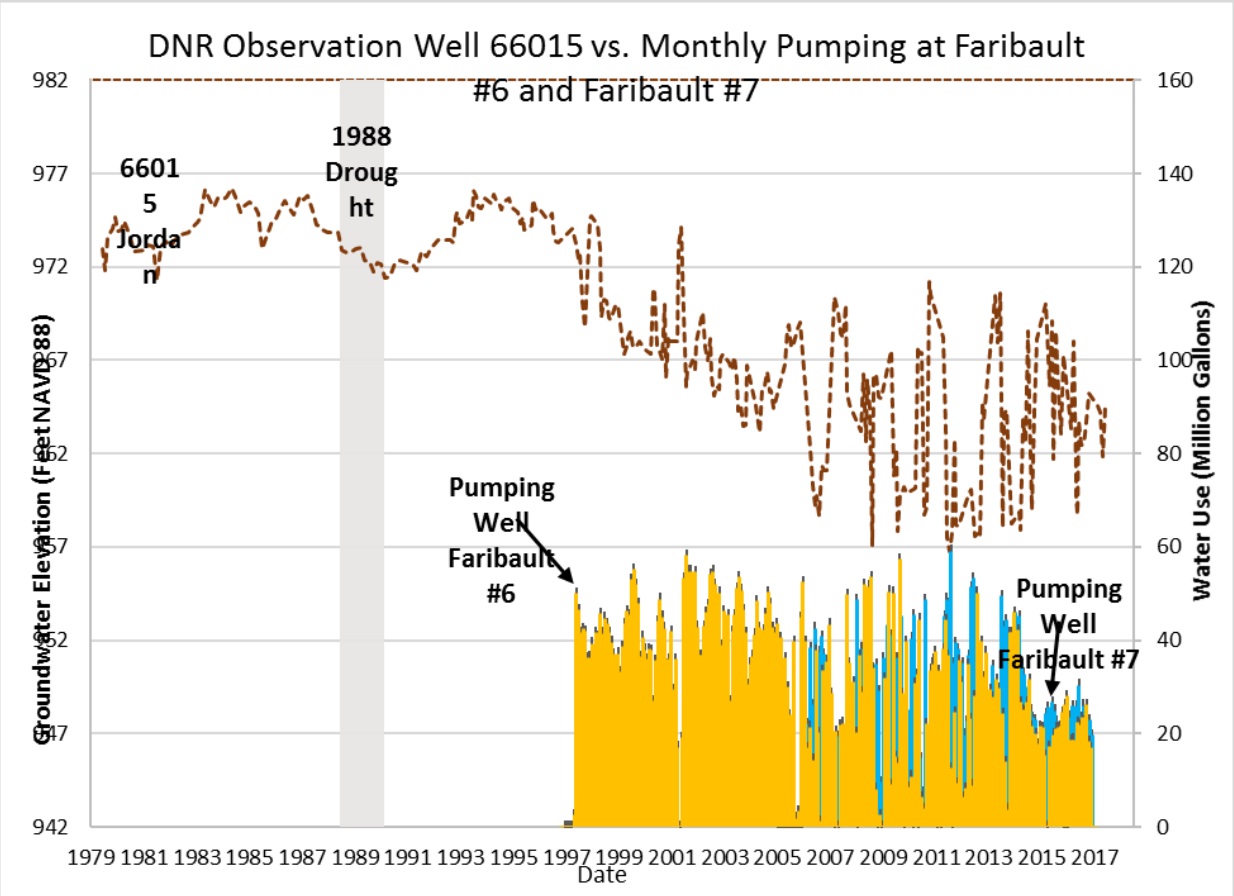

Figure 27: Cannon River Watershed Planning Boundary- Hydrograph of DNR Observation Well 66015 compared to monthly pumping volume in Faribault City wells 6 and 7

Figure 28 and Figure 29 are hydrographs for Prairie du Chien aquifer wells 66016 and 66017. Both have smaller water-level fluctuations than in well 66015, which indicate precipitation driven changes. Both hydrographs show the extent of the last severe drought as defined by the Palmer Drought Index of less than -3. Water levels decreased with the drought in 1988 and recovered as precipitation patterns increased back to normal by 1992.

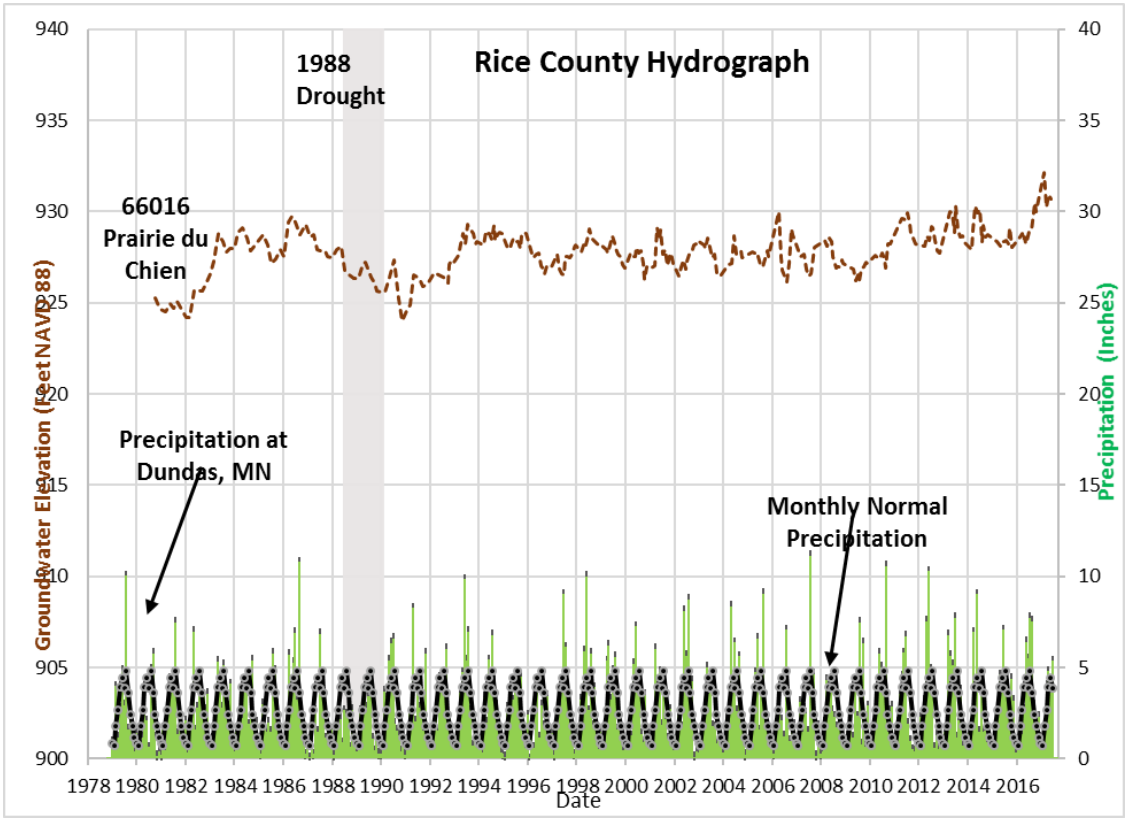

Figure 28: Cannon River Watershed Planning Boundary-Hydrograph of DNR Observation Well 66016 compared to monthly precipitation at Dundas

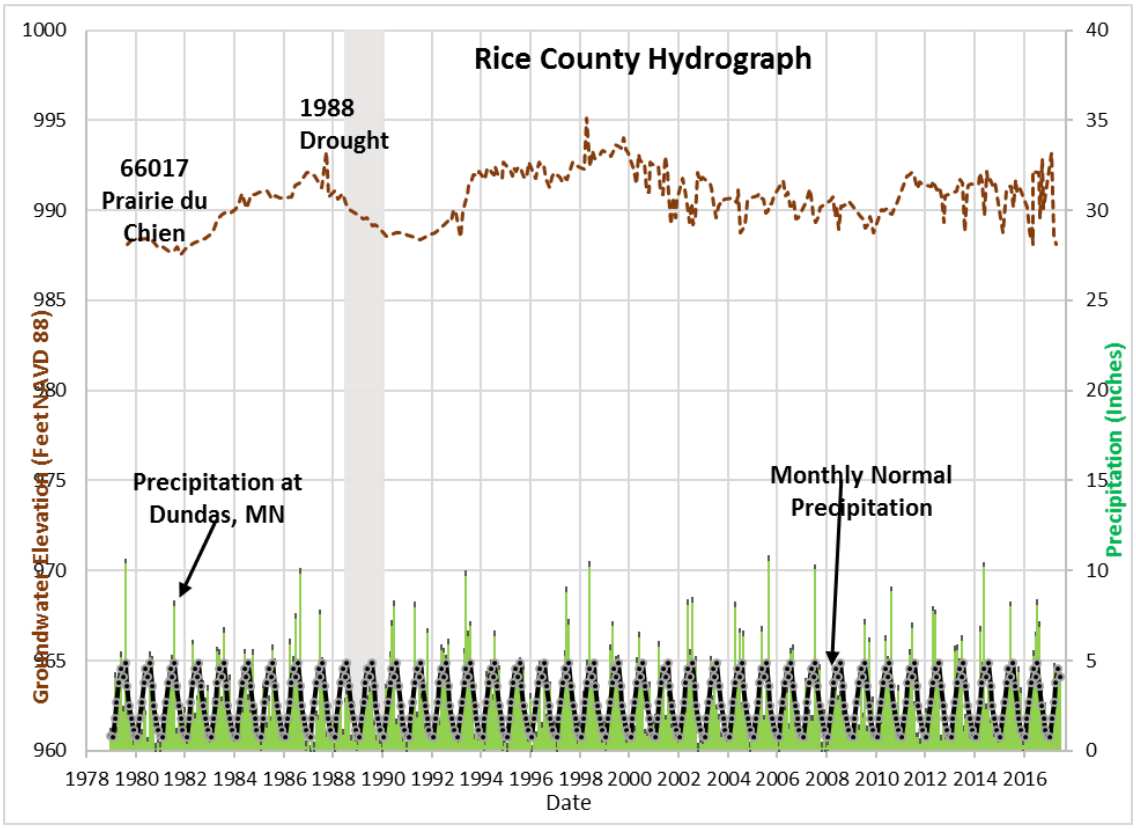

Figure 29: Cannon River Watershed Planning Boundary- Hydrograph of DNR Observation Well 66017 compared to monthly precipitation at Dundas.

Figure 30 shows hydrographs for two observation wells in Dakota County. The wells are close together and completed in different aquifers, forming a well nest. This well nest allows comparison of water levels in different aquifers at the same location. Well 19006 is completed in the water table aquifer and well 19007 is completed in the Prairie du Chien aquifer. Both hydrographs have no statistical trend. The water levels in both of these hydrographs appear to be largely driven by trends in precipitation, not pumping. Water levels in both wells were lower during the last two major droughts, 1976 and 1988. Otherwise, the water levels are fairly stable. Most of the permitted water appropriation wells near these two observation wells are used for seasonal agricultural irrigation. The total volume is less than that for municipal wells, so the effects on observation wells 19006 and 19007 are less than that at observation well 66015. The Prairie du Chien aquifer is highly productive and extensive. It can support more pumping than either surficial aquifers or buried sand and gravel aquifers.

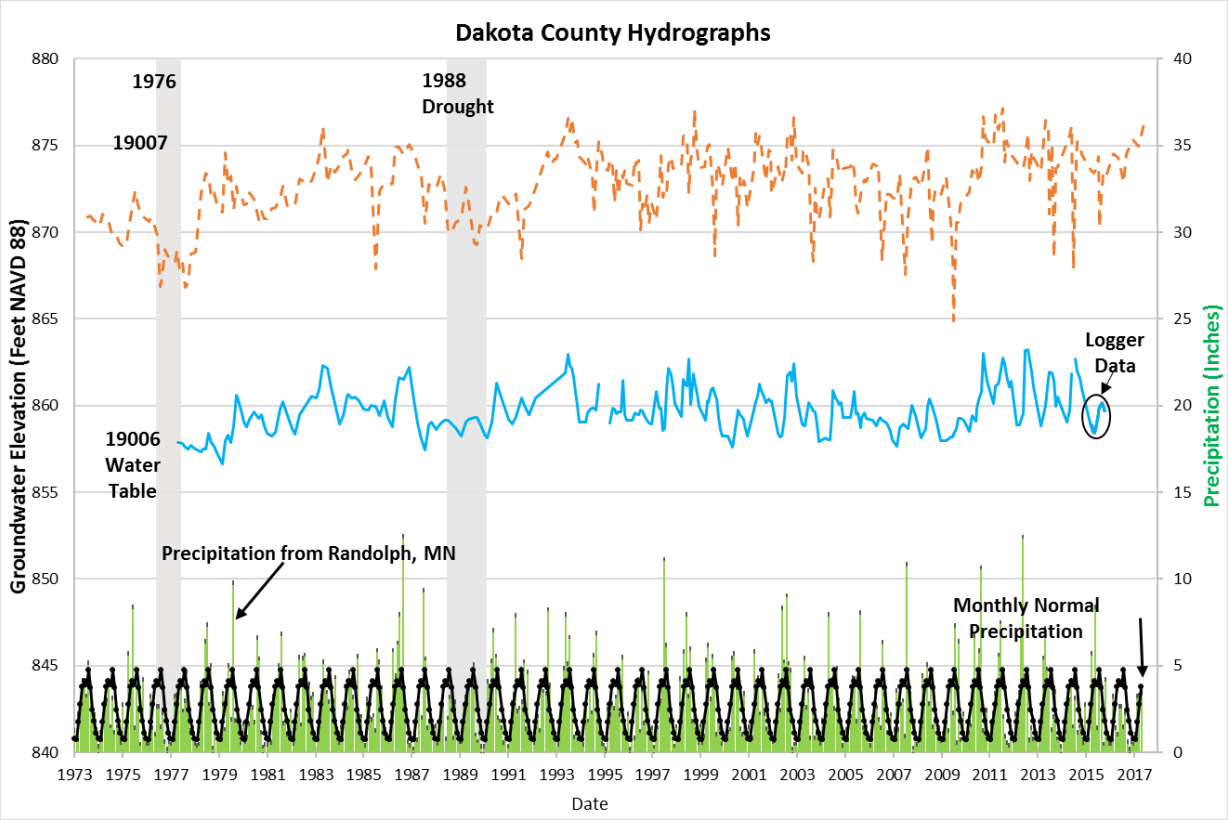

Figure 30: Cannon River Watershed Planning Boundary- Hydrographs of DNR Observation Wells 19006 and 19007 compared with precipitation at Randolph.

In summary, the data from observations well measure how water levels in an aquifer change with time. In aquifers connected to the land surface, the water levels in these wells generally fluctuate with precipitation and groundwater recharge. Pumping of nearby wells completed in the same aquifer will also lower water levels in the observation wells. The effects of groundwater recharge versus pumping can be separated on a hydrograph by the nature of the water-level change. In confined aquifers, nearby pumping wells will cause cyclic water level drops of greater magnitude than the drops in water level solely attributable to changes in precipitation and recharge. Large-capacity pumping wells should not be placed in close proximity to existing domestic wells or to groundwater dependent features.

Groundwater Connected Natural Features at Risk

The CRW boundary includes significant natural features, including surface waters that depend on groundwater to sustain them (Figure 32). Groundwater appropriations and land-use changes can impact the health of these natural resources. If groundwater quantity or quality is degraded, these resources are at risk. The following features occur within the CRW:

- Five designated calcareous fens
- Five designated trout streams
- Wetland complexes across the entire area
- Lakes that may be susceptible to changing aquifer levels
- Twenty-one kinds of groundwater associated native plant communities
- Twenty-two state-listed endangered, threatened, or special concern plant and animal species associated with groundwater

Rare Natural Features Connected with Groundwater in the CRW

Rare natural features (Figure 31 and Figure 32) contribute to the health of the habitat and environment. Some even contribute directly to local economies in the form of recreation—including hunting/fishing, wildlife viewing, and camping. Rare natural features can include species of rare plants and animals as well as native plant communities (habitats). These resources are at risk if groundwater quantity or quality is disrupted.

There are five designated calcareous fens in the CRW (Red Wing 21, Holden 1 West, Rice Co. Wilderness Area Bridge Water 22, Rice Co. Wilderness Area Bridge Water 34, and Pogones WMA). Calcareous fens are very rare prairie wetlands fed by a constant supply of cool, calcium rich groundwater that supports a unique set of plants and animals. Calcareous fens support five of the rare plants found in the CRW. These fens are protected from harm under Minnesota Statute (103G.223).

There are five designated trout streams in the CRW (Spring Creek, Little Cannon River, Spring Brook, Pine Creek, and Trout Brook). These streams are dependent on a constant supply of cold, oxygen-rich groundwater from springs or seeps. These streams are not only unique, but offer excellent recreation opportunities for fishing. Because surrounding land use changes and water appropriations can easily affect them, trout streams are waters designated by the DNR and protected from harm by law (Minnesota Rule 6264.0050).

There are 21 kinds of native plant communities associated or dependent on groundwater in the CRW. They range from wooded to grassland communities such as tamarack swamps, floodplain forests, cattail marshes, wet prairies, and sedge meadows. Nearly half of these communities are considered critically

imperiled or imperiled
(http://files.dnr.state.mn.us/natural_resources/npc/s_ranks_npc_types_&_subtypes.pdf). Three of the 21 native plant communities associated or dependent on groundwater are considered secure. There are 31 species of birds, fish, reptiles, mussels and plants that are either endangered, threatened, special concern, watch list, or are a state listed "Species In Greatest Conservation Need," that are dependent on habitats with groundwater or groundwater seepage areas in the CRW. A detailed list of native plant communities and rare features is available in the Additional Resources section at the end of the report in Table 8 through Table 11.

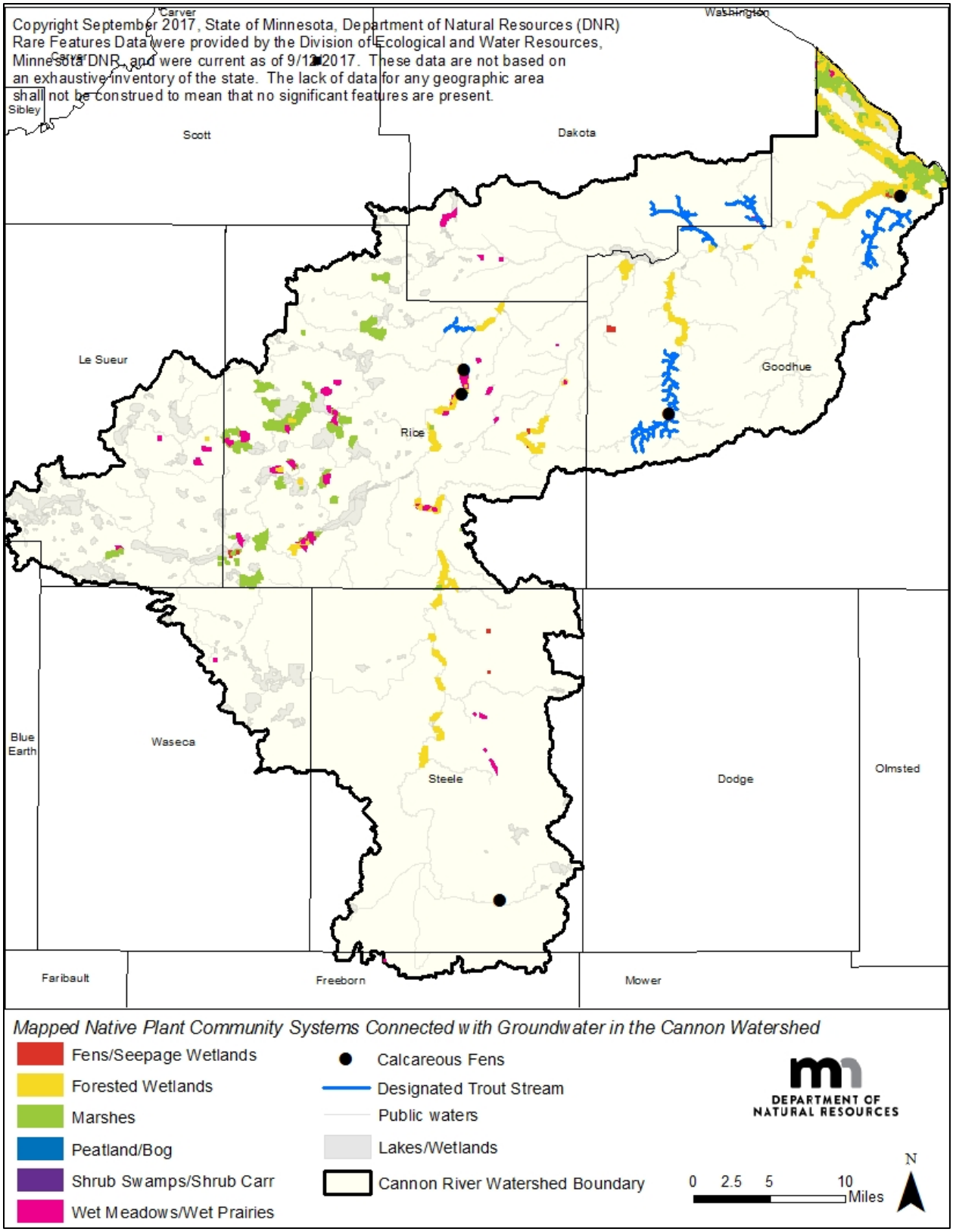

Figure 31: Cannon River Watershed Planning Boundary-Calcareous Fens, Trout Streams, and Native Plant Communities.

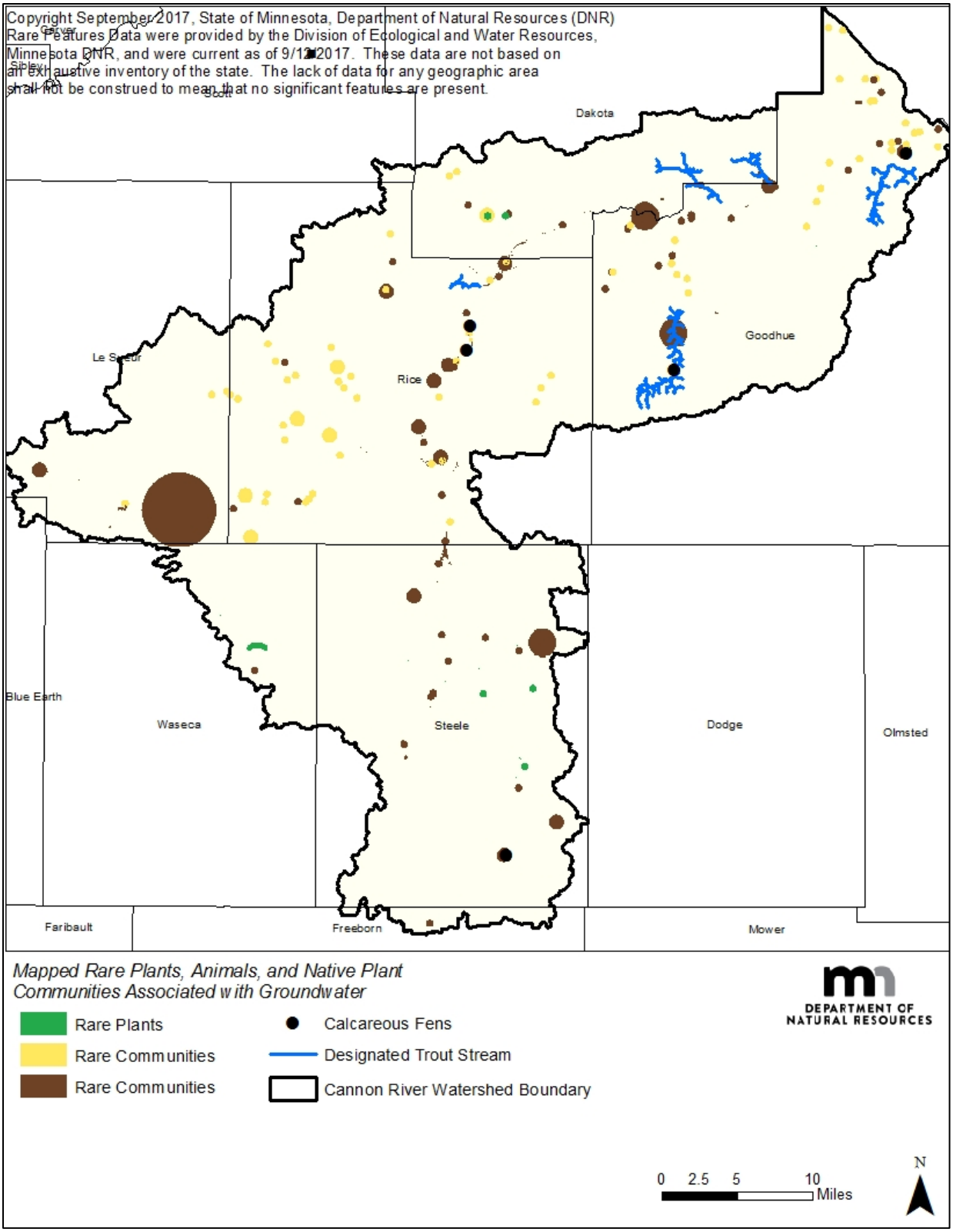

Figure 32: Cannon River Watershed Planning Boundary-Calcareous Fens, Trout Streams, and Rare Plants, Animals, and Native Plant Communities Associated with Groundwater.

Groundwater connections to wildlife species are many and often complex. Wildlife groups as diverse as birds, bats, spiders, snakes, turtles, frogs, toads, fishes, and snails all contain species that require some form of surface water body to complete their life cycles and persist on the landscape. If groundwater fluctuations or depletions affect a significant number of surface water features in this area, important wildlife habitats may be impacted or lost.

Groundwater Flow Dominated Lakes

Lakes require sufficient inflows of water to maintain their water levels, support their plant and animal communities, and allow a wide variety of recreational activities. However, groundwater is not equally important in the water budget of all lakes. Petersen and Solstad (2007) differentiated lakes into three basic types based on their water budgets:

1. *Lakes dominated by surface water inflow and outflow* resulting from a large ratio of contributing surface watershed area to lake area.
2. *Lakes dominated by groundwater inflow and outflow* resulting from a smaller ratio of contributing surface watershed area to lake area (10 or less). This lake type is often landlocked with no surface outlet. Although, the lake level versus outlet elevation has not been studied for this GRAPS report. Lakes have been put into this classification solely by watershed to lake area ratio.
3. *Lakes intermediate between the first and second types*. This applies to lakes that typically have a large watershed to lake area ratio, but during times of drought, the lake level will drop below the outlet level. Groundwater often becomes a significant part of the inflow to these lakes during extended dry periods.

Only the groundwater-dominant lakes as defined in type 2 above are shown in this report (Figure 33). Ninety-eight of the 203 lakes in the Cannon River watershed have a watershed to lake area ratio of 10 or less and are considered groundwater-dependent lakes. Large-scale groundwater pumping near a groundwater dominated lake will likely have more impact than if it was near a surface water dominant lake.

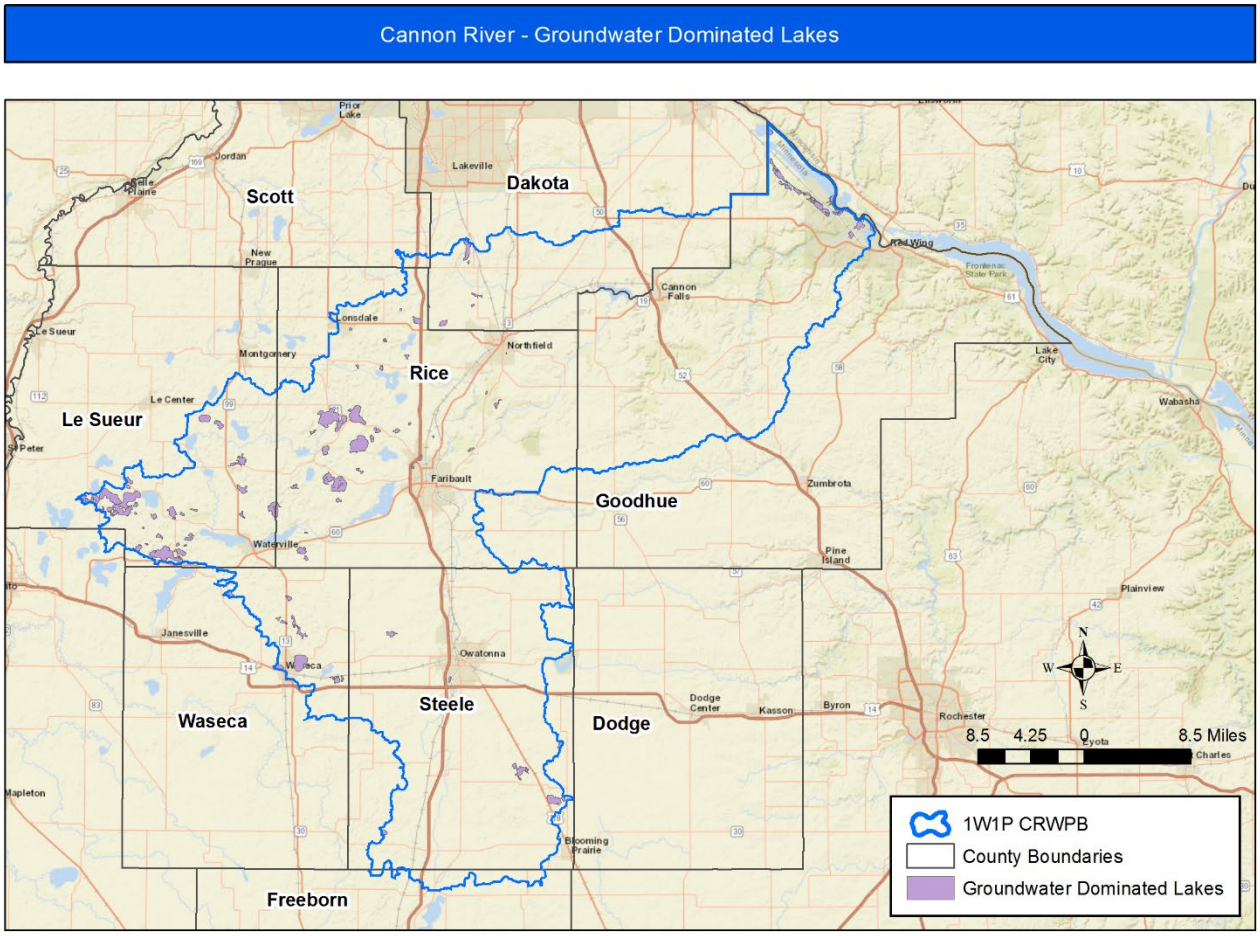

Figure 33: Cannon River Watershed Planning Boundary-Groundwater Dominated Lakes

How to Address Groundwater Quantity Issues

Most groundwater quantity (sustainability) issues are the result of overuse of groundwater and/or reduction in recharge to the underlying aquifer. Therefore, the strategies to address water quantity issues are similar, regardless of the groundwater quantity issue. The two primary goals to assure water sustainability are:

- **Water conservation:** Reduce or limit the amount of groundwater used
- **Promote or protect recharge:** Find ways for water to infiltrate back into the ground

There are a variety of strategies to help meet water conservation and recharge goals. The type of strategy used depends on the primary factor affecting quantity in the area in question. Strategies include: conservation easements, cropland management, education and outreach, irrigation water management, and land use planning and management. Table 7 provides a more comprehensive list of specific actions CRW can take to conserve water and promote recharge.

CRW Strategies and Actions to Restore and Protect Groundwater

This section provides tips for prioritizing and targeting restoration and protection strategies and makes suggestions about what strategies and actions would be most appropriate within different areas of the watershed. Information on the geological, ecological, and sociological conditions for each county and sub-watershed (HUC-10) informs which strategies and actions would be effective for each HUC-10 and county.

Tips for Prioritizing and Targeting Strategies and Actions

Determine Your Goal

You may decide to address an issue because of known instances or threats in an area, or maybe you are working in a geographic area because of jurisdiction or some other factors. The Actions and Strategies Table (Table 7) well help you focus on the goal, for instance, reducing nitrate in groundwater. Then you will need to decide, using the table, if you would like to focus on conservation easements, outreach and education, nutrient management, or some other strategy.

Match the Right Action with the Right Location

The Actions and Strategies Table (Table 7) will help you determine where the actions would be most effective. For instance, an activity that reduces nitrate in groundwater may be more valuable in sensitive areas or vulnerable wellhead protection areas. Or, if you are focused on a limited geography, the table will help you determine what actions are applicable to that area. Considering the sensitivity combined with the presence of drinking water wells and vulnerable wellhead protection areas can help further focus efforts. In another example, factors such as the presence of groundwater dependent features and a concentration of large appropriation wells can help determine where efforts to promote conservation and recharge would be most effective.

Know the Pollution Sensitivity

Groundwater quality is impacted by both point and non-point source pollution. These potential contaminant sources need to be managed according to the pollution sensitivity of the aquifer (Figure 7). Examining the sensitivity of the aquifer as it relates to contamination risk helps determine the level of management necessary to protect groundwater quality. For example, a failing septic system has a greater potential to contaminate the aquifer in a highly sensitive setting with coarse textured soils than an area with low sensitivity that has a protective soil layer that retards the movement of water into the aquifer.

Consider Multiple Benefits

Oftentimes, the restoration and protection strategies identified for both groundwater and drinking water positively influence other ecosystem services, such as surface waters, habitat, and pollinators, among others. Managing water as ‘one water’, rather than parceling it out to reflect the different aspects of water as it moves through the hydrologic cycle, allows for better planning and allocation of resources. The far right columns of the Actions and Strategies Table (Table 7) identifies the multiple benefits that could result from implementing the action.

Leverage Other Programs and Practices

Utilize existing Federal and State programs that are already working in CRW to conserve land, prevent erosion, and protect or improve surface water quality. Many of the practices that are being implemented have a benefit for groundwater. You can further target some of these efforts based on the information provided in this report to maximize the benefits by protecting groundwater. Table 7 includes a column that identifies which agencies can assist with a specific action; the listed agencies typically have some type of program in place that you can leverage. The Descriptions of Supporting Strategies section of this report lists existing programs and resources for each of the suggested strategies.

Emphasize Protection

There is often a bias in groundwater management towards strategies that emphasize protection because of the cost and difficulty in remediating contaminated resources. In contrast to surface water bodies, groundwater:

- is difficult to access;
- cannot be observed, sampled, or measured easily;
- travels slowly, often along complex pathways and through aquifer media that can absorb and store contaminants over long time periods; and
- is very difficult and expensive to treat if contaminated.

Timeframes associated with groundwater cleanup activities are often measured in decades and costs millions of dollars. Groundwater management strategies that emphasize prevention and protection are critical.

Although the tide is changing within water resources management in Minnesota, many funding streams and priorities focus on restoration activities that can show measureable outcomes. Even though it is difficult to demonstrate 'improvements' from protection strategies, it is important to stress the need to take a balanced approach and protect groundwater resources.

Strategies and Actions for CRW

This section provides a table of strategies and actions local partners in CRW can take to restore and protect groundwater resources. Many of the proposed actions require the participation of a willing landowner to execute. Other actions reflect opportunities to manage land use through local controls. Many of the proposed strategies and actions align with strategies to protect surface waters.

Each action aligns with one or more supporting strategies and goals.

- **Goals** identify how an action helps restore and/or protect groundwater.
- **Supporting Strategies** are general key approaches to achieving the goal.
- **Recommended Groundwater Action** is a specific action prescribed to a specific county or HUC-10 within the watershed that will help achieve the goal and pertains to the supporting strategy.

Figure 34 provides a visual representation of the relationship between goals, supporting strategies, and recommended groundwater actions. Note that each goal is supported by many supporting strategies, and each supporting strategy may have a variety of recommended groundwater actions.

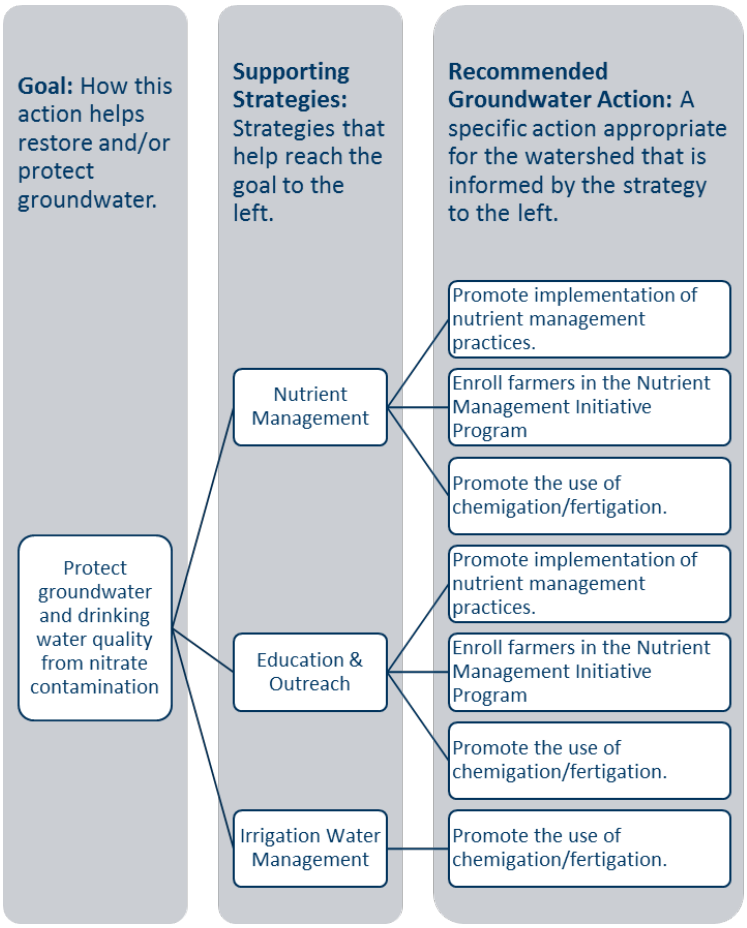

Figure 34: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 7) is designed so that you can find actions and strategies related to whatever your priorities may be when it comes to restoring and protecting groundwater. There are a variety of columns to facilitate the following:

- Finding actions for specific geographic areas (counties or HUC-10s).
- Finding actions or strategies that would help achieve a specific goal.
- Learning the additional benefits of implementing a specific action.
- Tips for determining where to target a specific action if you cannot implement the action in the entire recommended area.

The following list defines what each of the columns in Table 7 represent:

- **Goal:** How the action in this row helps restore and/or protect groundwater. The goals are sorted alphabetically as much as possible. Each goal identifies the main goal—such as whether it protects groundwater quality or sustains the amount of water available—and includes a keyword to explain how the goal is achieved. For example, a goal that is listed as 'Protect Groundwater and Drinking Water Quality: Closed Landfills' can be interpreted as: Protect groundwater and drinking water quality from landfill contamination.

- **Supporting Strategies**: Identifies and links you to general strategies that help accomplish the goal for the action in this row. Each strategy is hyperlinked to a section of the report that provides more information about the strategy and connects you with existing tools and programs that may assist you in implementing this strategy or implementing actions related to this strategy.
- **Recommended Groundwater Action**: A specific action CRW can take to help achieve the goal to the left in the row and is informed by the strategy to the left in the same row.
- **Target _____ Co.:** The 'X' denote which counties should consider using the action described in the corresponding row. An 'X' denotes the action would be most beneficial for that county. The addition of the counties helps to further prioritize and target where recommended groundwater actions should be implemented, narrowing the focus from a larger sub-watershed to a specific geographical area. For example, many of the sub-watersheds identify the need to work with irrigators; by adding the additional filter of counties, you are able to eliminate specific counties that do not have irrigators, targeting where implementation should occur. It also works as a quick reference to identify groundwater actions specific to the county in which your work.
- **HUC-10s Involved**: This column denotes which HUC-10 sub-watershed(s) within CRW should consider using the action described in the corresponding row. There are eleven HUC-10s within CRW. Table 6 provides the name and HUC-10 number assigned to each sub-watershed. Figure 35 is a map of the HUC-10s.
- **Agencies that can assist[9]:** This column lists agencies that may be able to assist with implementing the strategy through existing programs or providing more information or technical assistance.
- **Tips for Targeting & *Helpful Maps:*** This column helps identify the areas that should be targeted for the specific action if it is not feasible to implement the action in all the recommended counties or HUC-10s. The column also includes links to maps within the GRAPS report that may be helpful in identifying which specific areas within a county or HUC-10 to target. The maps are listed in *italicized font.* You can click on the *blue font* that says the figure number for the map to hyperlink directly to the map being referenced.
- **Benefit:_____ [10]:** This series of 'X's marks whether the corresponding action may have additional benefits. An 'X' denotes the action could create the described additional benefit.

[9] BWSR=Board of Soil and Water Resources; FSA=Farm Service Agency; MDA=Minnesota Department of Agriculture; MDH=Minnesota Department of Health; MPCA=Minnesota Pollution Control Agency; NRCS=Natural Resources Conservation Service; UMN=University of Minnesota Extension (*not a comprehensive list of agencies/partners*)

[10] Habitat=Improve/Protect Habitat, including pollinators; GWDF=Improve/Protect Groundwater Dependent Features; Soil Health=Improve/Protect Soil Health; Erosion=Control Erosion; Carbon=Carbon Sequestration; Nutrient Runoff=Control Nutrient Runoff, including pesticides (*The multiple benefits achieved are dependent on the placement and type of BMPs implemented; seed mixes planted; and other site conditions*).

Table 6: HUC-10 sub-watersheds within the Cannon River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Big River – Mississippi River	Big River	0704000101
Vermillion River	Vermillion	0704000102
Lower Cannon River	Lower Cannon	0704000209
Chub Creek	Chub	0704000204
Middle Cannon River	Middle Cannon	0704000206
Prairie Creek	Prairie	0704000205
Little Cannon River	Little Cannon	0704000207
Belle Creek	Belle	0704000208
Upper Cannon River	Upper Cannon	0704000201
Crane Creek	Crane	0704000202
Straight River	Straight	0704000203

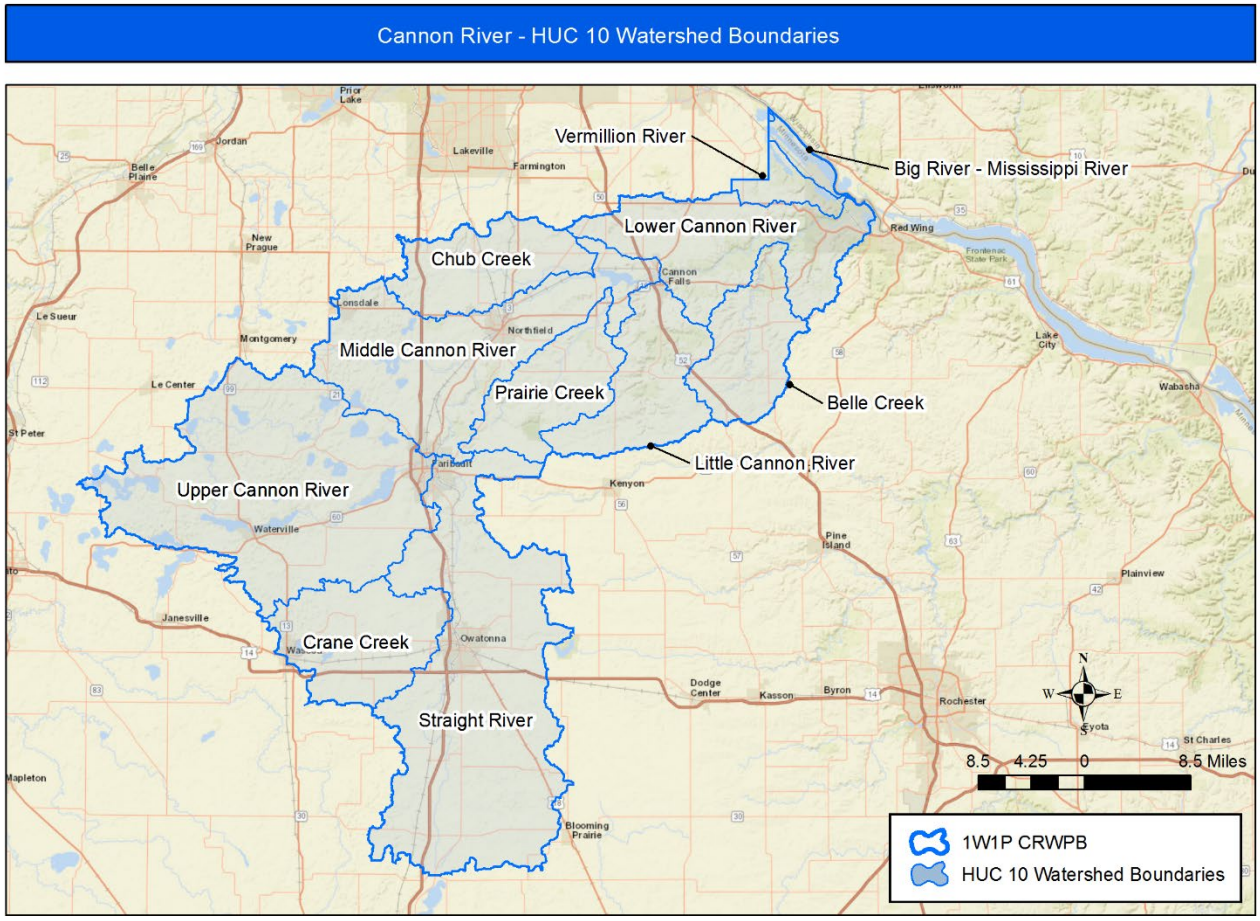

Figure 35: Cannon River Watershed Planning Boundary-HUC 10 Watershed Boundaries

Table of Actions and Strategies to Restore and Protect Groundwater

Table 7: Table of Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWCNF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
Protect Private Well Users: Arsenic	Education and Outreach	▪ Educate well users about the health risks of elevated arsenic levels in drinking water. ▪ Promote testing of private wells through education or cost share. ▪ Provide information from MDH about arsenic in Minnesota's well water to private well users to help answer health related questions and information on arsenic removal.	X	X	X	X	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells and areas with evidence of high levels of arsenic in private wells. *Arsenic Map (Figure 20)* *Well and Pumping (Figure 16)*						
Protect Private Well Users: Well Testing	Education and Outreach	Make information available to private well users about local drinking water quality and well testing. Host a well testing clinic or provide resources to well users to have their water tested.	X	X	X	X	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells, high pollution sensitivity, karst geology and/or where there are known groundwater contaminants. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *Arsenic Map (Figure 20)* *Well and Pumping (Figure 16)* *Nitrate in Wells Map (Figure 17)*						
Protect Private Well Users: Manage Wells **Protect Groundwater and Drinking Water Quality:** Manage Wells	Education and Outreach	Promote proper management of wells through MDH tools, such as the 'Well Owners Handbook' in landowner outreach efforts.	X	X	X	X	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells *Well and Pumping (Figure 16)*						
Protect Groundwater and Drinking	Education and Outreach	▪ Provide cost share to well owners for sealing of unsealed, unused wells. ▪ Provide educational materials on well sealing.	X	X	X	X	X	X	X	X	X	All	MDH	Prioritize areas with a high density of private wells and WHP areas. *Well and Pumping (Figure 16)* *Wellhead Protection Map (Figure 11)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Quality: Well Sealing													Well MGMT								
Protect Groundwater and Drinking Water Quality: Karst Sinkhole Treatment	Cropland Management	Treat karst sinkhole features to reduce the movement of contaminants into groundwater by installing a vegetative buffer around the sinkhole and managing nutrients and pesticides within the watershed that flows into the sinkhole.	X	X		X				X		Vermillion Lower Cannon Bell Little Cannon Chub Middle Cannon Prairie Upper Cannon Straight	NRCS	Prioritize areas of karst geology in agricultural settings. *Pollution Sensitivity Map (Figure 7)*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management Land Use Planning and Management	▪ Identify MPCA closed landfill location and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying the location will help assure drinking water and public health implications are considered when evaluating future growth or development near these sites. ▪ Consult and review the MPCA Closed Landfill Program to make sure any proposed changes in zoning districts or new land use planning proposals are not in conflict with the State Closed Landfill Plan.		X								Lower Cannon	MPCA CLP Land Manager	*Closed Landfill Map (Figure 24)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Contact the MPCA Closed Landfill Program for current information and any concerns or changes to the groundwater area of concern when considering land use changes or developments near the area. Request to be notified regarding any changes in the migration or movement of contaminants.																		
Protect Groundwater and Drinking Water Quality: Leaky Tanks	Contaminant Planning and Management Land Use Planning and Management	▪ Identify leaky and active tank sites in your area in comprehensive land use plans, zoning maps and ordinances. Identifying these locations will help assure drinking water and public health implications are considered when evaluating future growth or development near these sites. ▪ Contact the MPCA Tank Compliance and Assistance Program for current information and any concerns or changes to the groundwater area of concern when considering land use changes or developments near these areas. Request to be notified regarding any changes in the migration or movement of contaminants.	X	X		X				X	X	Lower Cannon Little Cannon Middle Cannon Upper Cannon Straight Crane	MPCA Tanks Program	Focus in areas with high pollution sensitivity, karst geology and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Contaminated Sites Map (Figure 23)*						
Protect Groundwater and Drinking Water Quality: Feedlots	Contaminant Planning and Management	Prioritize feedlot inspections, regardless of size, in areas of greatest risk to pollution, to minimize the loss of nitrate and harmful bacteria.	X	X	X	X	X	X	X	X	X	Lower Cannon Belle Little Cannon Chub Middle Cannon Prairie	MPCA Feedlot Program	*Focus in areas with high pollutions sensitivity, karst geology, and vulnerable DWSMAs.* *Pollution Sensitivity Map Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Active Feedlot Map (Figure 22)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
												Upper Cannon Crane Straight								
Protect Groundwater and Drinking Water Quality: Manure Management	Contaminant Planning and Management Education and Outreach Nutrient Management	▪ In delegated counties, all feedlots that apply manure in areas of high risk will conduct a Level 2 records review completed regardless of the size of facility. ▪ In delegated counties, conduct annual Level 3 review of manure acres in areas of high risk. ▪ Assist feedlot owners, especially sites with 300 or fewer animal units, in the development of a manure management plan. ▪ Host field days that promote; emergency response training, manure crediting, calibration of equipment, and the manure testing process. ▪ Evaluate local ordinances and revise to include manure timing guidelines to protect from nitrate loss. Follow the UMN Extension guidelines, including no summer application and fall application only after soil temperature is below 50 degrees.	X	X	X	X	X	X	X	X	X	Lower Cannon Belle Little Cannon Chub Middle Cannon Prairie Upper Cannon Crane Straight	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity, karst geology, and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)*			X	X		X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote implementation of nutrient management practices to improve farm profitability and reduce nitrogen loss. Practices include: ▪ Improve nitrogen efficiency by practicing the 4 R's of nitrogen stewardship (right	X	X		X	X		X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		source, right rate, right timing, and right place) ▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen for Southeastern or South Central Minnesota depending on your location. ▪ Properly credit nitrogen sources (soil/manure tests, past crops, & mineralization) ▪ Implement comprehensive nutrient management plans to improve nitrogen crediting, equipment calibration, and record keeping ▪ Spoon feed nitrogen to sync with plant growth through side dressing and split fertilizer application												*Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Map (Figure 17)*						
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Increase the number of farmers enrolled in the Nutrient Management Initiative Program to evaluate alternative nutrient management practices.	X	X		X	X		X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Map (Figure 17)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Identify programs and opportunities for growers to test and implement new nitrogen practices, innovative technology or cropping systems that protect groundwater quality that prevent or reduce nitrogen loss. (E.g. Cover Crops, Alternative Crops, Precision Ag / New Technologies, Nutrient Management Initiative, etc.)	X	X		X	X		X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)*	X		X		X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Cropland Management													*Nitrate in Wells Map (Figure 17)*							
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote the adoption of cover crops for scavenging nutrients under irrigated row crops.	X	X		X				X		Lower Cannon Chub Middle Cannon Prairie Upper Cannon Straight	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, karst geology, and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Nitrate in Wells Map (Figure 17)* *Township Testing Map (Figure 18)* *Water Use Map (Figure 16)*	X		X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water Management	Promote the use of chemigation/fertigation to synchronize nitrogen application to crop demand.	X	X		X				X		Lower Cannon Chub Middle Cannon Prairie Upper Cannon Straight	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, karst geology, and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Nitrate in Wells Map (Figure 17)* *Township Testing Map (Figure 18)* *Water Use Map (Figure 16)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management	Host an irrigation water-testing clinic to determine nitrate concentrations in raw water to calculate the irrigation water nitrogen crediting formula.	X	X		X				X		Lower Cannon Chub Middle Cannon	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, karst geology, and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
	Irrigation Water Management											Prairie Upper Cannon Straight		*Nitrate in Wells Map (Figure 17)* *Township Testing Map (Figure 18)* *Water Use Map (Figure 16)*						
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Cropland Management	Promote the benefits of farming using soil health principles that increase soil moisture holding capacity, organic matter, and nutrient cycling.	X	X		X	X		X	X	X	All	NRCS Field Office	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Irrigation Water Management Cropland Management	Contact state and federal agency resource partners and coordinate opportunities for local field days, training and outreach for farmers, co-ops, and crop consultants. Focus on irrigation management, alternative nitrogen management practices, soil health, and second crops.	X	X		X	X		X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*						
Protect Groundwater and Drinking Water Quality:	Education and Outreach	Promote the benefits of crop diversity and rotation, which include high yields for each crop in the rotation, pest and weed control, and enhanced soil fertility.	X	X		X	X		X	X	X	All	MDA Pesticide &	Focus on areas with high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program.		X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides	Cropland Management Integrated Pest Management												Fertilizer Division	*Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*						
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Provide information on best practices for turf management to the public. Include information on fertilizer application, crediting for grass clippings, lawn watering and herbicide and pesticide application.	X	X		X				X		Big River Lower Cannon Little Cannon Middle Cannon Upper Cannon Straight	UMN Lawns & Turfgrass MGMT Team	Focus in MS4 communities and residential developments with high pollution sensitivity, karst geology, along with vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)* *Pesticides Map (Figure 19)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach Integrated Pest Management	Promote the adoption and use of MDA's water quality BMPs for agricultural pesticides and insecticides.	X	X		X	X		X	X	X	All	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, karst geology, vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 19)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach	Promote to farmers and area businesses the Agricultural and Non-Agricultural Waste Pesticide Collection Program to dispose of unwanted and unusable pesticides.	X	X	X	X	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division								
Protect Groundwater and Drinking Water Quality: SSTS	SSTS Management	▪ Enforce state and locally adopted SSTS ordinances for the protection of groundwater and drinking water sources. ▪ Evaluate existing SSTS ordinances and identify opportunities to enhance groundwater protection. Activities may include adding a Point of Sale requirement to trigger a SSTS inspection during real estate transactions. ▪ Improve SSTS records by obtaining information on treatment system; age, type and function to understand potential risks to groundwater.	X	X		X	X			X	X	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, karst geology, vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Well Density Map (Figure 16)* *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)*						
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Educate citizens about SSTS including: ▪ The basic principles of how a septic system works ▪ How to operate the system efficiently and effectively ▪ Risks to human health and the environment ▪ Financial options to repair or replace failing or non-compliant system	X	X	X	X	X	X	X	X	X	All	MPCA SSTS Field Staff								
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Host local SSTS training and workshops for area contractors and citizens regarding SSTS technology, compliance, and maintenance.	X	X	X	X	X	X	X	X	X	All	MPCA SSTS Field Staff								

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Education and Outreach Cropland Management Land Use Planning and Management	Serve on wellhead protection planning teams to assist public water suppliers with planning and implementation activities to address land use planning concerns.	X	X	X	X	X		X	X	X	Lower Cannon Chub Middle Cannon Prairie Little Cannon Belle Upper Cannon Crane Straight	MDH SWP Unit	*Wellhead Protection Map (Figure 12)* *Wellhead Protection Plan Development Status (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Land Use Planning and Management	Integrate wellhead protection (WHP) plan strategies into local plans, such as the County Water Plan and land use plans.	X	X	X	X	X		X	X		Lower Cannon Chub Middle Cannon Upper Cannon Crane Straight	MDH SWP Unit	*Wellhead Protection Map (Figure 12)*						
Protect Groundwater and Drinking Water:	Education and Outreach	▪ Educate the public about the risks of improperly disposing of HHW and promote community-supported collection sites.	X	X	X	X	X	X	X	X	X	All	MPCA Hazardous Waste Program							

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Household Hazardous Waste (HHW)	Land Use Planning and Management	▪ Make disposal of HHW easy for the public by expanding collection sites through mobile units by stopping in many communities throughout the summer for free drop off. ▪ Promote other recycling options of various products at area businesses throughout the year.																		
Protect Groundwater and Drinking Water: Pharmaceuticals	Education and Outreach	Keep unused/unwanted medications out of drinking water supplies by educating the public about available safe and secure drop box locations at law enforcement facilities and pharmacies.	X	X	X	X	X	X	X	X	X	All	MPCA Hazardous Waste Program							
Protect Groundwater and Drinking Water: Contaminants of Emerging Concern (CEC)	Education and Outreach	Enhance Minnesotans' understanding of CEC's by communicating the health impacts and exposure potential of emerging contaminants in drinking water. Outreach and Education Grants are available through the MDH CEC Initiative. See Outreach and Education Grants (www.health.state.mn.us/divs/eh/risk/guidance/dwec/outreachproj.html) for opportunities.	X	X	X	X	X	X	X	X	X	All	MDH CEC Program							
Protect Groundwater and Drinking Water	Education and Outreach	Educate the public and decision makers about the hydrologic connectivity of groundwater and surface water and how this influences the vulnerability of drinking water resources.	X	X	X	X	X	X	X	X	X	All	DNR Ecological & Water Resources	Focus in areas with high pollution sensitivity and karst geology. *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)*							
Protect Groundwater and Drinking Water Quality	Education and Outreach	Develop a 'drinking water protection' page on the SWCD or county website or other communication tools that can be used to share information with citizens on what they can do to protect both public and private sources of drinking water. Include information	X	X	X	X	X	X	X	X	X	All	MDH Well MGMT & SWP Unit							

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Sustainability		about the connection between surface and groundwater, well sealing and water conservation. Dakota County's webpage Water Quality (https://www.co.dakota.mn.us/Environment/WaterQuality/WellsDrinkingWater/Pages/default.aspx) is a good example.																		
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Develop ordinances, overlay districts, performance standards, etc. to further protect drinking water and groundwater dependent features from future land use impacts for their long-term sustainability and use.	X	X		X	X	X		X	X	All	MN Assoc. of Counties	Focus in areas with high sensitivity, karst geology, vulnerable DWSMAs and groundwater connected natural features (GWCNF) *Pollution Sensitivity Map (Figure 7)* *Geologic Sensitivity Wells (Figure 10)* *DWSMA Vulnerability Map (Figure 12)* *GWCNF Map (Figure 31)*		X				
Protect Groundwater and Drinking Water Quality **Water Sustainability**	Land Use Planning and Management	Incorporate basic groundwater and drinking water information into local comprehensive plans and ordinances including: ▪ Local geology and aquifer information ▪ The sources of drinking water and the pollution sensitivity of public and private wells ▪ Maps of state approved WHP areas ▪ Groundwater dependent natural features ▪ Contaminant areas of concern ▪ Other local information needed to consider and protect groundwater and drinking water resources in local land use planning decisions	X	X	X	X	X	X	X	X	X	All	MDH SWP Unit							
Protect Groundwater and Drinking Water Quality	Conservation Easements	Enroll private lands in land acquisition programs or conservation easements. Programs may include; Continuous CRP, RIM Reserve for wellhead protection, and CREP.	X	X		X	X			X	X	All	BWSR	Prioritize areas of high pollution sensitivity, karst geology, and highly vulnerable WHP areas. Target areas of high water use, known groundwater connected natural features (GWCNF).	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Sustainability: Recharge														Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 7)* *Wellhead Protection Map (Figure 12)* *Water Use Map (Figure 16)* *GWCNF Map (Figure 31)* *RIM Easements Map (Figure 36)*						
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	Conservation Easements	Maintain and expand set-aside acres in sensitive areas, including areas in publicly supported conservation programs like CRP, from being converted to high intensity uses, such as corn and soybeans.	X	X		X	X			X	X	All	FSA	Prioritize private lands with existing CRP contracts, along with state and federal easement, such as RIM and DNR and USFW habitat easements. Target areas of known groundwater connected natural features (GWCNF), areas of high pollution sensitivity, karst geology, and highly vulnerable WHP areas. *RIM Easements Map (Figure 36)* *GWCNF Map (Figure 31)* *Pollution Sensitivity Map (Figure 7)* *Wellhead Protection Map (Figure 12)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Stormwater Management **Water Sustainability:** Recharge	Land Use Planning and Management Education and Outreach	Manage stormwater runoff to minimize adverse impacts to groundwater. Refer to the Minnesota Stormwater Manual for infiltration guidance on project sites located in wellhead protection areas and special requirements for karst geology.	X	X	X	X			X	X		Lower Cannon Chub Middle Cannon Upper Cannon Straight	MPCA MS4 Program	Prioritize MS4 communities and target highly sensitive areas, karst geology and vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*	X	X		X		X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCNF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Promote and encourage the adoption of irrigation water management BMPs that increase water conservation and decrease conditions for nitrogen loss to the root zone by utilizing: ▪ Irrigation water scheduling to control the volume, frequency, and application of irrigation water ▪ Conversion to low flow pressure irrigation nozzles ▪ Proper timing of irrigation through the use of online tools that identify local climate, growing degree days (GDD) and evapotranspiration (ET) conditions ▪ Test irrigation water and take credit for nitrate present as a fertilizer source	X	X		X				X		Lower Cannon Chub Middle Cannon Prairie, Little Cannon Straight	MDA Pesticide & Fertilizer Division	Prioritize areas of high water use intensity by agricultural irrigators, highly sensitive areas, karst geology, and vulnerable DWSMAs. *Water Use Map (Figure 16)* *Pollution Sensitivity Map (Figure 7)* *DWSMA Vulnerability Map (Figure 12)*		X		X		X
Groundwater Sustainability: Water Conservation	Education and Outreach	Provide education on water conservation practices to adopted in people's homes and businesses. Use the Met Council's Water Conservation Toolbox.	X	X	X	X	X	X	X	X	X	All	DNR Ecological & Water Resources			X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management	Assist communities serving over 1,000 people with water conservation measures outlined in their DNR municipal water supply plans.	X	X	X	X	X	X	X	X	X	All	DNR Ecological & Water Resources			X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers applying for a water appropriate permit by developing a water resource plan that identifies water conservation measures that improve water use efficiencies and reduce water demand.	X	X		X				X		Lower Cannon Chub Middle Cannon	DNR Ecological & Water Resources	Prioritize areas of high water use intensity by agricultural irrigators. *Water Use Map (Figure 16)*		X				X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target **Goodhue** Co.	Target **Dakota** Co.	Target **Scott** Co.	Target **Rice** Co.	Target **Le Sueur** Co.	Target **Blue Earth** Co.	Target **Waseca** Co.	Target **Steele** Co.	Target **Freeborn** Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: **Habitat***	*Benefit: **GWCNF***	*Benefit: **Soil Health***	*Benefit: **Erosion***	*Benefit: **Carbon***	*Ben: **Nutrient Runoff***
												Prairie, Little Cannon Straight								
Water Sustainability: Recharge **Water Sustainability:** Rare or Declining Habitats	Land Use Planning and Management	Promote and increase the adoption of recharge BMPs including wetland construction/restoration, perennial establishment, riparian buffers, and conservation easements.	X	X		X	X		X	X	X	Lower Cannon Chub Middle Cannon Prairie Little Cannon Upper Cannon Crane Straight	DNR Ecological & Water Resources	Target areas near groundwater connected natural (GWCNF)features and groundwater dominated lakes *GWCNF Map (Figure 31)* Groundwater Dominated Lakes Map *(Figure 33)*	X	X	X	X	X	X

Descriptions of Supporting Strategies

Conservation Easements

Conservation easements are a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. Easements allow landowners to continue to own and use their land. They can also sell it or pass it on to heirs. Maintaining and expanding set-aside acres, including areas in publicly supported conservation programs (like CRP) from being converted to high intensity uses, such as row crop agriculture, will help protect groundwater quantity and quality.

Existing Programs and Resources

- MDA Conservation Reserve Program (www.mda.state.mn.us/protecting/conservation/programs/ccrp.aspx): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR Reinvest in Minnesota (RIM) Wetlands Conservation Easements (www.bwsr.state.mn.us/easements/wetlands/): A program that restores wetlands and grasslands through permanent conservation easements on privately owned lands. Figure 36 shows where RIM easements are in the CRW.

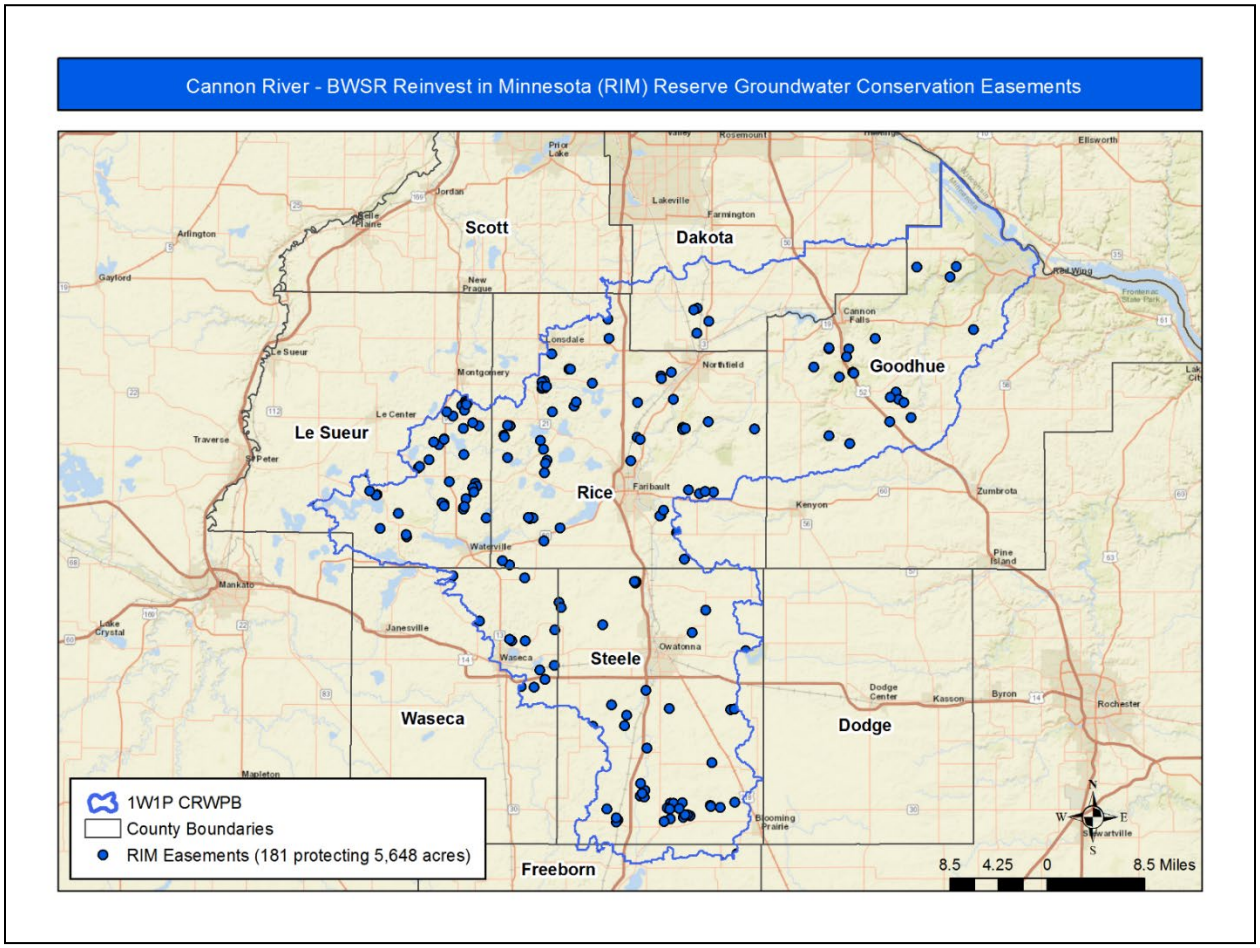

Figure 36: Cannon River Watershed Planning Boundary-RIM easements

Contaminant Planning and Management

Protect groundwater and drinking water supplies from contaminant releases in the environment through land use planning, ordinances, and collaboration with state regulatory agencies.

Existing Programs and Resources

- MDA **What's in My Neighborhood? Agricultural Interactive Mapping** (www.mda.state.mn.us/chemicals/spills/incidentresponse/neighborhood.aspx): A tool that tracks and maps spills of agricultural chemicals and sites contaminated with agricultural chemicals.
- MPCA **Manure Management** (https://www.pca.state.mn.us/quick-links/feedlot-nutrient-and-manure-management): Resources such as fact sheets, guidelines, computer tools, and forms for feedlot nutrient and manure management.
- MPCA **Tank Compliance and Assistance Program--Storage Tanks** (https://www.pca.state.mn.us/waste/storage-tanks): A program that provides information and assistance to tank owners and others regarding technical standards required of all regulated underground storage tanks and aboveground storage tank systems.
- MPCA **Closed Landfill Program** (https://www.pca.state.mn.us/waste/closed-landfill-program): A voluntary program to properly close, monitor, and maintain Minnesota's closed municipal sanitary landfills.
- MPCA **Feedlots** (https://www.pca.state.mn.us/quick-links/feedlot-program): Information about feedlot rules, permits, and management.
- MPCA **What's in My Neighborhood** (https://www.pca.state.mn.us/data/whats-my-neighborhood)**:** An online tool for searching out information about contaminated sites and facilities all around Minnesota.
- UMN Extension **Manure Management in Minnesota** (www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.
- USDA & NRCS **Manure Management in Minnesota** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.
- MDH **Contaminants of Emerging Concern** (www.health.state.mn.us/cec): A program that investigates and communicates the health and exposure potential of contaminants of emerging concern in drinking water.

Cropland Management

Voluntary practices to manage resource concerns while minimizing environmental loss. Practices may include conservation tillage, cover crops, soil health, and other agricultural BMPs.

Existing Programs and Resources

- MDA **The Agricultural BMP Handbook for Minnesota** (www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- NRCS **Conservation Stewardship Program** (www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/csp/): A voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner.
- NRCS **Environmental Quality Incentives Program** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/eqip/): A program

that provides financial and technical assistance to agricultural producers so they can implement structural and management conservation practices that optimize environmental benefits on working agricultural land.
- NRCS **Cover Crops** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/?cid=nrcs142p2_023671): Provides information, fact sheets, and tools about cover crops.
- NRCS **Karst Sinkhole Treatment** (https://efotg.sc.egov.usda.gov/references/public/MN/MN527_Karst_Sinkhole_Treatment_Sept2016.pdf)
- NRCS **Soil Health** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/soils/health/): Provides information about the basics and benefits of soil health.
- **Midwest Cover Crop Council** (mccc.msu.edu/statesprovince/minnesota/): Provides resources to help with technical support and answer questions from a local perspective for no cost.
- MDA **Minnesota Agricultural Water Quality Certification Program** (www.mda.state.mn.us/awqcp): A voluntary program for farmers to implement conservation practices to protect water quality.

Education and Outreach

Educate landowners, private well users, and other stakeholders about how their actions impact groundwater quality and quantity. Provide information about potential health risks related to groundwater quality. Identify actions individuals, households, and partner agencies can take to sustain groundwater and protect or improve drinking water quality. Some ideas include managing household hazardous waste, maintaining household septic systems, and household water conservation measures.

For educational materials and programs related to a specific topic, go to the strategy about that topic. For example, go to 'nutrient management' to learn more about potential education opportunities regarding reducing nitrogen use. The list below provides some additional tools that may be helpful.

Existing Programs and Resources

- Metropolitan Council **Water Conservation Toolbox** (https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Guidance-Planning-Tools/Water-Conservation/Toolbox.aspx): Information about how residents and businesses, suppliers, learners, and communities can conserve water.
- Minnesota Rural Water Association **Source Water Protection Resources** (www.mrwa.com/sourcewater.html): Resources to help public water suppliers develop plans to use local community resources to protect drinking water quality.
- MPCA **Waste** (https://www.pca.state.mn.us/waste): Information about managing waste, recycling, composting, and preventing waste and pollution.
- MPCA **Manual for Turfgrass Maintenance with Reduced Environmental Impacts** (https://www.pca.state.mn.us/sites/default/files/p-tr1-04.pdf): Practical advice for those who manage turfgrass (golf courses and athletic fields excluded).
- MDH Contaminants of Emerging Concern **Outreach and Education Grants** (www.health.state.mn.us/divs/eh/risk/guidance/dwec/outreachproj.html): The purpose of the grant program is to enhance Minnesotans' understanding and knowledge of contaminants of emerging concern in water that may be used for drinking.
- MDH **Wells Laws and Rules** (www.health.state.mn.us/divs/eh/wells/rules/index.html): Minnesota State Well Code (MR 4725.0050 – 4725.7605).

- MDH **Wells and Borings—Well Management Program** (www.health.state.mn.us/divs/eh/wells/index.html): Information about proper well construction, maintenance, testing, and sealing.
- MDH **Wellowner's Handbook** (www.health.state.mn.us/divs/eh/wells/construction/handbook.pdf): A consumer's guide to water wells in Minnesota.
- MDH **Arsenic in Minnesota's Well Water** (www.health.state.mn.us/divs/eh/wells/waterquality/arsenic.html): Information about arsenic in Minnesota.
- MDA **Waste Pesticide Collection Program** (https://www.mda.state.mn.us/chemicals/spills/wastepesticides.aspx): Information about the safe disposal of unwanted and unusable pesticides from farms and area businesses.
- MPCA **Managing Unwanted Medications** (https://www.pca.state.mn.us/living-green/managing-unwanted-medications)**:** Information about the safe disposal of unwanted or unused medications from households.

Integrated Pest Management

Integrated Pest Management (IPM) is a balanced approach to pest management that incorporates the many aspects of plant health care/crop protection in ways that mitigate harmful environmental impacts and protect human health. Some of the IPM program activities include generating and distributing IPM information for growers, producers, land managers, schools, and the general public. Information should help them make alternative choices in their pest management decisions.

Existing Programs and Resources

- MDA **Integrated Pest Management Program** (https://www.mda.state.mn.us/plants/pestmanagement/ipm.aspx): A program that develops and implements statewide strategies for the increased use of IPM on private and state managed lands.
- MDA **Water Quality BMPs for Agricultural Pesticides** (www.mda.state.mn.us/protecting/bmps/herbicidebmps.aspx): Information to address pesticide use and water resource protection.

Irrigation Water Management

The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner (NRCS Codes 442 & 449).

Existing Programs and Resources

- MDA **Irrigation Management** (www.mda.state.mn.us/protecting/conservation/practices/irrigation.aspx): Provides information about irrigation management, similar practices, guidance from NRCS, and links to additional resources.
- DNR **Minnesota Water Use Data** (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html)**:** Data gathered from permit holders who report the volume of water used each year.

Land Use Planning and Management

This broad strategy encompasses many different concepts including regulations, ordinances, BMP implementation, conservation measures, and education to protect groundwater levels, quality, and contributions to groundwater dependent features.

Land use planning focuses on the application of city or county government planning and regulations to restore and protect groundwater and groundwater levels. Local planning and regulations can help restrict land uses in groundwater sensitive areas, areas of high aquifer sensitivity, or regions of limited water supply to prevent conflict.

Land management implements voluntary practices that manage resource concerns while minimizing environmental loss. This may include the efficient use of groundwater through conservation measures and use of emerging technology to increase water conservation at the field or local level.

Existing Programs and Resources

- Association of Minnesota Counties (www.mncounties.org/): A voluntary, non-partisan statewide organization that helps provide effective county governance to Minnesotans. The Association works closely with the legislative and administrative branches of government in seeing that legislation and policies favorable to counties are enacted.
- DNR Water Supply Plans (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/eandc_plan.html)**:** Provides information about Minnesota public water supply plans.
- DNR MPARS (MNDNR Permitting and Reporting System) (www.dnr.state.mn.us/mpars/index.html): DNR is the permitting authority for high capacity water use.
- DNR Groundwater Management Program (www.dnr.state.mn.us/gwmp/index.html): A strategic plan to ensure that use of groundwater is sustainable and does not harm ecosystems, water quality, or the ability of future generations to meet their needs.
- DNR Sustainability of Minnesota's Groundwaters (www.dnr.state.mn.us/waters/groundwater_section/sustainability/index.html): Resources to help promote the sustainable use of groundwater, including a statement of issues and needs and factsheets.
- DNR Water Conservation (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/conservation.html): Provides tips and tools for promoting water conservation at home, public water supply systems, and other environments.
- League of Minnesota Cities (lmc.org/): Promotes excellence in local government through effective advocacy, expert analysis, and trusted guidance for all Minnesota cities.
- MPCA Condition Groundwater Monitoring (https://www.pca.state.mn.us/water/condition-groundwater-monitoring).
- MPCA Groundwater Report for the Cannon River Watershed (https://www.pca.state.mn.us/sites/default/files/wq-ws1-08.pdf): An overview of the physiography, land use, geology, and hydrogeology of the watershed.
- MPCA Stormwater and Wellhead Protection (stormwater.pca.state.mn.us/index.php/Stormwater_and_wellhead_protection): Guidance and recommendations for determining the appropriateness of infiltrating stormwater in a Drinking Water Supply Management Area.
- MPCA Minnesota Stormwater Manual (stormwater.pca.state.mn.us/index.php/Main_Page): A manual to help the everyday user better manage stormwater.

- MPCA **Enhancing Stormwater Management in Minnesota** (https://www.pca.state.mn.us/water/enhancing-stormwater-management-minnesota): Information about standards and tools for minimal impact designs for stormwater management.
- MPCA **Stormwater** (https://www.pca.state.mn.us/water/stormwater): MPCA regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems, construction activities, and industrial facilities.
- MDH **Source Water Protection** (www.health.state.mn.us/divs/eh/water/swp/): MDH works with communities to protect the source(s) of their drinking water.
- DNR and Minnesota Geological Survey **County Geologic Atlas Program** (www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html): Provides additional information on the groundwater resources and hydrogeology of the watershed through maps and reports of geology, groundwater, pollution sensitivity, and special studies.
- MPCA **Household Hazardous Waste** (https://www.pca.state.mn.us/waste/household-hazardous-waste-managers-and-operators): Resources for HHW managers and operators, education resources, searchable by county HHW facilities.

Nutrient Management

This strategy addresses both nutrient and manure management.

Nutrient management concepts are centered on applying crop fertilizer or manure using the right source, right rate, right time, and right place (NRCS Codes 327, 340, 345, 393, 590, 656).

Manure management targets the collection, transportation, storage, processing, and disposal of animal manure.

Existing Programs and Resources

- MDA **Nutrient Management** (www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt.aspx). MDA is the lead state agency for all aspects of pesticide and fertilizer environmental and regulatory functions. This page provides information on nutrient management programs, reports, publications, factsheets, and related external sources.
- MDA **Nutrient Management Initiative Program in Minnesota** (www.mda.state.mn.us/nmi): The program assists farmers and crop advisers in evaluating alternative nutrient management practices for their fields.
- MDA **Township Testing Program** (www.mda.state.mn.us/townshiptesting): The program tests private wells for nitrate and pesticides in areas of the state with the greatest potential for nitrate and pesticide contamination.
- MDA **Nitrogen Fertilizer Best Management Practices** (www.mda.state.mn.us/nitrogenbmps): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan.aspx): The state's blueprint for preventing or minimizing impacts of nitrogen fertilizer on groundwater.
- MDA **Ag Chemicals & Fertilizers** (www.mda.state.mn.us/chemicals.aspx): Promotes proper use, handling, and safety of agriculture chemicals and fertilizers.
- MDA **Monitoring & Assessment for Agricultural Chemicals in the Environment** (www.mda.state.mn.us/chemicals/pesticides/maace.aspx): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (www.extension.umn.edu/agriculture/nutrient-management/): The page focuses on helping farmers and agriculture professionals optimize crop production using appropriate nutrient inputs while minimizing effects on the environment.

- UMN Extension **Best Management Practices for Nitrogen Use in Southeastern Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08557-southeastMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Best Management Practices for Nitrogen Use in South-Central Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08554-southcentralMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Nitrogen Application with Irrigation Water: Chemigation** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/nitrogen-application-with-irrigation-water-chemigation/): Information about risks, benefits, and methods.
- UMN Extension **Crop Calculators** (www.extension.umn.edu/agriculture/nutrient-management/crop-calculators/): Use crop calculators to help determine needed nutrients.
- UMN Extension **Nutrient/Lime Guidelines** (www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/): Guidelines for corn, fruit crops, vegetables crops, lawns, turf, gardens, soybeans, sugar beets, wheat, and more.
- NRCS **Nutrient Management Planning** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023693): Information about nutrient management policy and tools for developing nutrient management plans.
- MDA **The Agricultural BMP Handbook for Minnesota** (www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- Nutrient Stewardship **What are the 4Rs** (www.nutrientstewardship.com/4rs): Information about the 4Rs of Nutrient Stewardship.
- MPCA **Manure Management** (https://www.pca.state.mn.us/quick-links/feedlot-nutrient-and-manure-management): Resources such as fact sheets, guidelines, computer tools, and forms for feedlot nutrient and manure management.
- UMN Extension **Manure Management in Minnesota** (www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.
- USDA & NRCS **Manure Management in Minnesota** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.

SSTS Management

Monitoring, maintenance, and/or upgrading of individual septic treatment systems to maintain proper operation and treatment of septage by the system. In some areas, the intensity of use may require upgrading to a sanitary sewer to eliminate risks to the environment.

Existing Programs and Resources

- MPCA **Subsurface Sewage Treatment Systems** (https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems). This program protects public health and the environment through adequate dispersal and treatment of domestic sewage from dwellings or other establishments generating volumes less than 10,000 gallons per day.
- UMN Extension **Septic System Owner's Guide** (www.extension.umn.edu/environment/housing-technology/moisture-management/septic-system-owner-guide/): Provides information about the basic principles of how a septic systems works and how to operate and maintain the system.

Making Sense of the Regulatory Environment

State agencies and programs play a variety of roles in restoring and protecting groundwater. Understanding the groundwater-related authorities and resources available at the state level and leveraging strengths of local water resource professionals are key to implementing effective groundwater protection strategies. Figure 37 provides a very basic introduction into the roles Minnesota state agencies have for groundwater.

- MDA works with groundwater that is or could be affected by pesticides and/or fertilizers.
- MDH focuses on proper well construction, assessing health risks related to groundwater, and protecting drinking water supplies.
- MPCA works with groundwater that is or could be affected by chemical releases and/or industrial pollutants.
- DNR focuses on assuring the availability of groundwater and protecting groundwater dependent features.

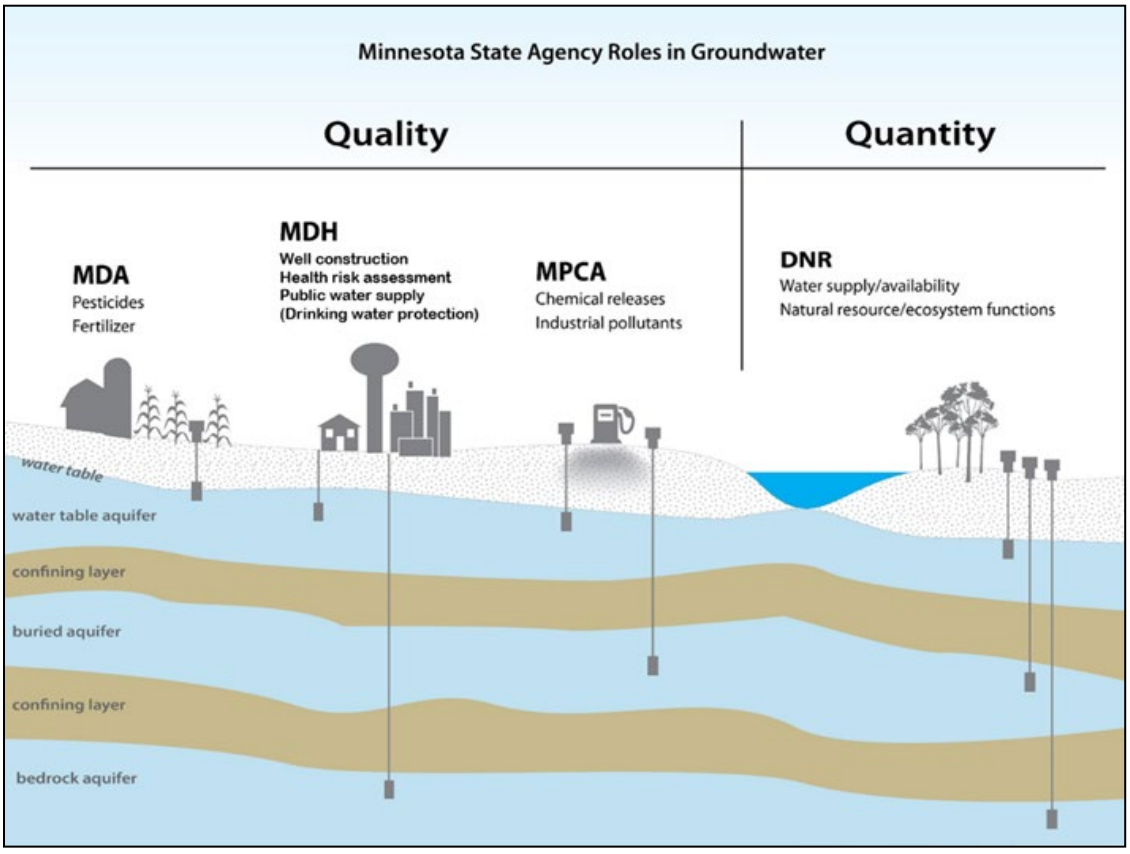

Figure 37: Minnesota State Agency Roles in Groundwater

Each of the state agencies listed above has a variety of programs to help meet their role in groundwater restoration and protection. Programs each of the agencies manage are referenced in the Descriptions of Supporting Strategies Section. Programs are listed under the restoration or protection strategy they mostly closely correspond to.

In addition to state agencies, the Metropolitan Council is the regional policy-making body, planning agency, and provider of essential services for the Twin Cities metropolitan region that informs water planning. The Metropolitan Council covers Dakota and Scott Counties within the CRW. As a result, additional resources are available for land within the Metropolitan Council jurisdiction. These resources are identified in the "additional resources" table on the following pages.

Figure 38 provides a more detailed overview of the different roles agencies play within Minnesota's Water Management Framework. Principal water resource management agencies are DNR, MPCA, MDA, BWSR, and MDH. These agencies are responsible for state or federal programs, including:

- the Clean Water Act for MPCA,
- the Safe Drinking Water Act for MDH, and
- Appropriation Permitting for the DNR.

The strength of these programs is that they provide technical assistance and regulatory oversight (including enforcement) to safeguard public health, natural resources, ecological needs, and the environment. These programs are generally effective at managing most types of point sources of contamination in the state and at managing quantity issues at the local and regional level. In addition, these programs often set standards for performance that can be used to drive action.

Two weaknesses of state or federal programs are that they (with few exceptions) are ineffective against non-point sources of contamination and lack authority relative to managing general land use practices. Non-point source management is a vexing issue for water resource managers at all levels. With few regulatory options available, the most common approaches involve the use of financial incentives, technical assistance, and education and communication about sound land and water stewardship. Seldom are representatives from state agencies able to spend the necessary time in the local community to build trust among landowners. As a result, these approaches benefit greatly from the perspectives and relationships that local water resource professionals can forge by working locally.

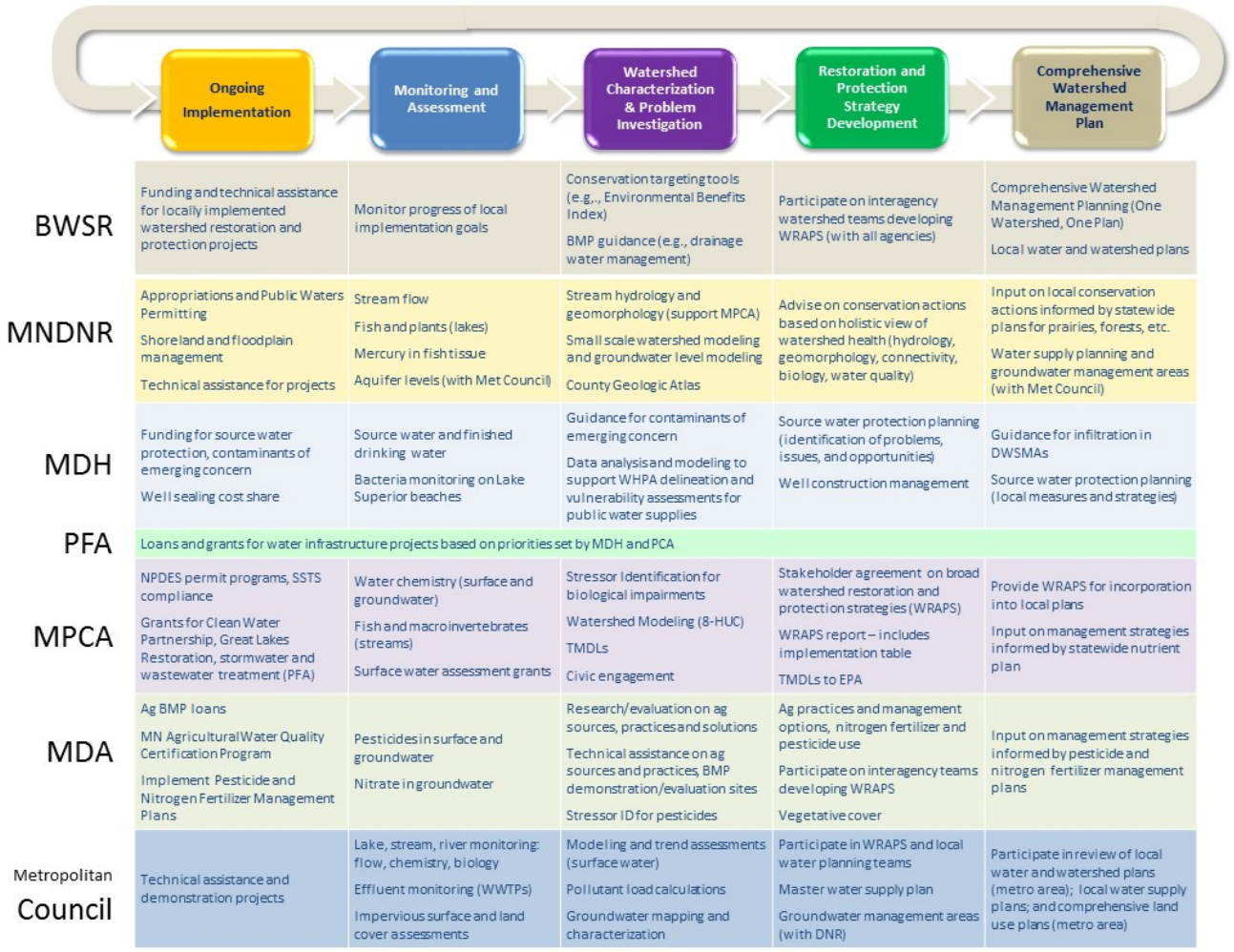

Figure 38: Roles agencies play within the Minnesota Water Management Framework

Appendices

List of Acronyms

1W1P	One Watershed One Plan
BMP	Best Management Practices
BWSR	Board of Soil and Water Resources
CAFO	Concentrated Animal Feeding Operation
CRP	Conservation Reserve Program
DWSMA	Drinking Water Supply Management Area
EPA	United States Environmental Protection Agency
GRAPS	Groundwater Restoration and Protection Strategies
HUC	Hydrologic Unit Code
IPM	Integrated Pest Management
MCL	Maximum Contaminant Level
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MWI	Minnesota Well Index
NRCS	United States Department of Agriculture Natural Resources Conservation Service
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
PFA	Public Facilities Authority
QBAA	Quaternary Buried Artesian Aquifer
QWTA	Quaternary Water Table Aquifer

RIM	Reinvest in Minnesota Program
SSTS	Subsurface Sewage Treatment System
SDWA	Safe Drinking Water Act
SWCD	Soil and Water Conservation District
TTP	MDA Township Testing Program
UMN	University of Minnesota Extension
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WIMN	What's in My Neighborhood
WHP	Wellhead Protection
WHPAS	Wellhead Protection Areas
WRAPS	Watershed Restoration and Protection Strategy

Glossary of Key Terms

Aquifer

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

Aquifer Vulnerability

Defined as the ease with which recharge and contaminants from the ground surface can be transmitted into the subsurface aquifer. MDH uses the terminology 'vulnerability'; whereas the MNDNR references 'sensitivity'. Both terms cite the risk to groundwater degradation.

Community Water System

A public water system that serves where people live. The system has at least 15 service connections or living units used by year-round residents, or regularly serves at least 25 year-round residents.

Drinking Water Supply Management Area (DWSMA)

The surface and subsurface area surrounding a public water supply well, including the wellhead protection area that must be managed by the entity identified in a wellhead protection plan. The boundaries of the DWSMA are roads, public land survey and fractions thereof, property lines, political boundaries, etc. (See MN WHP Rules 4720.5100, Subp. 13.)

Groundwater recharge

The process through which water moves downward from surface water to groundwater. Groundwater recharge is the main way water enters an aquifer.

Hydrologic Unit Code (HUC)

HUCs are assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the St. Croix River Basin is assigned a HUC-4 of 0703 and the Sunrise River Watershed is assigned a HUC-8 of 07030005.

Maximum Contaminant Level (MCL)

The highest level of a contaminant that EPA allows in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible.

Noncommunity Water System

A public water system that is not a community water supply and that serves a transient population.

Nontransient Noncommunity System

A public water system that serves at least 25 of the same people over 6 months of the year (such as schools, offices, factories, and childcare facilities).

Protection

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

Pollution Sensitivity

The ease with which recharge and contaminants from the ground surface can be transmitted into the subsurface.

Public Water System

A water system with 15 or more service connections or regularly serves at least 25 people for 60 or more days a year. A system that serves water 60 or mores day a year is considered to 'regularly serve' water. Public water systems can be publicly or privately owned. Public water systems are subdivided into two categories: community and noncommunity water systems. This division is based on the type of consumer served and the frequency the consumer uses the water.

Restoration

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

Source (or Pollutant Source)

Actions, places, or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Source Water Protection

Protecting sources of water used for drinking, such as streams, rivers, lakes, or underground aquifers.

Transient Noncommunity System

A public water system that serves at least 25 people at least 60 days of the year but does not serve the same 25 people over 6 months of the year (places such as restaurants, campgrounds, hotels, and churches).

Water Budget

An accounting of all the water that flows into and out of a particular area. This area can be a watershed, wetland, lake, or any other point of interest.

Water Table

The boundary between the water filled rock and sediment of an aquifer and the dry rock and sediment above it. The depth to the water table is highly variable. It can range from zero when it is at land surface, such as at a lake or wetland, to hundreds or even thousands of feet deep. In Minnesota, the water table is generally close to the land surface, typically within a few tens of feet in much of the state.

Wellhead Protection (WHP)

A method of preventing well contamination by effectively managing potential contaminant sources in all or a portion of a well's recharge area. This recharge area is known as the wellhead protection area.

Wellhead Protection Area (WHPA)

The surface and subsurface area surrounding a well or well field that supplies a public water system, through which contaminants are likely to move toward and reach the well or well field. This definition is the same for the federal Safe Drinking Water Act (40 Code of Federal Regulations, Section 1428) and the Minnesota Groundwater Protection Act (Minnesota Statute 103I).

Dataset Sources

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Additional Resources

The following resources may be helpful for gathering data and learning more about groundwater in the CRW. The resources are listed alphabetically by the topic they address.

Aquifer Vulnerability

For information on aquifer vulnerability ratings DWSMA, please contact MDH or the public water supplier in question.

- health.drinkingwater@state.mn.us
- 651-201-4700

Groundwater Quality Data

Find water-related monitoring data on Minnesota streams, lakes, wells, Superfund Program, closed landfills, other remediation sites, open landfills, data from MDA, MPCA, and USGS.

- Environmental Quality Information System (EQuIS) (https://www.pca.state.mn.us/quick-links/environmental-quality-information-system-equis)
- Environmental data (https://www.pca.state.mn.us/environmental-data)
- Groundwater (https://www.pca.state.mn.us/water/groundwater)

Drinking Water Annual Reports

MDH has issued a report regarding the state of drinking water in Minnesota each year since 1995. These reports provide test results, an overview on the role of the Department's drinking water program in monitoring and protecting drinking water, and an examination emerging issues.

- Drinking Water Protection Annual Reports (www.health.state.mn.us/divs/eh/water/com/dwar/)

DWSMA maps and Shapefiles

PDF maps and shape files of the DWSMAs can be downloaded from the MDH website.

- Source Water Assessments (www.health.state.mn.us/divs/eh/water/swp/swa/)
- Maps and Geospatial Data (www.health.state.mn.us/divs/eh/water/swp/maps/index.htm)

Metropolitan Council Information

The Metropolitan Council information is limited to Dakota and Scott Counties only within the CRW.

- Forecasts for population, households, and employment for 2010, 2020, 2030, and 2040 (https://metrocouncil.org/Data-and-Maps/Publications-And-Resources/Files-and-reports/Thrive-MSP-2040-Forecasts-(January-2017).aspx)
- Water Supply Plan (https://metrocouncil.org/Wastewater-Water/Publications-And-Resources/WATER-SUPPLY-PLANNING/MASTER-WATER-SUPPLY-PLAN-2015/Master-Water-Supply-Plan-Appendix-1-Communitie.aspx)

- GIS Data (https://metrocouncil.org/Data-and-Maps/Maps/Map-Gallery.aspx)
- Watershed Data (https://eims.metc.state.mn.us/)

Point Source Pollution

Visit the following sites for more information on point source pollution:

- Nonpoint Source Pollution (oceanservice.noaa.gov/education/kits/pollution/03pointsource.html)
- Point Source Pollution (www.mncenter.org/point-source-pollution.html)
- Water Permits and Forms (https://www.pca.state.mn.us/water/water-permits-and-forms)

Well Construction and Use Data

Most of the construction and use data pertaining to wells in the state is housed in the Minnesota Well Index (MWI), an online database. All of the key data in the MWI is also available in spatial datasets, designed for use in geographic information systems (GIS). The Minnesota Geological Survey and MDH work together to maintain and update the data in the Index. MWI provides basic information, such as location, depth, geology, construction and static water level, for many wells and borings drilled in Minnesota. It by no means contains information for all the wells and borings and the absence of information about a well on a property does not mean there is no well on that property.

- Welcome to the Minnesota Well Index (MWI) (www.health.state.mn.us/divs/eh/cwi/)

Wellhead Protection Plans

These plans can be obtained directly from the communities or from MDH with permission from the communities. Water chemistry data collected from these systems can be provided by request to MDH.

- health.drinkingwater@state.mn.us
- 651-201-4700

Process Flowchart for Pollution Sensitivity of Wells Figure

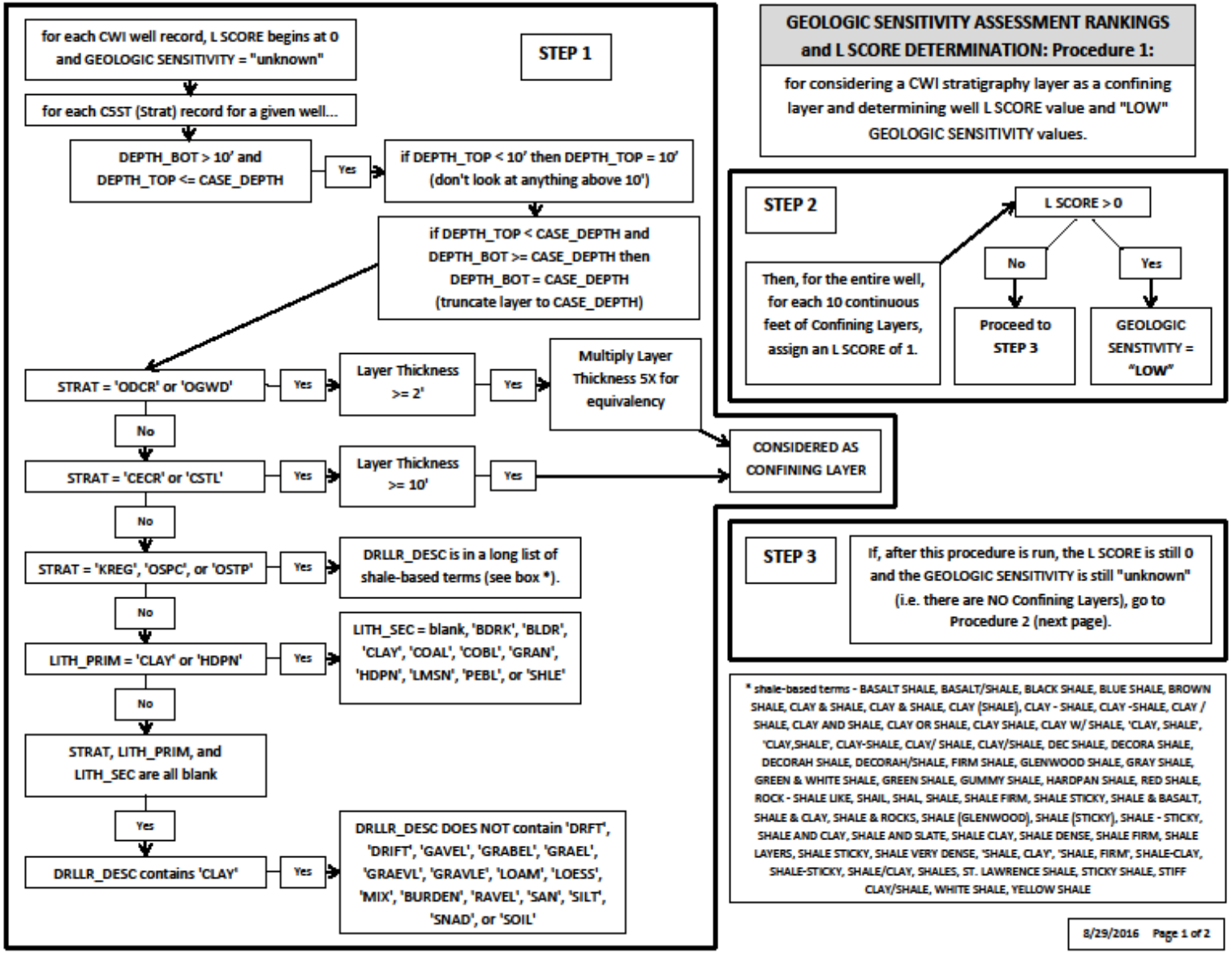
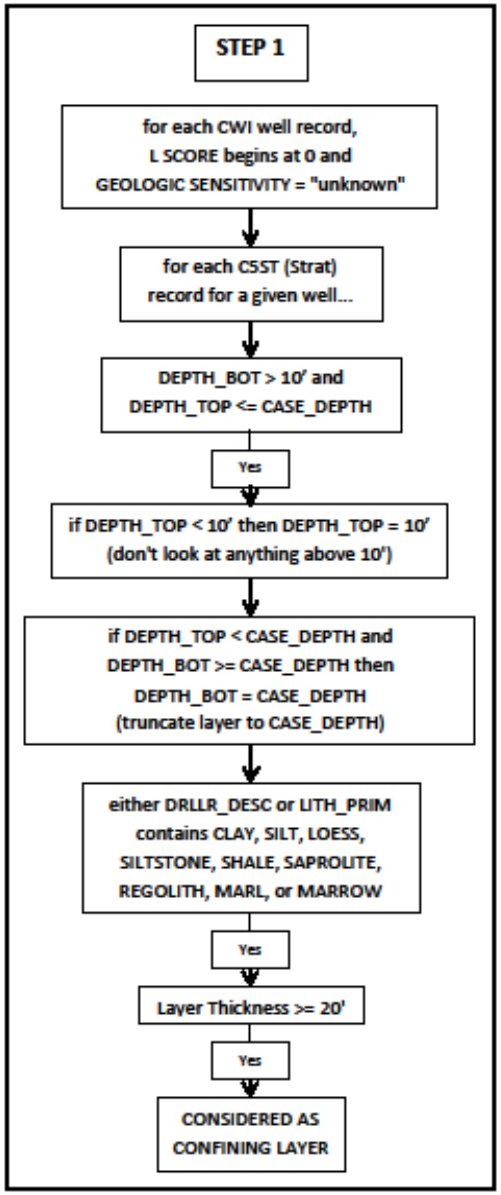


Figure 39: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 10)

Process Flowchart for the Pollution Sensitivity of Wells Figure



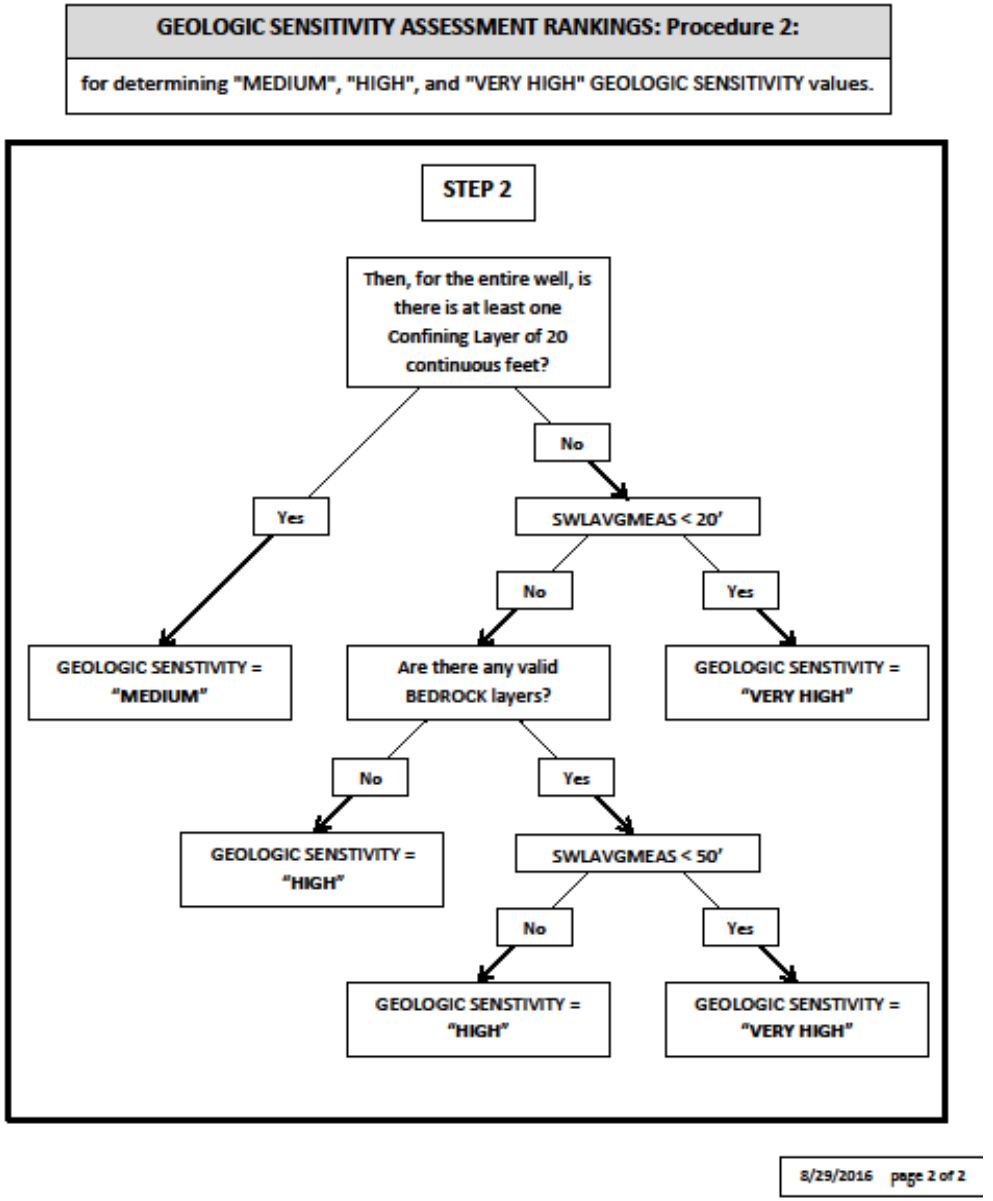


Figure 40: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 10) continued.

Table 8: Cannon River Watershed - Rare Species Associated with Groundwater in the Cannon River Watershed [11]

Scientific Name	Common Name	Species Class	Listing Status[12]	General Habitat Type
Rare Plant: *Berula erecta*	stream parsnip	Aquatic Plant	THR	Calcareous fens; alkaline springs; usually occurs in active seepage areas
Rare Plant: *Atrichum crispum*	Wave-leaved Crane's-bill Moss	Terrestrial Plant: Moss	SPC	Sandy soil along streams, roadside ditches, and the margins of swamps and marshes with shade
Rare Plant: *Carex crus-corvi*	Raven's Foot Sedge	Terrestrial Plant	Watch list	Wetland habitats and along floodplains
Rare Plant: *Carex sterilis*	Sterile Sedge	Terrestrial Plant	THR	Calcareous fens that are mineral rich
Rare Plant: *Cypripedium candidum*	Small White Lady's-slipper	Terrestrial Plant	SPC	Calcareous seeps; wet prairie
Rare Plant: *Valeriana edulis var. ciliata*	Valerian	Terrestrial Plant	THR	Moist, sunny, calcareous fens, springs, seeps
Rare Plant: *Oxypolis rigidior*	Cowbane	Terrestrial Plant	Watch list	Calcareous fens, wet prairies, sedge meadows, swamps, and marshes
Rare Plant: *Rubus stipulatus*	Big Horseshoe Lake Dewberry	Terrestrial Plant	END	Wet meadow/carr
Rare Animal: *Actinonaias ligamentina*	Mucket	Mussel	THR; SGCN	Medium to large rivers with sand and gravel substrates
Rare Animal: *Alasmidonta marginata*	Elktoe	Mussel	THR; SGCN	Medium to large rivers with sand

[11] Updated 5/30/2017

[12] END =State Endangered; THR = State Threatened; SPC = State Special Concern; Watch list = Species the DNR is tracking because they are in suspected decline SGCN= Species of Greatest Conservation Need

Scientific Name	Common Name	Species Class	Listing Status[12]	General Habitat Type
				and gravel substrates
Rare Animal: *Elliptio dilatata*	Spike	Mussel	THR; SGCN	Small to large rivers; Reservoirs and lakes
Rare Animal: *Lasmigona compressa*	Creek Heelsplitter	Mussel	SPC; SGCN	Creeks, small rivers, and the upstream portions of large rivers with sand, fine gravel, or mud substrates
Rare Animal: *Obovaria olivaria*	Hickorynut	Mussel	Watch List; SGCN	Large rivers with sand and gravel substrates
Rare Animal: *Pleurobema sintoxia*	Round Pigtoe	Mussel	SPC; SGCN	Medium to large rivers with sand, gravel, or mud substrates
Rare Animal: *Venustaconcha ellipsiformis*	Ellipse	Mussel	THR	Gravel riffles in headwaters and silty areas of stream banks
Rare Fish: *Clinostomus elongatus*	Redside Dace	Fish	SPC	Small streams with shade
Rare Fish: *Etheostoma microperca*	Least Darter	Fish	SPC; SGCN	Freshwater streams and lakes with excellent water clarity; prefer pools with dense aquatic vegetation
Rare Fish: *Lethenteron appendix*	American Brook Lamprey	Fish	Watch list	Small to medium rivers
Rare Fish: *Notropis anogenus*	Pugnose Shiner	Fish	THR; SGCN	Glacial lakes and streams with good water clarity and an abundance of submerged vegetation
Rare Fish: *Notropis nubilus*	Ozark Minnow	Fish	SPC	Slow currents near gravel and pebble riffles in the Zumbro, Root, Cedar Rivers and tributaries
Rare Fish: *Opsopoeodus emiliae*	Pugnose Minnow	Fish	Watch list	Rivers and shallow lakes with slow, clear water

Scientific Name	Common Name	Species Class	Listing Status[12]	General Habitat Type
Rare Animal: *Lithobates catesbeianus*	Bullfrog	Amphibian	Watch list	Lakes, ponds, rivers, and bogs
Rare Animal: *Coluber constrictor*	North American Racer	Reptile	SPC; SGCN	Forested hillsides, bluff prairies, grasslands, and open woods
Rare Animal: *Crotalus horridus*	Timber Rattlesnake	Reptile	THR	Forested bluffs, south-facing rock outcrops, and bluff prairies; particularly in the Mississippi River valley
Rare Animal: *Emydoidea blandingii*	Blanding's Turtle	Reptile	THR; SGCN	Wetland complexes, small streams, and adjacent uplands, typically, but not always mapped as sandy soils
Rare Animal: *Glyptemys insculpta*	Wood Turtle	Reptile	THR	Forested riverine systems and well-drained soils
Rare Animal: *Pantherophis ramspotti*	Western Fox Snake	Reptile	Watch List	Woodland and woodland edges, prairies, lowland meadows, and rocky outcroppings near rivers
Rare Animal: *Pituophis catenifer*	Gopher Snake	Reptile	SPC; SGCN	Dry sand prairies or bluff prairies
Rare Animal: *Grus canadensis*	Sandhill Crane	Bird	Watch list	Open prairies, grasslands, and wetlands
Rare Animal: *Parkesia motacilla*	Louisiana Waterthrush	Bird	SPC; SGCN	Mature, riparian forests
Rare Animal: *Colonial Waterbird Nesting Area*	Colonial Waterbird Nesting Site	Grouping of a variety of nesting bird species		Large, shallow lakes; marsh complex

Tables 9-11[13] show the documented wetland native plant communities connected to groundwater in the CRW.

Table 9: Cannon River Watershed – Wetland Native Plant Communities Dependent on Sustained Groundwater Discharge

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Fens and Seepage Wetlands:		
OPp93c	Calcareous Fen (Southeastern)	S1=Critically Imperiled
WMs83a	Seepage Meadow/Carr	S3=Vulnerable to Extirpation
WMs83a1	Seepage Meadow/Carr, Tussock Sedge Subtype	S3

Table 10: Cannon River Watershed - Documented Wetland Native Plant Communities Dependent on Groundwater Associated with Consistently High Water Tables

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
WFs57	Southern Wet Ash Swamp	SNR= State Not Ranked
FPs63a	Tamarack Swamp (Southern)	S2S3= Imperiled or Vulnerable to Extirpation
Wet Meadows/Wet Prairies		
OPn92a	Graminoid Rich Fen (Basin)	S4=Apparently secure
WPs54b	Wet Prairie (Southern)	S2
Marshes		
MRn83	Northern Mixed Cattail Marsh	SNR
MRn83a	Cattail - Sedge Marsh (Northern)	S2
MRn93	Northern Bulrush-Spikerush Marsh	SNR
p	Bulrush Marsh (Northern)	S3
MRn93b	Spikerush - Bur Reed Marsh (Northern)	S2
MRp93b	Spikerush - Bur Reed Marsh (Prairie)	S1

Table 11: Cannon River Watershed - Documented Wetland Native Plant Communities Dependent on Groundwater Associated With Water Tables That Are High For Some Part of The Growing Season

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
FFs59	Southern Terrace Forest	SNR
FFs59a	Silver Maple - Green Ash - Cottonwood Terrace Forest	S3
FFs59c	Elm - Ash - Basswood Terrace Forest	S2
FFs68a	Silver Maple - (Virginia Creeper) Floodplain Forest	S3
Wet Meadows/Wet Prairies		
WMn82a	Willow - Dogwood Shrub Swamp	S5
WMn82b	Sedge Meadow	S4 or S5= Apparently secure or Abundant

[13] Updated 5/30/2017

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
WMn82b1	Sedge Meadow, Bluejoint Subtype	S5
WMn82b2	Sedge Meadow, Tussock Sedge Subtype	S4
WMn82b4	Sedge Meadow, Lake Sedge Subtype	S5

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