Sauk River Watershed (SRW)

Groundwater Restoration and Protection Strategies Report

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GRAPS Report #7

MINNESOTA

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Contributors

The following agencies dedicated staff time and resources toward the development of the Sauk 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)

Photo Credit: The photo on the front page is in Stearns County in the Sauk River Watershed and is courtesy of the Stearns County Soil and Water Conservation District.

Summary

Groundwater is an important resource in the Sauk River Watershed (SRW). Groundwater accounts for 89 percent of reported water use in most years. More than 28 percent of groundwater withdrawn is for public water supply use, with nearly 57 percent used for agricultural irrigation. In addition, groundwater accounts for 100 percent of the region's drinking water, except for the City of St. Cloud that uses the Mississippi River as its water source. It is important to make sure that adequate supplies of high quality groundwater remain available for the region's residents, businesses, and natural resources.

The SRW depends on the sand and gravel aquifers, both surficial (water table) and buried (confined) for drinking water. These aquifers are shallower and have a greater risk to pollution when lacking a sufficient confining layer.

Groundwater has a greater risk to contamination in areas of high pollution sensitivity[1]. A large band of 'high' pollution sensitivity extends through the middle part of the watershed, typically along the Sauk River and its tributaries and in the southeastern portion of the watershed. Understanding pollution sensitivity is a key consideration to prevent groundwater pollution. Many land-use activities (including row crop agriculture, stormwater, septic systems, and tanks/landfills) within the watershed could contaminate groundwater if pollutants are not carefully managed, especially in areas of high pollution sensitivity.

Contamination, both naturally occurring and from human activity, is present in parts of the watershed groundwater, specifically:

- **Arsenic** – almost 32 percent of the tested wells have elevated arsenic with approximately eight percent exceeding the Safe Drinking Water Act (SDWA) of 10 µg/L. 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.
- **Nitrate** – almost two percent of tested drinking water wells had levels at or above the SDWA standard of 10 mg/L. Shallow wells, less than 50 feet deep, had approximately seven percent of samples exceed the SDWA standard.
  - MDA ambient monitoring wells recorded nitrate results ranging from 12.5 mg/L to 50.7 mg/L in the surficial aquifer. All samples exceeded the SDWA standard.
  - MDA Township Testing Program (TTP) sampled almost 2700 drinking water wells for nitrate in 18 townships in the SRW. Nitrate exceedances were most prevalent in Stearns County where row crop production combined with vulnerable geology has resulted in samples exceeding the SDWA standard.
  - MPCA ambient monitoring wells detected nitrate at seven of the 8 monitoring wells and in 71.2 percent of all samples. Six percent of the detections exceeded the SDWA standard.
- **Pesticides** were detected in all nine MDA monitoring wells, but not at concentrations above human-health based drinking water standards or reference values.
- **Contaminated sites –** Over one quarter of all registered tanks are leaking chemicals into the environment and have the potential to cause localized groundwater pollution.
  - Two closed landfills with known groundwater contamination plumes are found within the watershed.

These contaminants can affect both private wells and public water systems when levels exceed drinking water standards. Some of the public water systems have water quality issues in their untreated source

[1] Areas of high pollution sensitivity allow the rapid downward movement of water into surficial sands (water table) aquifers, increasing the risk for groundwater contamination from surface pollutants.

water that requires either blending or treating the water to meet SDWA standards. About 60 percent of the people living in the watershed get their drinking water from a public water supply system. Wellhead Protection Plans have been developed for most of the community public water suppliers in the SRW and identify land use protections strategies for the approximately 50,011 acres in Drinking Water Supply Management Areas (DWSMAs).

Groundwater is sourced from sand and gravel aquifers, both surficial (water table) and buried (confined). The crystalline bedrock in this area is not used as an aquifer source due to low yield. All calculated trends from observation wells in the SRW were no trend, indicating water use has remained consistent over the period of record. Groundwater levels generally follow multiyear cycles that correlate with precipitation. There is also seasonal variation that is likely due to pumping. The surficial (water table) aquifer water levels vary over approximately a 5-foot range and the buried (confined) sand aquifer levels vary over a 10-foot range.

Activities on the land surface 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.

The SRW includes significant natural features, including surface waters that depend on groundwater to sustain them. If groundwater quantity or quality is degraded, these resources are at risk. The following features occur within the watershed:

- Three designated calcareous fens (Spring Hill Fen, Big Lake SW, and Roscoe North) and five designated trout streams.
- Two-hundred-six of the 423 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes, susceptible to changing aquifer levels.
- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Twenty-three kinds of native plant communities and 11 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater that are at risk to changing aquifer levels and degraded groundwater quality.

To address risks both from groundwater overuse and from the introduction of pollutants, this report outlines a broad range of strategies that can be implemented, as well as specific actions that individuals, local government, and other partners can take. The nine categories of strategies highlighted below were selected to address the key risks to groundwater and drinking water within the 1W1P planning area. Additionally, BWSRs Working Lands Initiative studied part of the SRW to identify land management alternatives to address water quality concerns. Areas of higher pollution sensitivity are often an appropriate place to prioritize pollution prevention activities.

1. **Education and Outreach:** Educate landowners, private well users, and others about how their actions affect groundwater and how they can conserve, restore, and protect groundwater.
2. **SSTS Management:** Monitor, maintain, and/or upgrade SSTS to ensure proper operation and treatment.
3. **Irrigation Water Management:** Control the volume, frequency, and application rate of irrigation water to sustain groundwater.
4. **Land Use Planning and Management:** Use city or county government planning and regulations along with land management goals that implement best management practices (BMPs), conserve water, and educate stakeholders to protect groundwater levels, quality, and contributions to groundwater dependent features.
5. **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.
6. **Conservation Easements:** Maintain and expand the amount of land protected from being converted to high intensity uses, such as row crop agriculture.

7. **Cropland Management:** Encourage the implementation of voluntary practices to manage resource concerns while minimizing environmental loss.
8. **Nutrient Management:** Assure that application of crop fertilizer or manure follows guidelines for the right source, right rate, right time, and right place.
9. **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.

This GRAPS report was designed to help prioritize and target local efforts to restore and protect groundwater resources in the watershed. Representatives from BWSR, MDA, MDH, DNR, and MPCA compiled existing state and regional data, and developed maps to establish a baseline understanding of groundwater conditions and associated resource management concerns for the 1W1P planning boundary. The team highlighted strategies and supporting actions that can be applied at a county or watershed-level to help restore and protect groundwater. To target local implementation, actions listed in this report are paired with those counties and subwatersheds (HUC-10) where risks have been identified. 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.[2]

[2] It is important to note that groundwater science lacks the predictive tools available for surface water analysis and as such cannot provide quantifiable strategies commonly found in WRAPS. BWSR recognizes this challenge and has provided guidance in the Setting Measurable Goals document (www.bwsr.state.mn.us/planning/1W1P/Setting_Measurable_Goals.pdf) to meet the 1W1P measurability requirement.

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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[3]. Major watersheds are denoted by an 8-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).

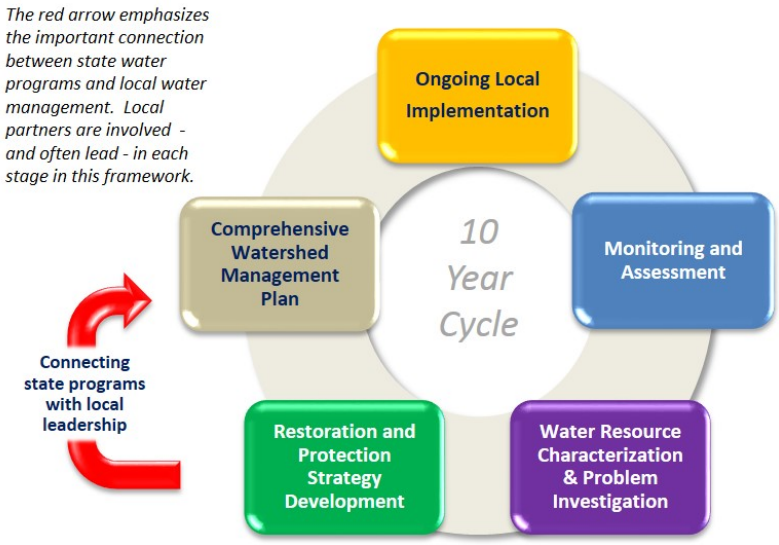

Figure 1: Watershed Approach Framework

Groundwater Restoration and Protection Strategies (GRAPS) reports are designed to help prioritize and target local efforts to restore and protect groundwater resources in the One Watershed One Plan (1W1P) planning process. 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 groundwater. GRAPS reports are meant to be used in conjunction with Watershed Restoration and Protection Strategies (WRAPS) reports in the development of 1W1P plans. WRAPS inform how to restore and protect surface water, and GRAPS inform how to restore and protect groundwater in the same geographic area.

WRAPS is initiated through an intensive monitoring effort to determine if a surface water body is meeting its designated use. WRAPS identify actions and the rate of adoption needed to restore water quality, as well as recognizing protection based activities to maintain the health of high quality surface waters. GRAPS 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

[3] 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).

address the issue can result in restoration as well as protection. In most cases it is very difficult determine the rate of BMP adoption needed to restore groundwater, therefore quantification is not 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 six parts to accommodate the different needs and information partners and agencies may seek. This report is not necessarily designed to be read cover to cover. Rather, you can flip to the parts that are most relevant to the issues facing your community. If you are accessing this document electronically, you can click on hyperlinks throughout the report to jump to related information and/or access webpages (all hyperlinks are in blue type).

The report is divided into the following parts:

1. Watershed Overview: This section provides a brief overview of the watershed.
2. Watershed 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. Watershed 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 subwatersheds, 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

Sauk River Watershed 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 Sauk River Watershed (SRW) groundwater quality and quantity. You can find more detailed information about the SRW and groundwater through the following resources:

Restoration and Protection Plans

- MPCA Sauk River Watershed WRAPS (https://www.pca.state.mn.us/water/watersheds/sauk-river)

The Sauk River Watershed (070102020) encompasses 667,749 acres in central Minnesota within the Mississippi River Basin. The watershed includes portions of Douglas, Todd, Pope, Meeker, and Stearns counties (Figure 2). There are several municipalities in the watershed of which the city of St. Cloud is the largest. This central portion of the watershed has seen a population increase of ten percent between 2000 and 2010.

Of the roughly 58,896 people living in the watershed, approximately 35,526 (60 percent) utilize community public water and the remaining 40 percent obtain their drinking water from private wells.

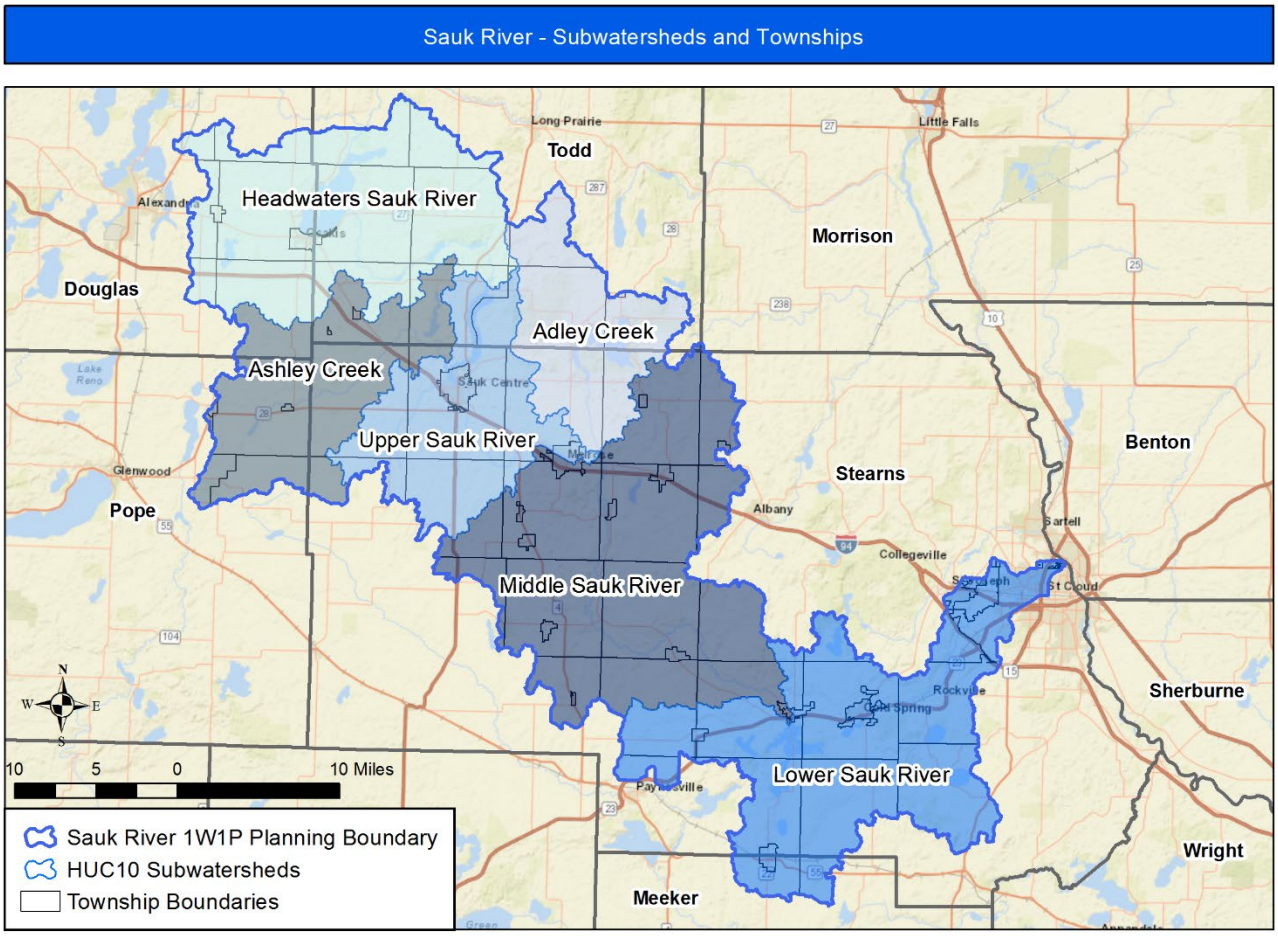

Figure 2: Sauk River Watershed – Six Subwatersheds (HUC-10): Headwaters-Sauk River, Ashley Creek, Adley Creek, Upper Sauk River, Middle Sauk River, Lower Sauk River

Land Use

The headwaters of the watershed is primarily agricultural with wetland areas and spotted with forests (Figure 3 and Figure 4). The middle of the SRW, row crops with artificial drainage begin to dominate the landscape, along with feedlots. The lower stretch of the watershed becomes increasingly urbanized as it meanders through several small municipalities and eventually through the city of St. Cloud where it converges with the Mississippi River.

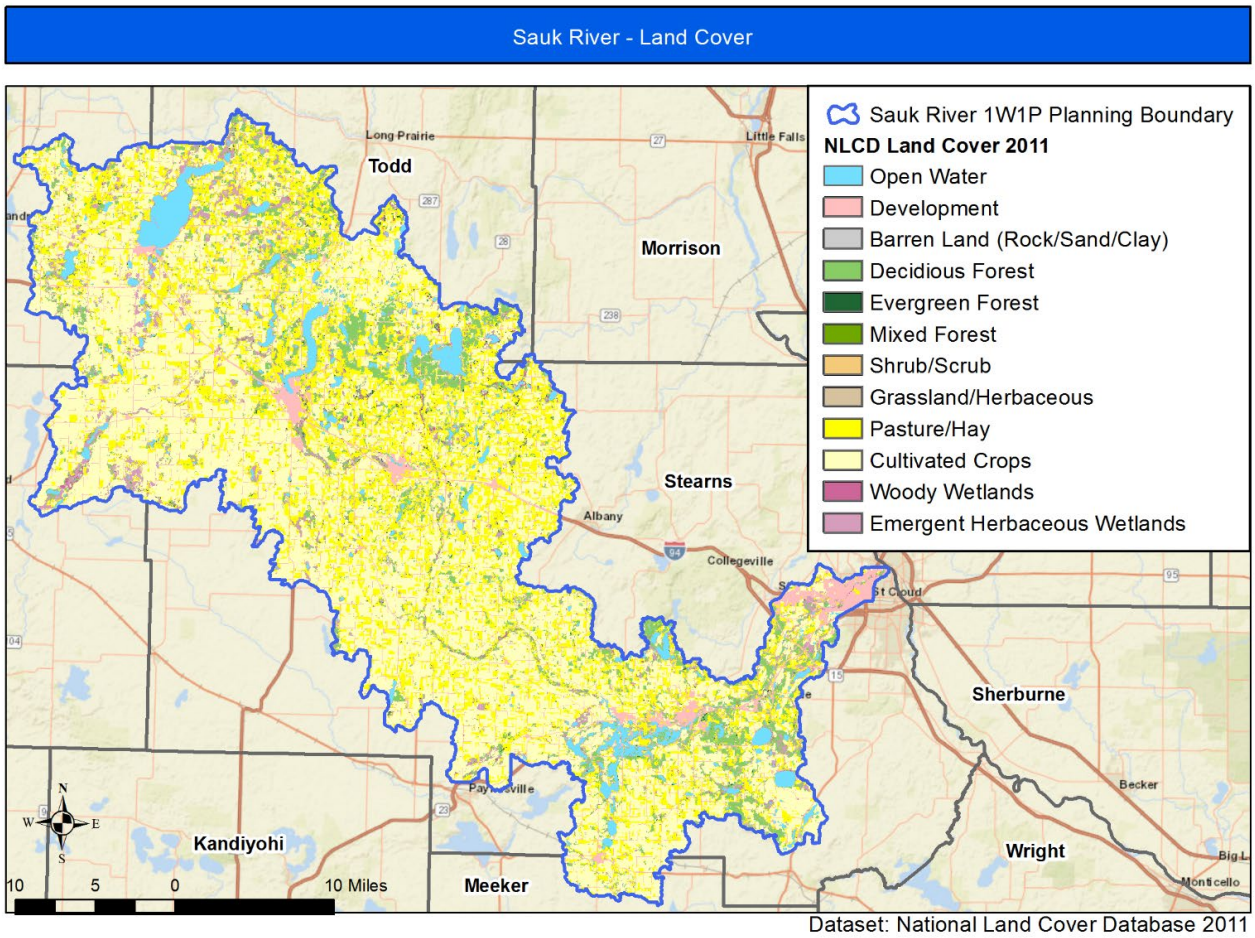

Figure 3: Sauk River Watershed - Land Cover

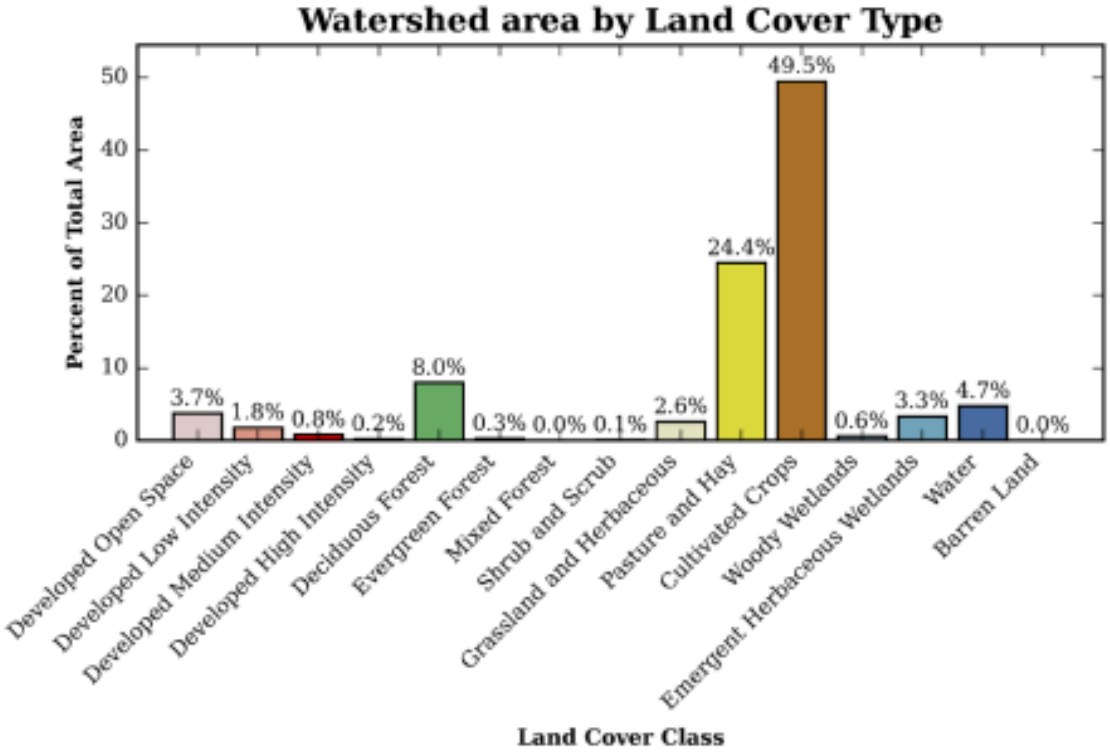

Figure 4: A summary of land cover type in the Sauk River Watershed

Geology and Hydrogeology

Groundwater sources within the SRW vary according to the underlying geology. The geology in the SRW is the result of complex processes, which occurred from igneous, metamorphic, sedimentary and glacial action that took place in the region over several geologic time periods. Figure 5 depicts a generalized map of aquifers in the watershed.

There are three main types of aquifers in the watershed (Figure 5):

- Surficial (unconfined) sand and gravel aquifers derived from glacial outwash material. These units are depicted in yellow on Figure 5.
- Buried (confined) sand and gravel aquifers enclosed in glacial till. These units serve as the major aquifers in the watershed and are depicted in blue on Figure 5.
- Cretaceous and pre-Cambrian bedrock aquifers are also utilized for water supply within the SRW and consist mainly of sandstone, siltstone and shale. These aquifers are of limited extent are not considered major aquifers in the region.

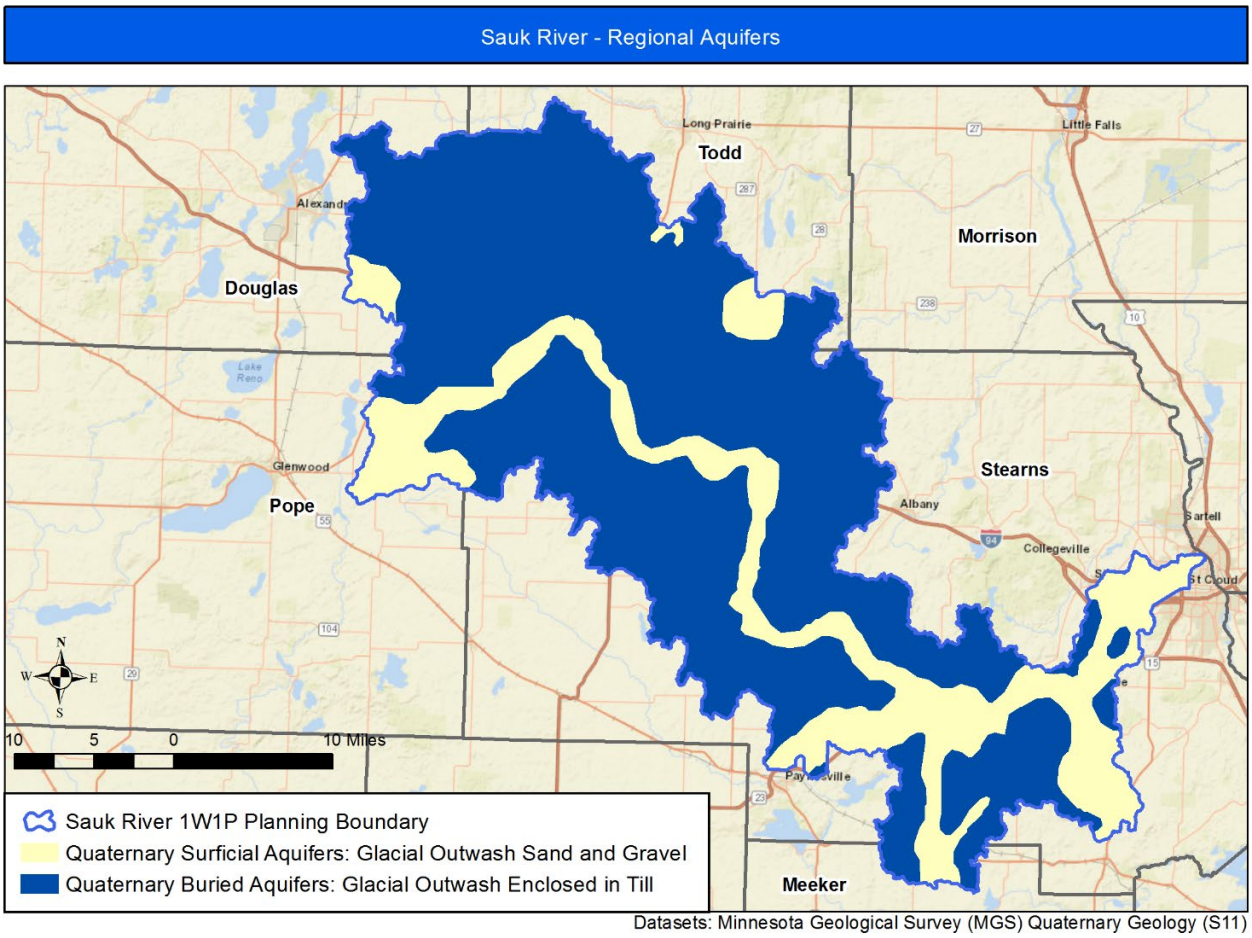

Figure 5: Sauk River Watershed - Regional Aquifers: Surficial sand and gravel aquifers; buried sand and gravel aquifers.

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. Certain aquifers may be deeper and more geologically protected than water table aquifers, or surficial sand aquifers, in a given area. Figure 7 depicts the pollution sensitivity of near-surface materials dataset 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 the watershed has a mix of pollution sensitivity ratings based on surficial materials. Much of the watershed has a pollution sensitivity of 'low', but spans of 'high' pollution sensitivity exist, particularly in areas where glacial outwash is the predominant type of geomorphology. These areas also coincide with the surficial aquifers in the watershed. More information on this dataset can be found on the DNR website Minnesota Hydrogeology Atlas (MHA) (http://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 9 was created by calculating the sensitivity at individual wells in the watershed and then interpolating 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 employed due to the absence of an available statewide dataset depicting pollution sensitivity, or vulnerability, of aquifers. This figure shows

that the watershed has a predominantly 'low' pollution sensitivity rating. Small patches of 'moderate' and 'high' pollution sensitivity exist throughout the center of the watershed, as well as in the eastern end in Stearns County, and the western portion of the watershed in Pope County. Similar to Figure 7, the ratings of 'moderate' and 'high' tend to be associated with the glacial outwash units in the SRW. More information on the geologic sensitivity calculations used to make this figure is included in the references section of this report as Figure 37and Figure 38.

It is also important to understand how recharge travel time ratings (Figure 7 and Figure 9) for surficial water table aquifers differ from those used for deeper aquifers (Table 1). For example, a pollution sensitivity rating of 'moderate' for surficial materials reflects vertical travel times on the order of weeks (Figure 7); 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 infiltrating water and contaminants reach surficial materials more quickly than deeper 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.

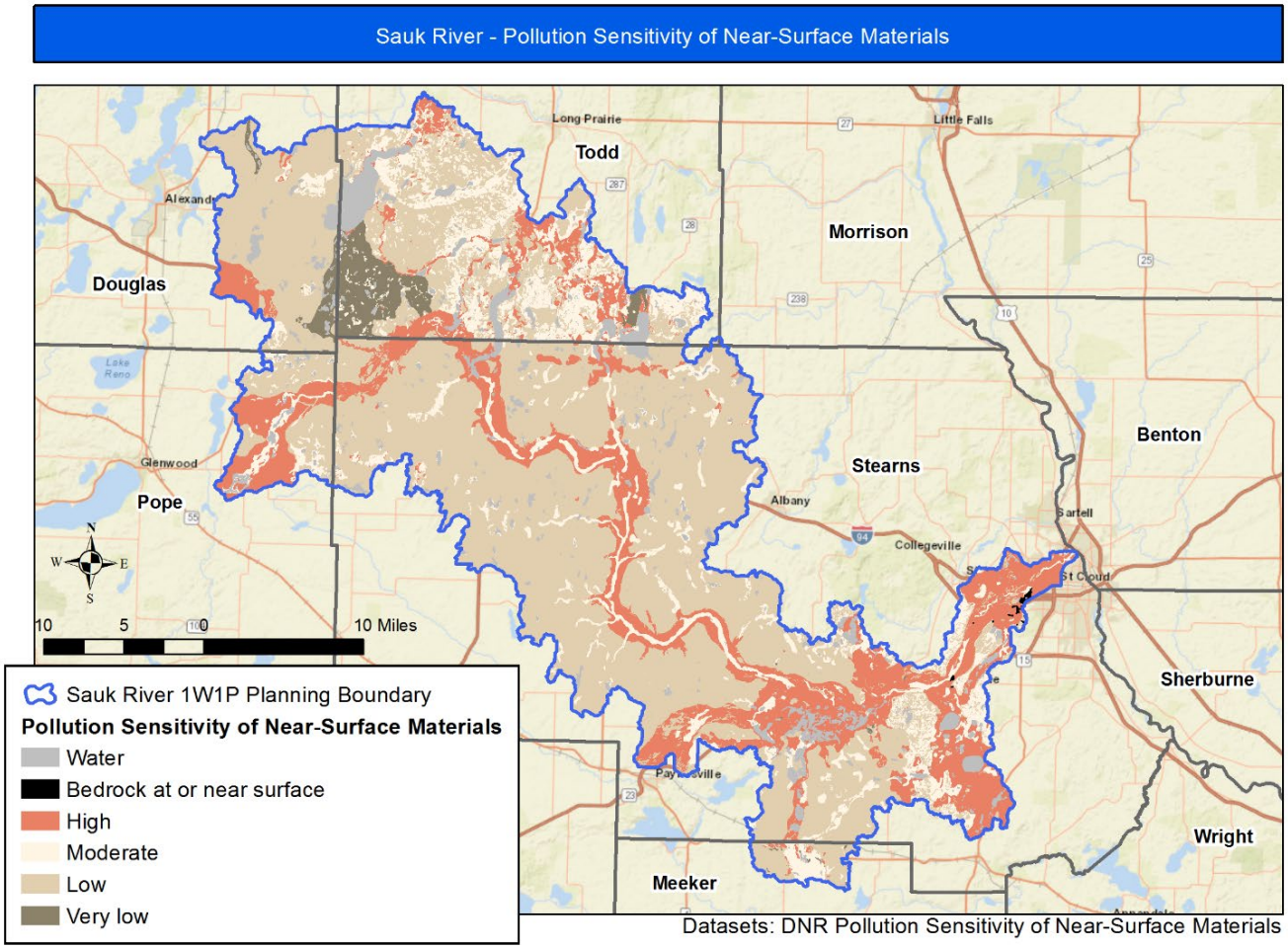

Figure 6: Sauk River Watershed - Pollution Sensitivity of Near Surface Materials

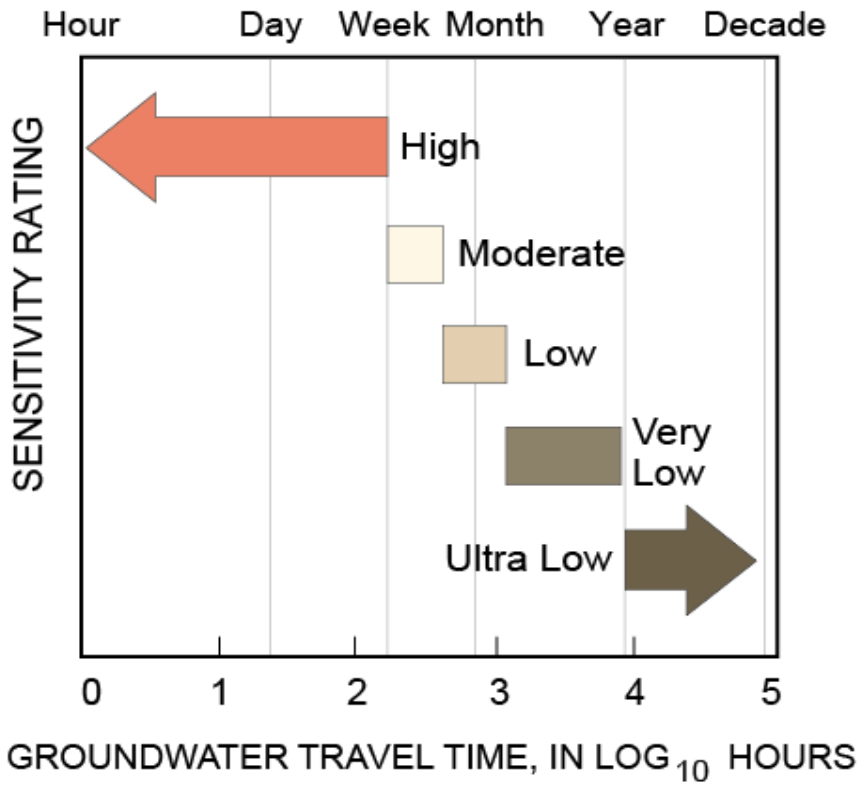

Figure 7: Recharge Travel Time for Near-Surface Materials

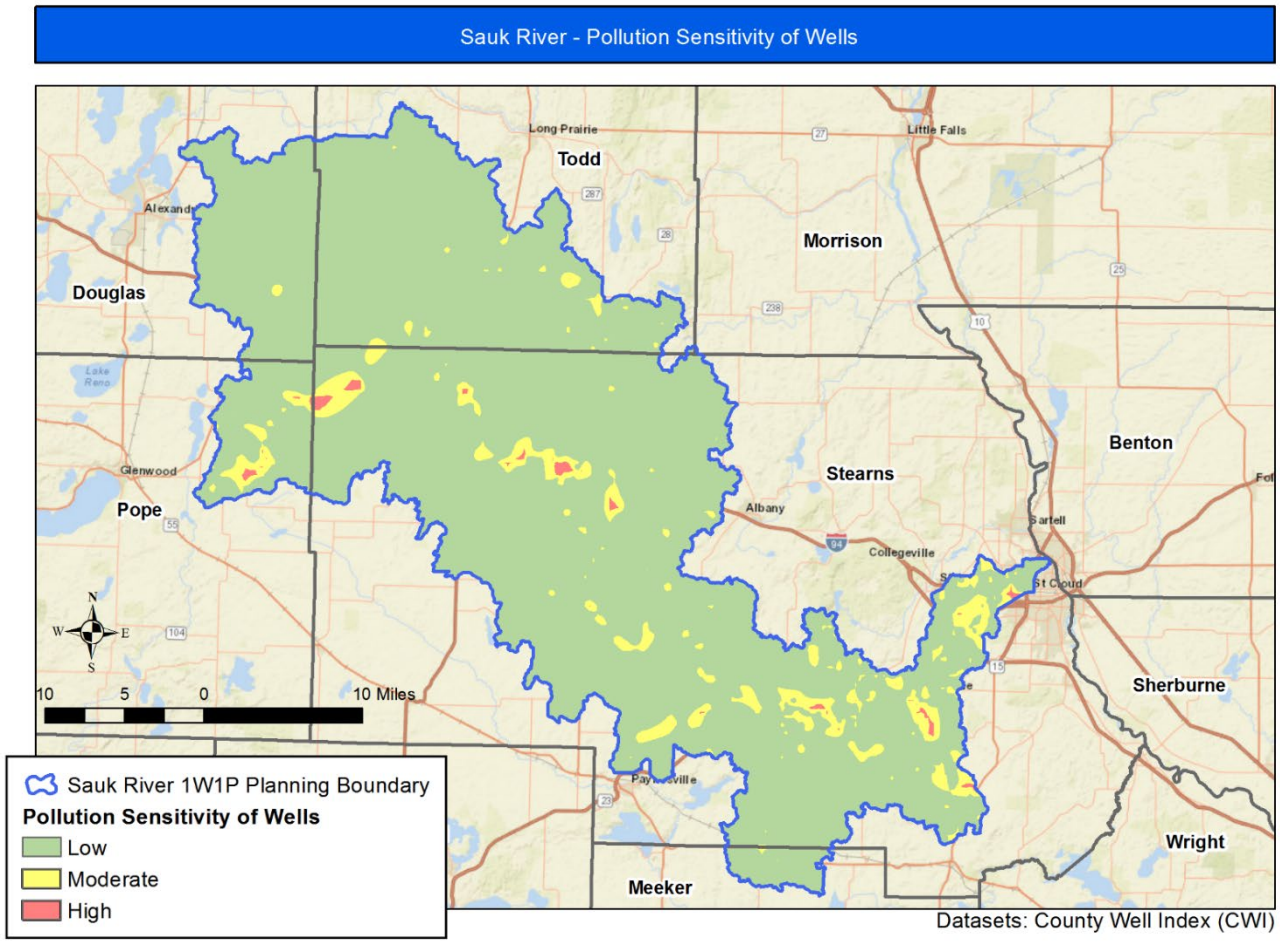

Figure 8: Sauk River Watershed - Pollution Sensitivity of Wells

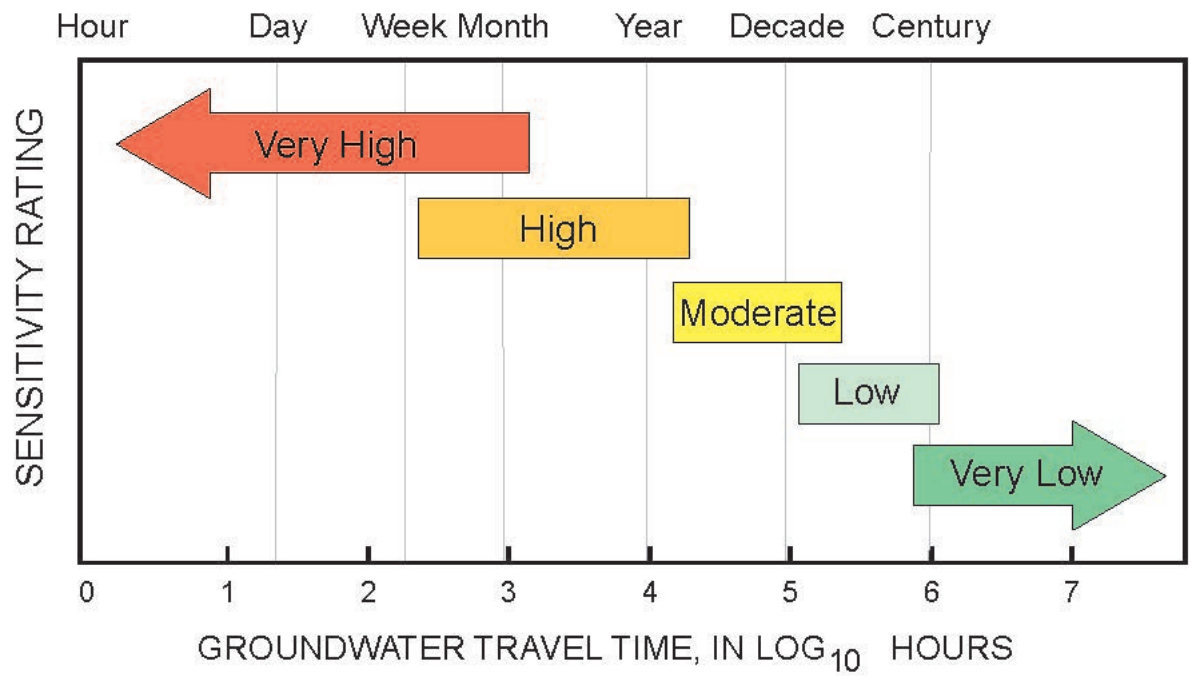

Figure 9: Recharge Travel Time for Buried Aquifers

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

Pollution Sensitivity Rating	Aquifer Recharge Time Period[4] for Surficial Aquifers	Aquifer Recharge Time Period for Buried Aquifers
High	Hours to a week	Days to months
Moderate	A week to weeks	Years up to one or two decades
Low	Weeks to a year	Several decades to a century

[4] 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 process 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 vulnerability and are appropriate for safeguarding drinking water supplies. Community public water suppliers, including municipal and nonmunicipal systems, 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 in order to more easily manage the groundwater below. 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 used 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. The types of management activities required within WHPAs will vary based largely on these vulnerability assessments. Highly vulnerable WHPAs require a greater level of management to prevent potential contaminants at the ground surface from entering the aquifer. Whereas for WHPAs with low vulnerability the primary focus is on sealing unused/unsealed wells, since this is the primary pathway for contaminants to reach the aquifer.

Seventeen of the twenty-one community public water supply systems, within the SRW are engaged in the wellhead protection planning process or are implementing their plans. Of the 17 systems with approved plans, the vulnerability varies across the watershed from low to very high. Thirteen of the approved wellhead protection plans exhibit a high and very high vulnerability in all or part of their DWSMA and are considered vulnerable to contamination from the land surface, with all others exhibiting moderate or low vulnerability. Figure 10 shows the status of wellhead protection planning for the public water supply systems in the watershed. Figure 11 shows the DWSMAs delineated at the time the report was compiled in the SRW, covering approximately 50,011 acres. It is important to note that WHP areas do not follow watershed boundaries therefore; five DWSMAs are located in two watersheds.

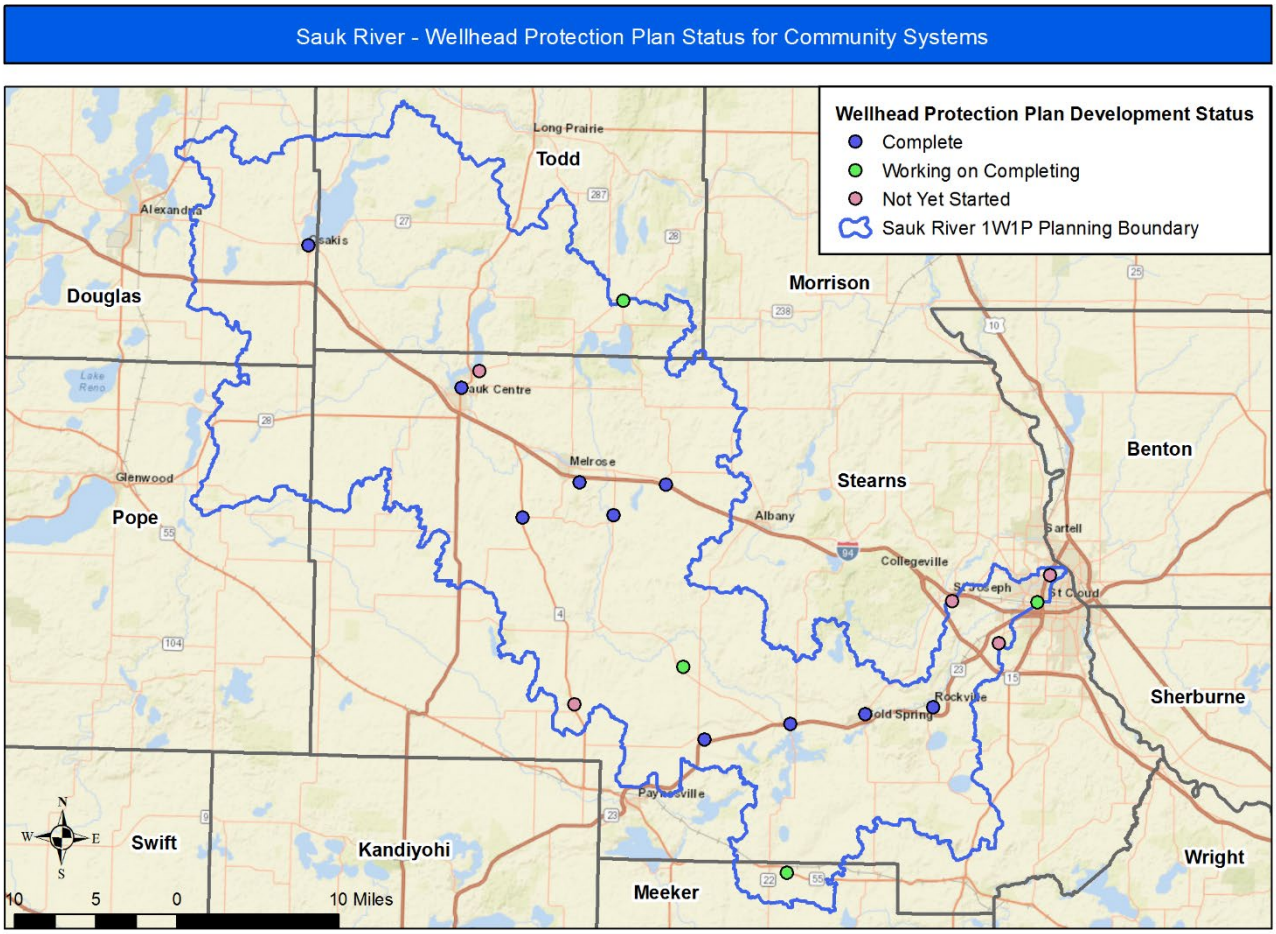

Figure 10: Sauk River Watershed - Wellhead Protection Plan Development Status for Community Public Water Supply Systems. Nineteen *of the twenty-one community public water supply systems are engaged in the wellhead protection planning process or are implementing their plans.*

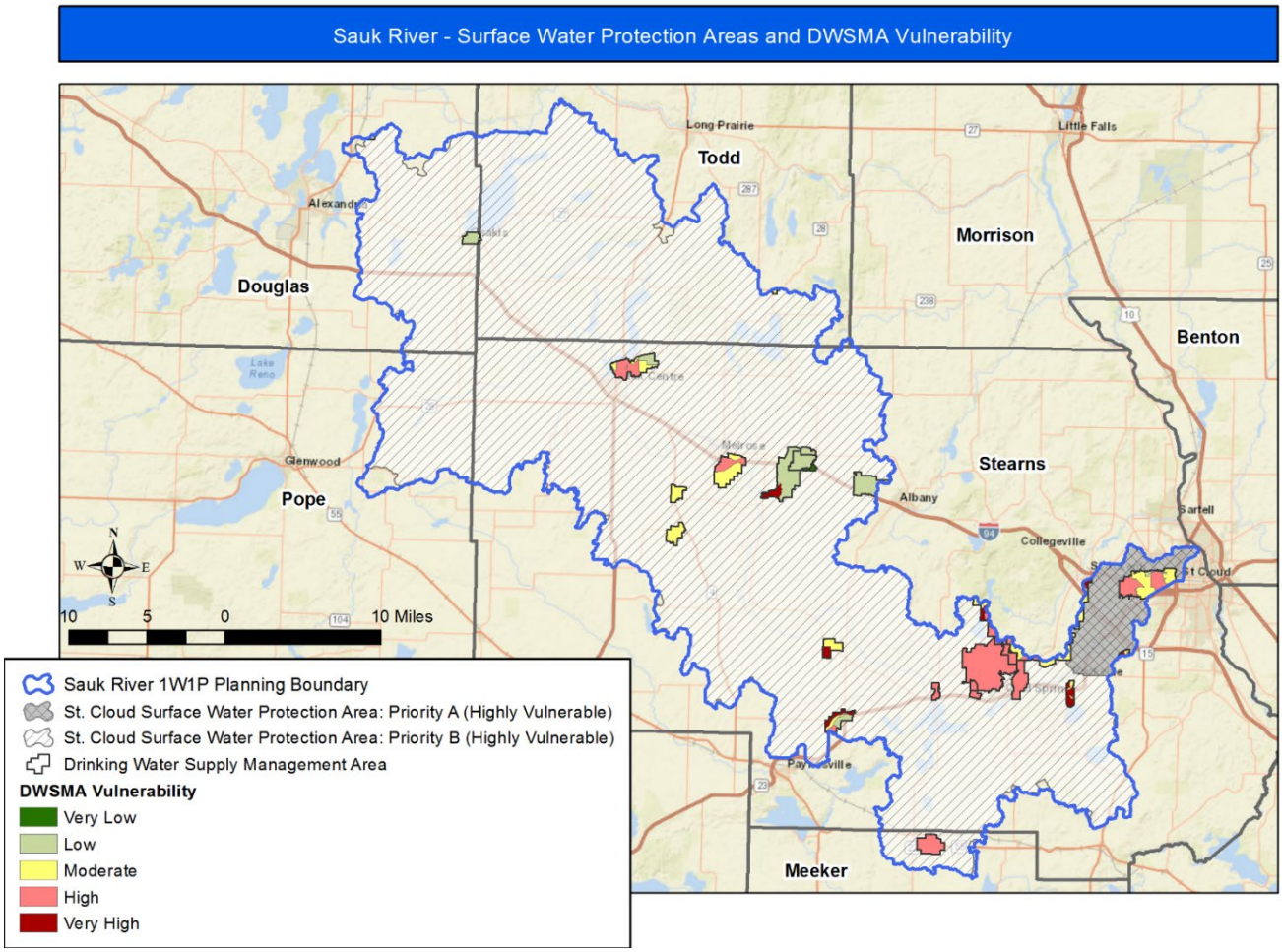

Figure 11: Sauk River Watershed - Drinking Water Supply Management Areas. There are 17 approved Drinking Water Supply Areas (DWSMA) for community public water supply systems in the watershed.

Three of the WHPAs in the SRW include a conjunctive delineation: New Munich, Cold Spring and St. Joseph. A conjunctive WHPA delineation occurs when a strong connection exists between the groundwater capture zone for a well and either a surface water body or the land surface area intersected by that capture zone. In these instances, the WHPA consists of a composite area created by merging the well capture zone (abbreviated GWCA for groundwater capture area) and the watershed area for the surface water body or land surface area which it intersects (abbreviated SWCA for surface water contribution area). An example of this type of conjunctive WHPA is the Rock County Rural Water WHPA, which includes a GWCA within a channel sand aquifer that is composited with a SWCA that represents the surrounding watershed area that contributes to it (Figure 12).

The management of conjunctive WHPAs can present challenges because of their large size relative to more traditional WHPAs that are based solely on groundwater capture areas. In addition, management practices of potential contaminant sources can differ between the GWCA and SWCA. Within the GWCA, the focus will be on contaminants likely to soak into the ground; whereas, in the SWCA, the focus will be on those contaminants most likely to runoff during rainfall or snowmelt events. It should be noted that conjunctive WHPAs do provide a means of achieving multiple benefits within a watershed. Improvements in land use management in these areas stand to benefit both the aquifer used by the public water supplier and associated surface water bodies.

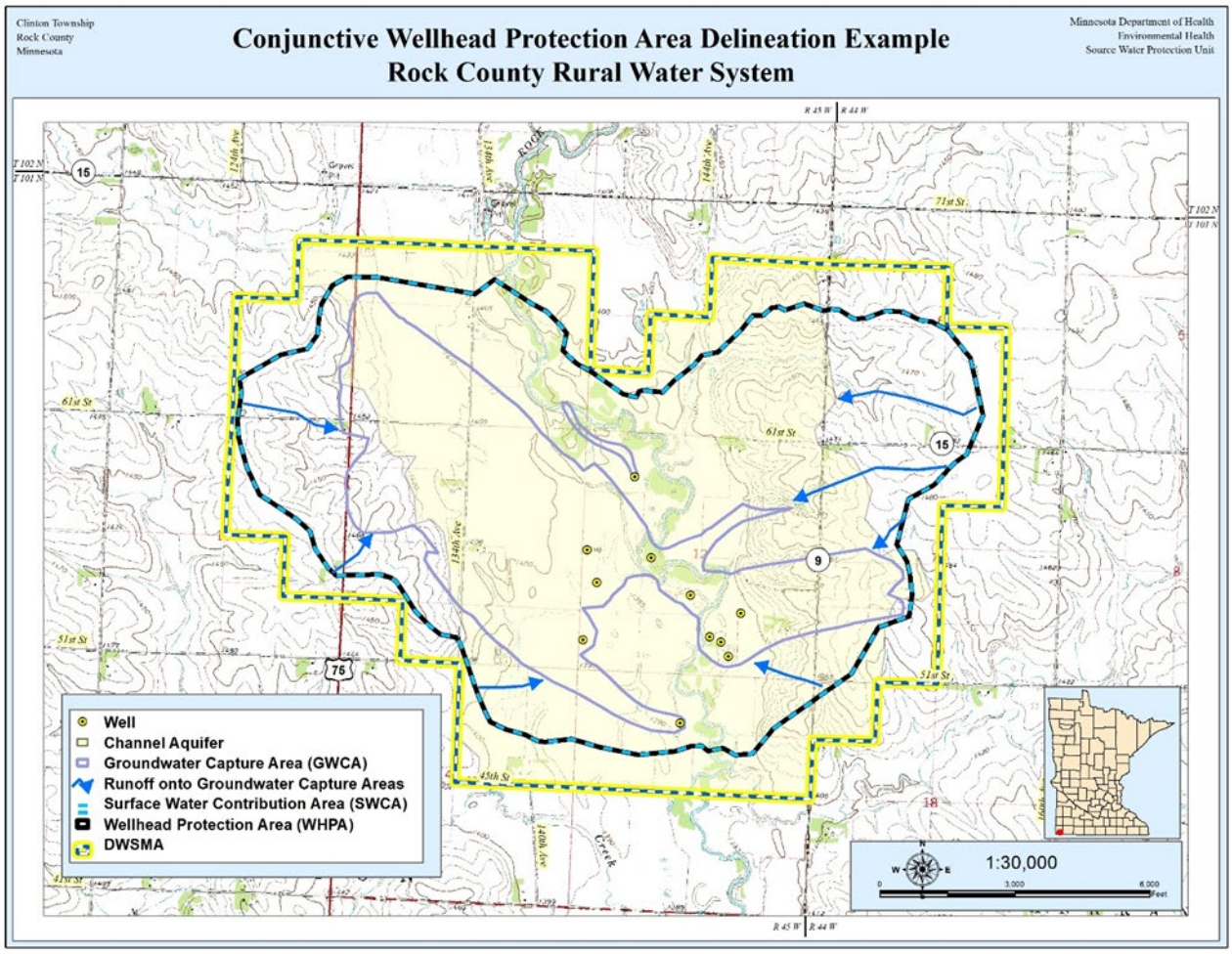

Figure 12: Conjunctive WHPA example. Rock County Rural Water has a strong connection between the Groundwater Capture Area (GWCA) for their wells and the surface water runoff onto the GWCA in the Drinking Water Supply Management Area (DWSMA) resulting in a conjunctive delineation, a merging of the well capture zone and the watershed for surface water runoff.

Groundwater Use

Groundwater accounts for 89 percent of reported water use in most years (Figure 13). Groundwater use totals between 3500 and 8000 million gallons per year. Groundwater is sourced primarily from the surficial sand aquifer and the buried sand and gravel aquifer. Less than 1 percent of groundwater comes from bedrock aquifers (Figure 14).

Agricultural irrigation is the largest water use most years and public water supply is the second largest water use. Agricultural irrigation was very high in 1988, 2007, and 2012-2013, which were dry years (Figure 15).

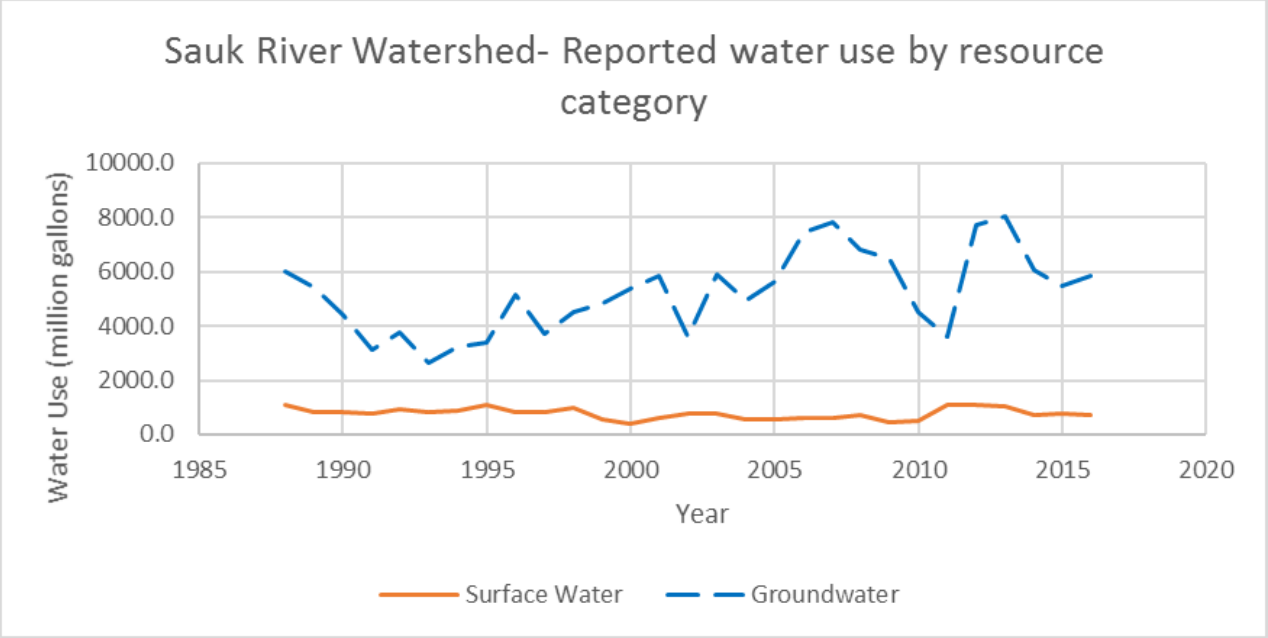

Figure 13: Reported water use by resource category. Groundwater accounts for about 80 to 90 percent of the total reported water use in the Sauk River Watershed.

Groundwater is sourced from three aquifer types (Figure 14): historically, 50 to 60 percent is pumped from the surficial (water table) aquifer. The buried sand and gravel (confined) aquifer accounts for between 30 and 40 percent of water use. Bedrock aquifers account for a very small percentage of permitted water use. Water use was high during the 1989 drought, dropped to a low point in 1993 and from 1993 to the present it has risen from about 3000 million gallons in 1993 to about 6000 million gallons in 2016, with the highest water use occurring in 2007 and 2012-2013, all dry years.

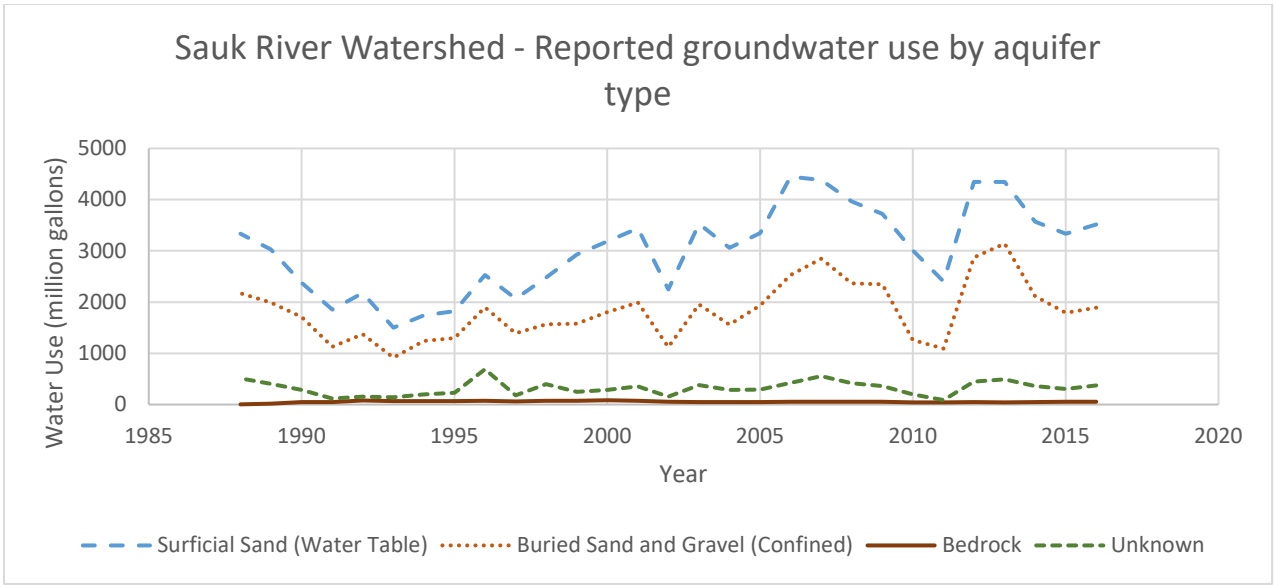

Figure 14: Reported groundwater use by aquifer type. Most groundwater used in the Sauk River Watershed is taken from Surficial Sand (Water Table) and Buried Sand and Gravel (Confined) aquifers. Bedrock aquifers account for a small percentage of groundwater use.

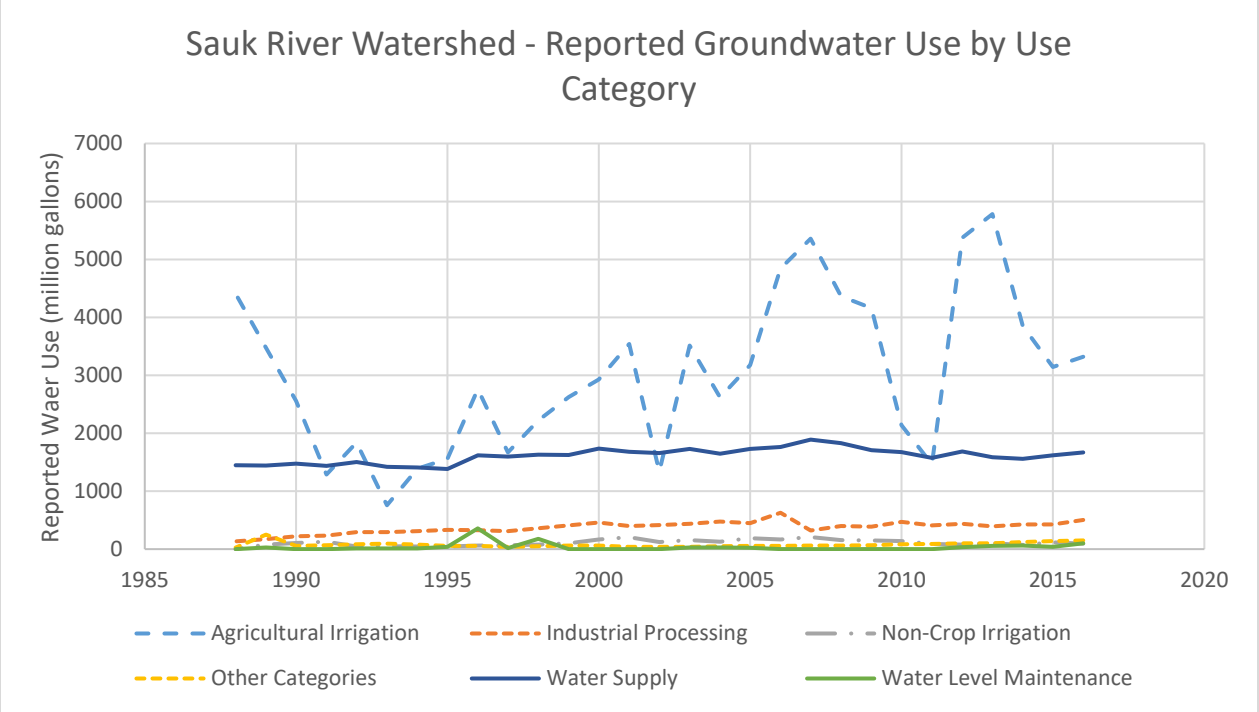

Figure 15: Reported groundwater by Use Category. Approximately 20 to 50 percent of permitted groundwater withdrawals are used for agricultural irrigation. The higher percentages are used during dry years. Approximately 20 to 25 percent are used for water supply, which has largely remained stable. Other uses have remained stable. The most growth in water use is from increased demand for agricultural irrigation.

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 1 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 [5] provides data from the Minnesota DNR Permitting and Reporting System (MPARS).

[5] MGY means million gallons per year; dash marks (-) indicate no use in those categories; percentages may not total to 100 due to rounding.

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

Aquifer Use Categories	Water Supply	Agricultural Irrigation	Industrial Processing	Non-Crop Irrigation	Water Level Maintenance	Other Categories	Total (MGY)	Total (percent)
Surficial Sand (Water Table)	1276.6	1641.1	488.8	65.7	0.0	46.1	3518.3	60.3
Buried Sand and Gravel (Confined)	335.6	1428.1	7.5	24.2	44.4	53.2	1892.9	32.4
Bedrock	43.2	12.0	--	--	--	--	55.3	0.9
Unknown	12.2	240.1	5.9	7.1	55.5	49.2	369.9	6.3
Total (MGY)	1667.6	3321.3	502.2	96.9	99.8	148.5	5836.3	--
Total (percent)	28.6	56.9	8.6	1.7	1.7	2.5	100.0	100.0

Most groundwater is used for agricultural irrigation. Water supply is the second largest water user, followed by industrial processing. Other uses account for less than six percent of reported water use.

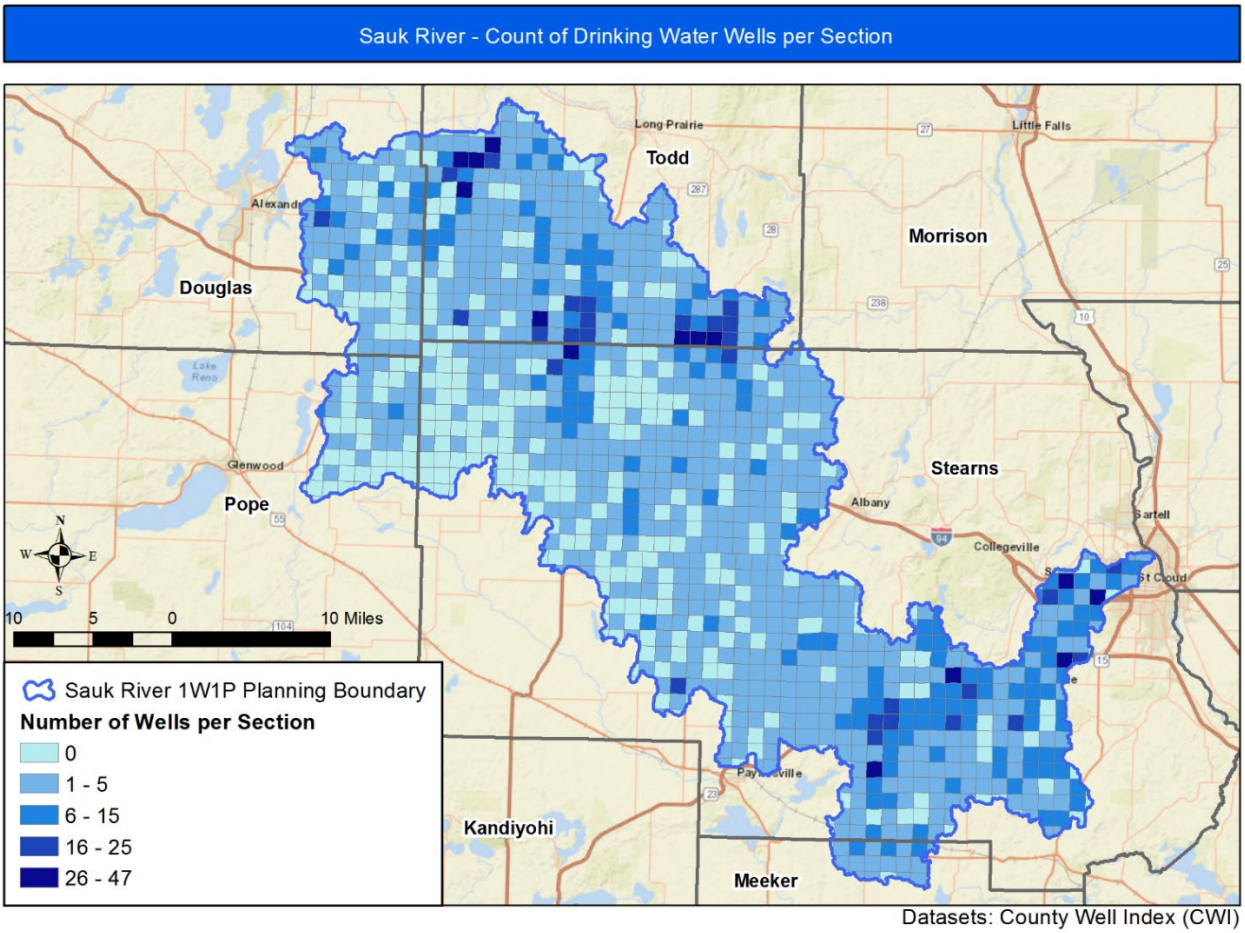

Figure 16: Sauk River Watershed - Density of drinking water wells per section.

Figure 16 illustrates well density and water use data in the SRW. This figure contains a grid that depicts the number of wells in each six by six-mile section of the watershed. Deeper colors correspond to a higher concentration of wells. Well density is variable across the watershed. Only wells used for drinking water were included in this analysis.

Sauk River Watershed Groundwater Issues and Concerns

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

Groundwater Quality Issues and Concerns

Both naturally occurring and human-made contaminants affect the SRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate, pesticides, arsenic, and radium have been detected in wells sampled in the SRW. This section provides context and data about these contaminants and their occurrence in the watershed. It also provides information about the following land uses: feedlots, row crop production, subsurface sewage treatment systems, contaminated sites (leaky tank sites and closed landfills), and household hazardous waste in the watershed that may affect groundwater quality.

All public water systems in the watersheds 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)[6] in groundwater, human activity is the likely cause (State of Minnesota Workgroup). 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 found in groundwater used for drinking water. The SDWA standard for nitrate in drinking water is 10 mg/L. Almost two percent of the 2013 samples taken from wells within the watersheds 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 the Minnesota Department of Health (MDH). Sampling of newly constructed wells for nitrate began in 1974. Many older wells, pre-well code, are not included in this dataset. Table 3 shows nitrate test results for samples taken from these wells.

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

Table 3: Summary of Nitrate-N results in drinking water wells of the Sauk River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)	Samples at or above 3 mg/L (%)	Samples at or above 10 mg/L (%)
< 50	310	0	99.3	0.63	31.9	6.5
50 - 99	892	0	21.19	0.5	11.9	1.9
100 - 149	581	0	6.2	0.5	5	0
150 - 199	182	0	5.5	0.25	1.1	0
>= 200	48	0	5.25	0.15	2.1	0
Total	2013	0	99.3	0.5	11.8	1.8

Where Is Nitrate in Sauk River Watershed?

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

- Figure 17 compares nitrate levels in wells in the SRW 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 the Minnesota Department of Health (MDH).
- Figure 18 shows the Township Testing Program (TTP) schedule. Eighteen townships were tested for nitrate in the SRW. Sampling results are final in Pope and Stearns counties. Douglas and Todd counties results are going through the final review. MDA identified townships where groundwater is vulnerable and row crop agriculture is present as the focus of the testing program.

  Stearns County – 971 wells were sampled through the initial round of the TTP in 2014. When measurable nitrate was detected during the first sample, a second test was offered. Through this process, 59 wells samples were eliminated from the results for well construction issues or a localized impact from a point source, such as a septic tank or nearby feedlot, reducing the final total of wells included in the study to 912. It is important to note that the 59 wells excluded from the study may be at greatest risk of nitrate contamination for the reasons they were discarded.

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate	Final Well Water Dataset	Wells eliminated after second round of testing	Final percentage of wells ≥ 10 mg/L nitrate
Grove	46	13%	44	2	11.4%
Wakefield	314	12%	281	23	8.2%
Munson	201	6%	197	9	4.6%
Melrose	67	6%	61	6	3.3%
Maine Prairie	204	6%	194	10	3.6%
Oak	52	2%	51	1	0%

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate	Final Well Water Dataset	Wells eliminated after second round of testing	Final percentage of wells ≥ 10 mg/L nitrate
Millwood	87	2%	84	3	1.2%

Table 4- Summary of MDA Township Testing Program results for Stearns County

Pope County – 187 were sampled through the initial round of the TTP in 2015. When measurable nitrate was detected during the first sample, a second test was offered. The results for Pope County are final, however the final report has is not yet complete.

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate – Round One	Final percentage of wells ≥ 10 mg/L nitrate
Westport	29	10%	≤ 5%
Grove Lake	33	12%	≤ 5%
Glenwood	125	1%	≤ 5%

Table 5- Summary of MDA Township Testing Program results for Pope County.

Douglas County – 1168 wells were sampled through the initial round of the TTP in 2017. MDA is in the process of conducting a second test when measurable nitrate was detected.

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate – Round One
Orange	47	0%
Hudson	177	1.1%
Alexandria	434	0%
Carlos	467	1.5%
Belle River	43	4.7%

Table 6- Summary of MDA Township Testing Program results for Douglas County.

Todd County – 358 wells were sampled through the initial round of the TTP in 2016. MDA is in the process of conducting a second test when measurable nitrate was detected.

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate – Round One
West Union	34	5.9%
Gordon	116	2.6%
Kandota	121	0.8%
Round Prairie	87	5.7%

Table 7- Summary of MDA Township Testing Program results for Todd County.

Learn more about the TTP at Township (Nitrate) Testing Program (http://www.mda.state.mn.us/townshiptesting).

- Figure 19 shows the nitrate concentrations recorded at each MDA ambient monitoring well location in the SRW in 2016. The sampling data collected from Pope and Stearns counties, records the highest nitrate result at 50.7 mg/L.
- Figure 22 shows the MPCA ambient monitoring well locations. Nitrate detected at seven of the eight wells and in 71.2 percent of all samples, only 6.1 percent of the detections exceeded the SDWA of 10 mg/L; two of which were private water supply wells with all others being monitoring wells.

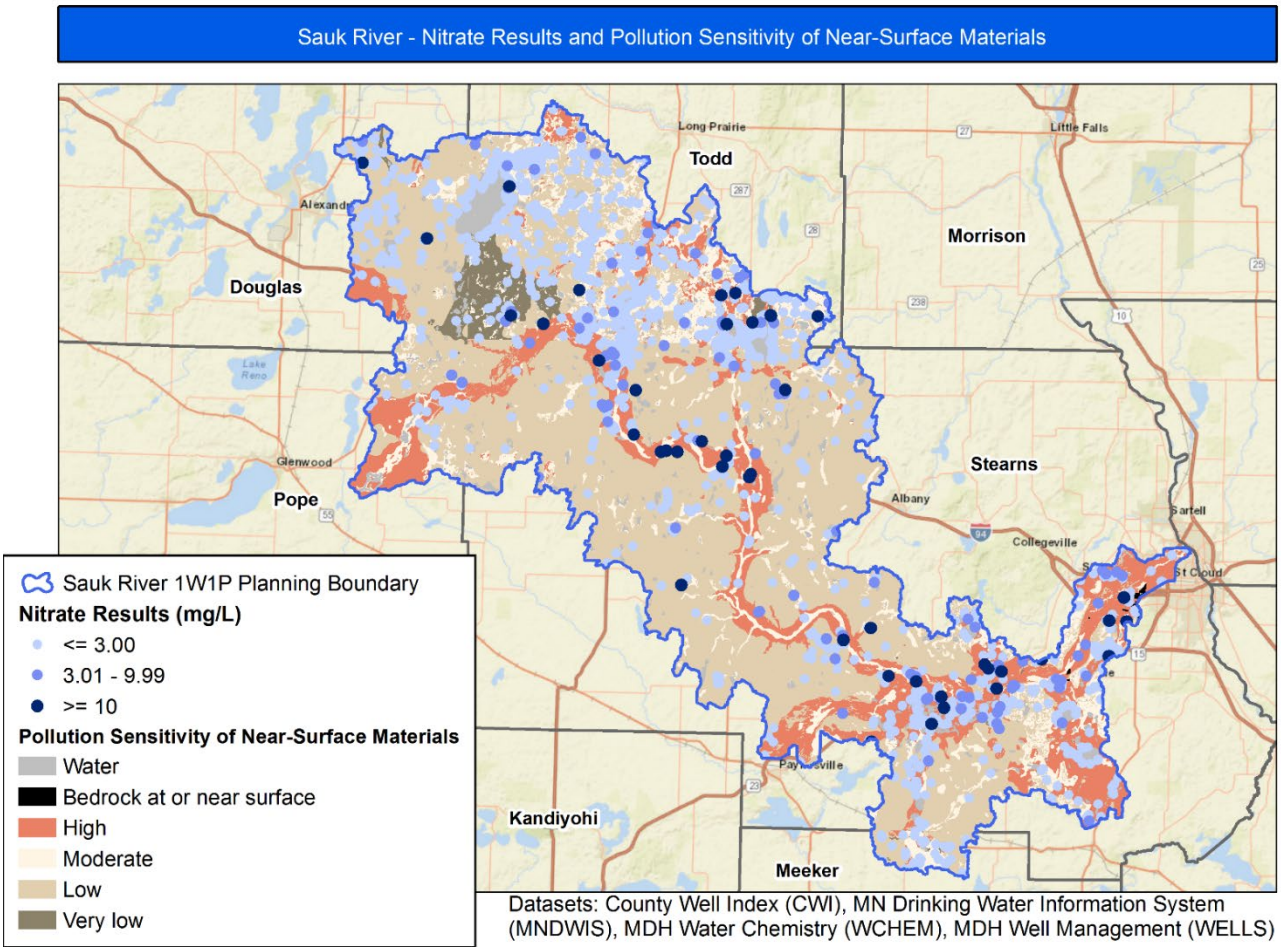

Figure 17: Sauk River Watershed - Nitrate Results and Pollution Sensitivity of Wells

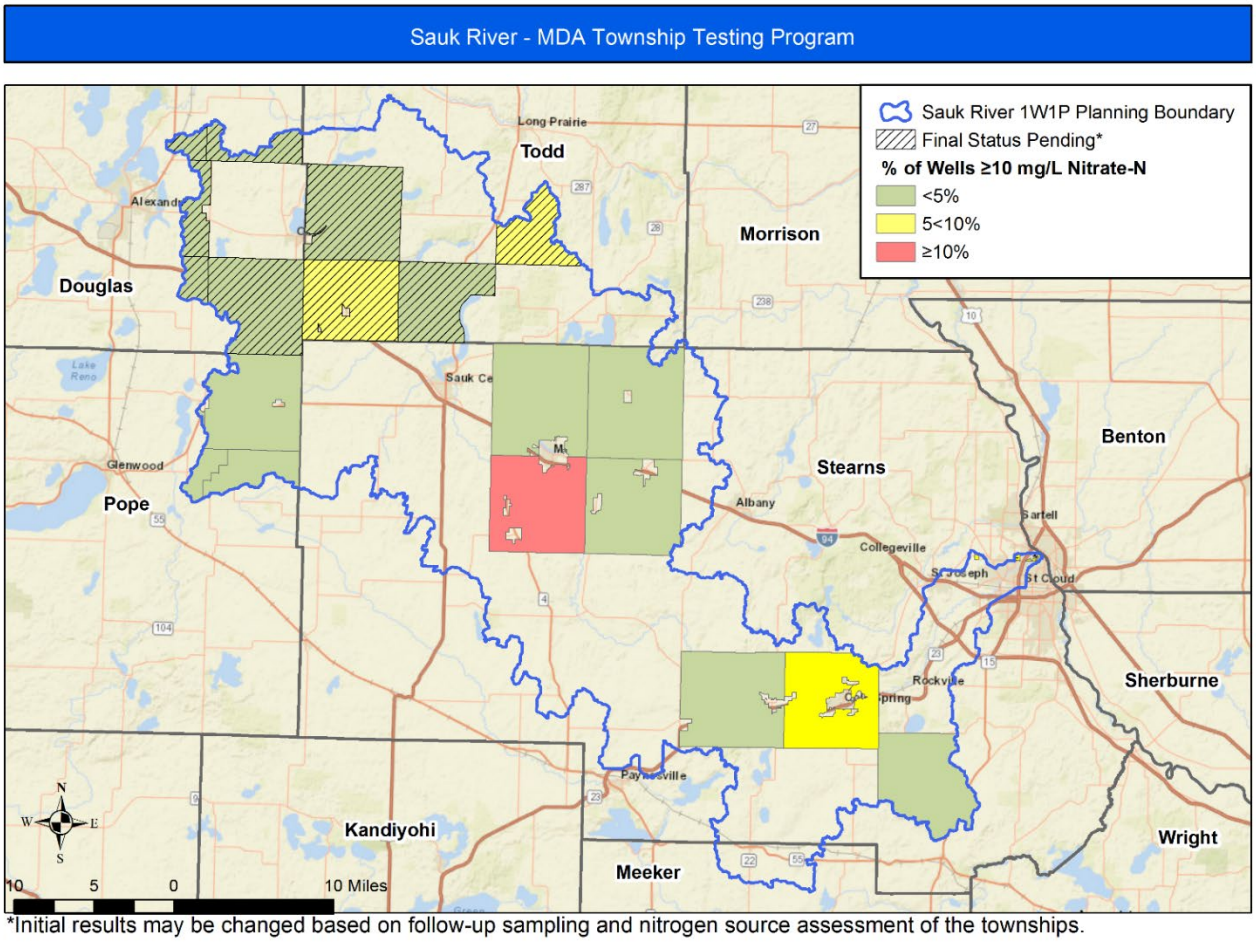

Figure 18: Sauk River Watershed - MDA Township Testing Program. Eighteen townships in four counties tested 2684 wells for nitrate.

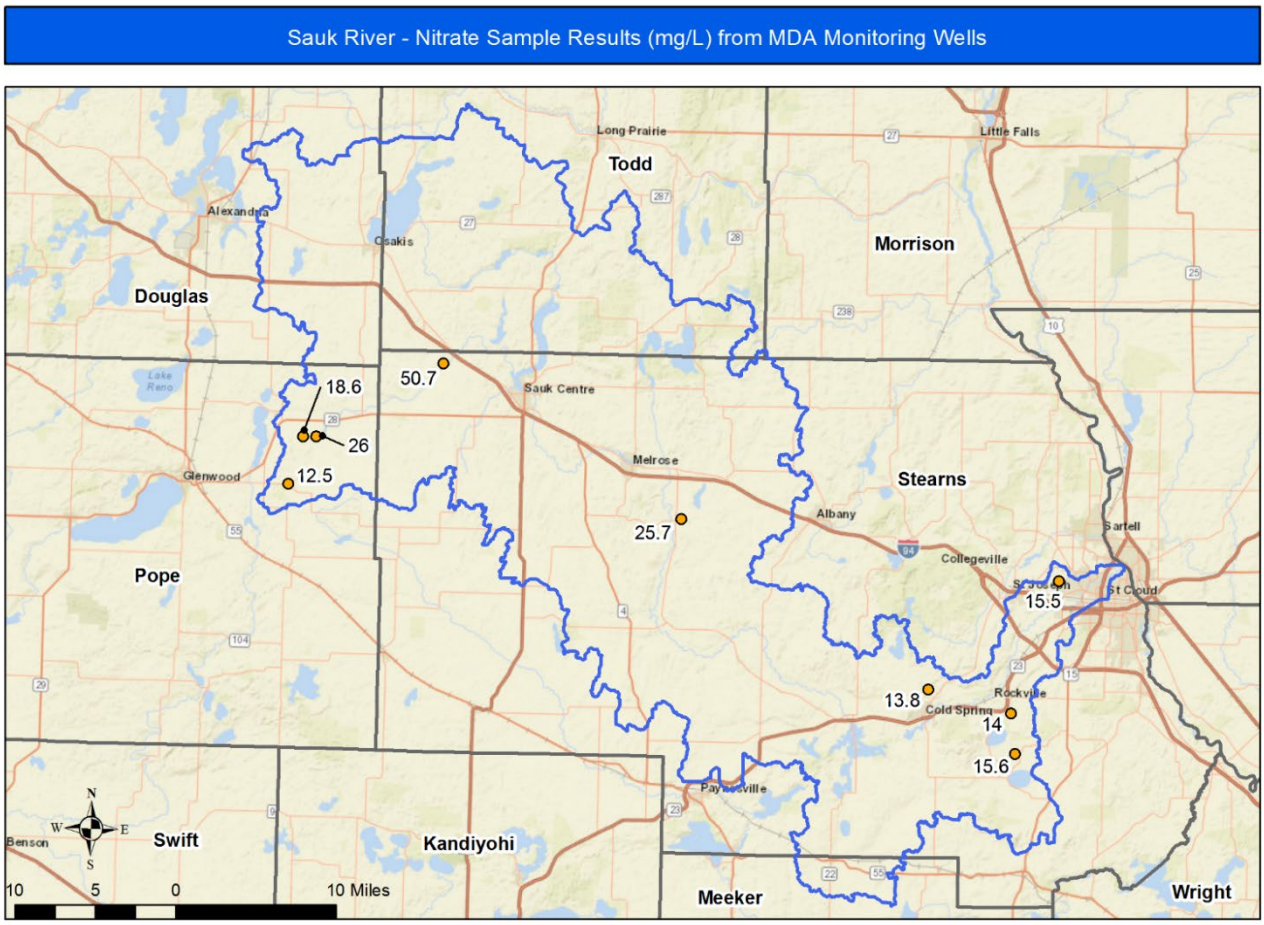

Figure 19: Sauk River Watershed - MDA Monitoring Wells and Nitrate Results.

How to Address Nitrate in Groundwater

The Minnesota Groundwater Protection Act established a prevention goal that groundwater be maintained in its natural condition, free from any degradation caused by human activity. When degradation exists, it is important to understand the reflected level of management required based on the nitrate concentration. Table 8 provides a protection framework that identifies management priorities reflective of nitrate concentrations.

Table 8: Nitrate protection framework and associated land use management goals. Implementation activities should build as you move from one classification to the next.

Nitrate Protection Framework	Nitrate Concentration	Implementation Emphasis
Protection – Maintain	0 – 4.9 mg/L	Proactive and preventive; ▪ Maintain existing land cover by discouraging or preventing land conversion ▪ Contaminant source management on existing land uses (Agricultural BMPs, SSTS management, easements, forest management plans)

Nitrate Protection Framework	Nitrate Concentration	Implementation Emphasis
Protection – Threatened	5.0 – 9.9 mg/L	Contaminant source reduction or elimination; ▪ Shifting land uses away from those that may leach excess nitrogen (Alternative Management Tools[7], upgrade failing SSTS, easements)
Restoration – Treatment	10.0 mg/L and above	Active intervention required by public water supplies to avoid drinking water consumption (new sources; treatment) while still aiming for long term contaminant source mitigation through reduction and elimination

Table 12 provides a more comprehensive list of specific actions counties and subwatersheds in the SRW 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 Sauk River Watershed?

MDA uses nine monitoring wells in the SRW to monitor for common detection pesticides. The monitoring wells are in these regions due to the sensitive geology and row crop agriculture, which increases the potential for pesticides or pesticide degradants to get into groundwater. Figure 20 shows the number of common detection pesticides recorded at each monitoring location in the SRW in 2016. A range of one to three common detection pesticides were detected in the samples from the monitoring wells. No detections exceeded any human health-based drinking water standards or reference values. MDA's monitoring wells only provide information about pesticides at their 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 watersheds.

[7] MN Dept. of Agriculture developed Alternative Management Tools to protect groundwater quality from nitrate contamination. For more information, visit MDA Alternative Management Tools (http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/nitrogenmgmt/amts/amtools.aspx)

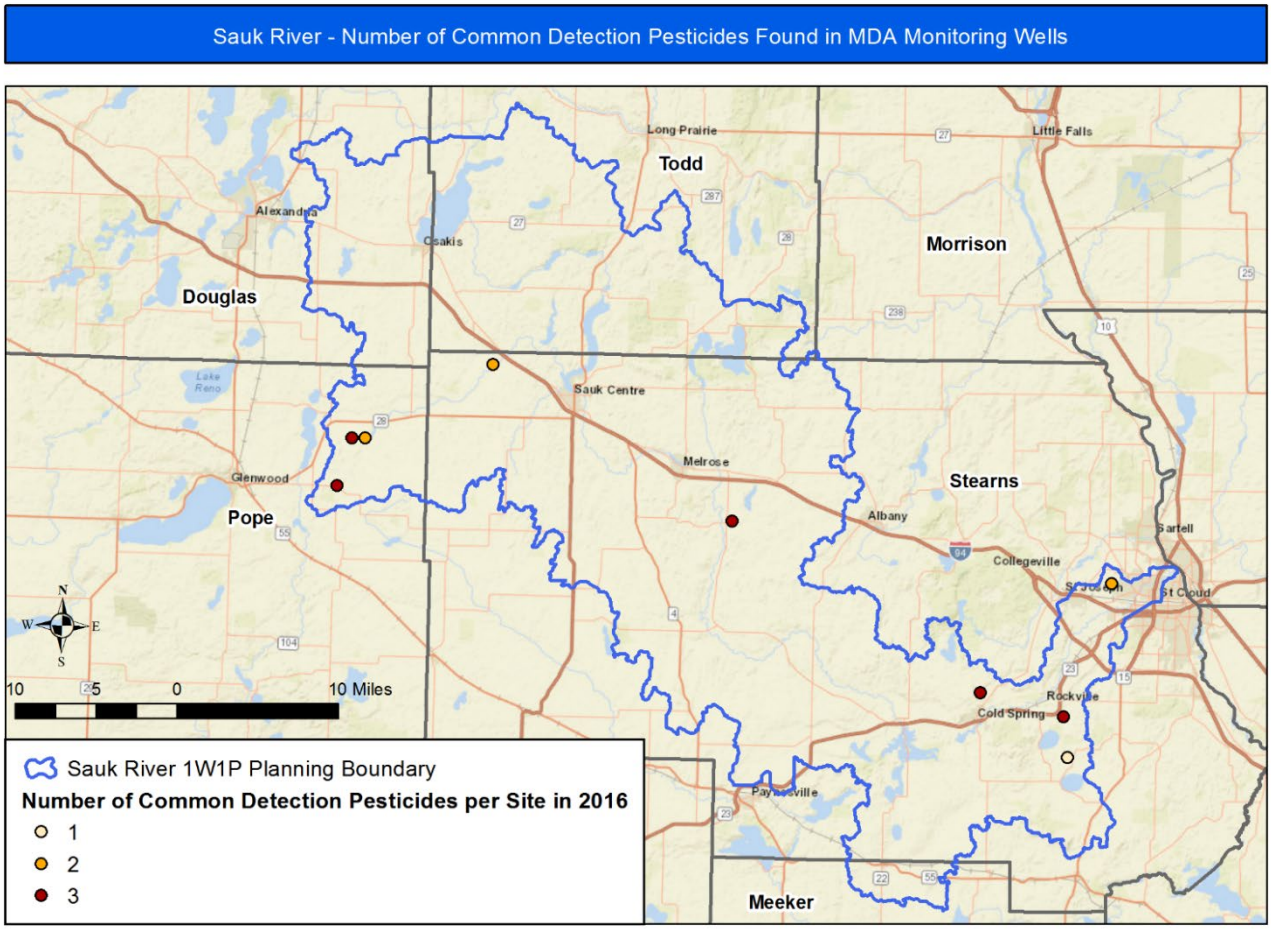

Figure 20: Sauk River Watershed - Common Detection Pesticides Found in MDA Monitoring Wells

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 13 provides a more comprehensive list of specific actions the counties and subwatersheds in the SRW can take to restore and protect groundwater quality related to pesticides.

Arsenic

Approximately eight percent of the 481 arsenic samples taken from wells in the SRW 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 (chronic exposure) 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;

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

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 9 outlines the number of well water samples tested for arsenic in the SRW 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 9: Summary of arsenic (As) concentrations in wells of the Sauk River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)	Samples at or above 5 µg/L (%)	Samples at or above 10 µg/L (%)
< 50	75	0	131	1	12	6.7
50 - 99	202	0	22.3	1	17.8	5.9
100 - 149	138	0	26.9	2	23.9	9.4
150 - 199	49	0	40.9	1	28.6	12.2
>= 200	17	0	13.7	3.28	23.5	11.8
Total	481	0	131	1	31.8	7.9

Where Is Arsenic in the Sauk River Watershed?

Figure 21 shows that arsenic is found throughout the watershed. The dataset used to create Figure 21 is the same information displayed in Table 9. These samples were taken from newly constructed wells, domestic wells, and other drinking water supply wells sampled by MDH.

Arsenic is most prevalent in 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).

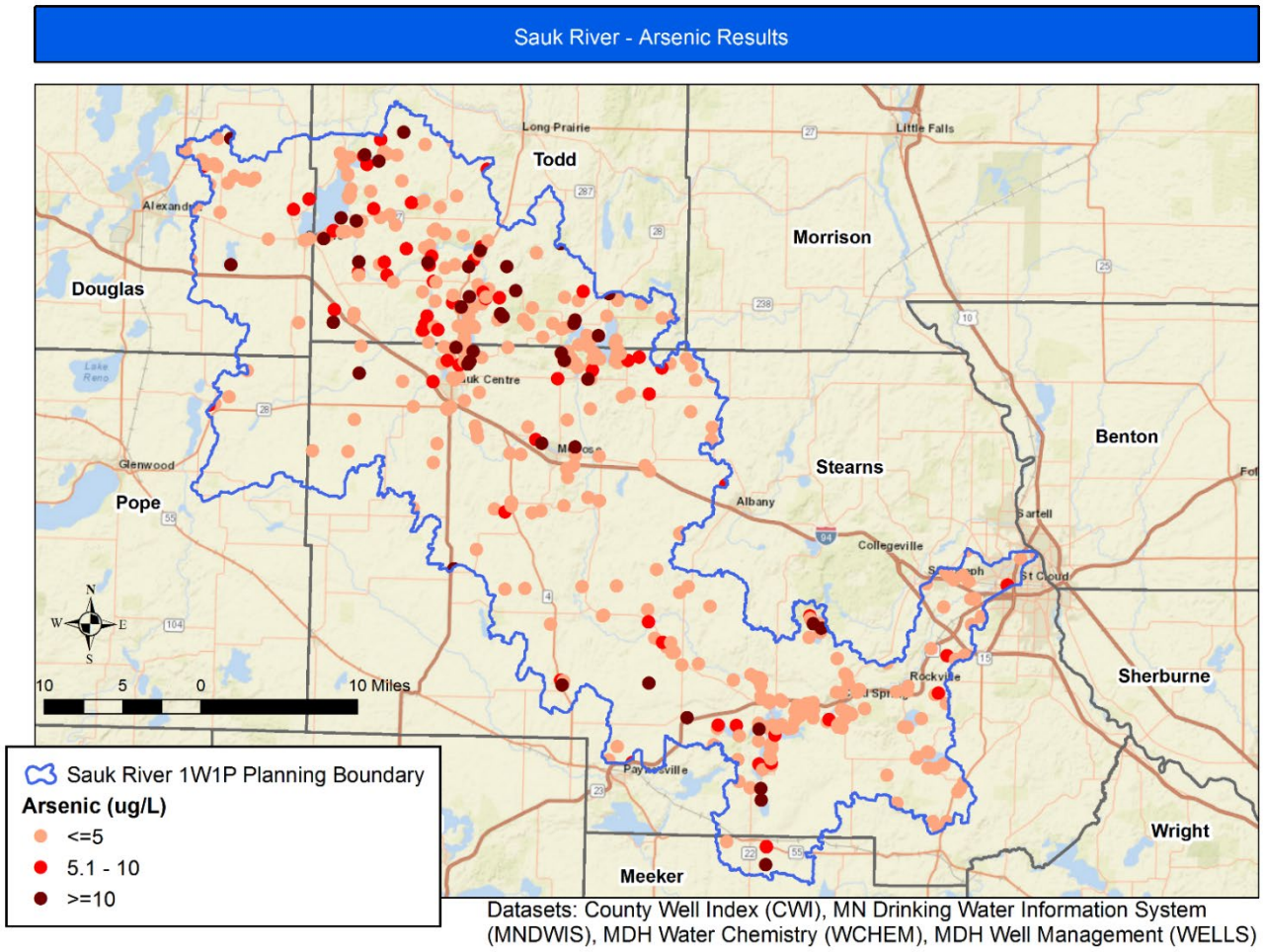

Figure 21: Sauk River Watershed - Arsenic Results

How to Address Arsenic in Groundwater

Unlike nitrate and pesticides, human activity rarely causes arsenic in Minnesota 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 associated with arsenic, 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

Concentrations of naturally occurring radioactive radium have been detected in some groundwater samples in the SRW. In certain areas of the SRW, the levels at which these chemicals are found are not considered drinking water contaminants. The exact source of these compounds is not well understood. They may originate in the clay-rich glacial sediments or may be part of the original mineral composition of the Mt. Simon or fractured Sioux Quartzite geologic units. 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 theses bedrock layers.

Where are Radionuclides in the Sauk River Watershed?

Not enough is known about radium (or other radionuclide) distribution in the Quaternary buried aquifers beneath the SRW. The sparse results do not indicate a problem at this time.

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in the SRW groundwater. Therefore, actions cannot reduce the amount of radionuclides present in groundwater. Implementation efforts should focus on awareness that radionuclides may be found in groundwater. The factors that contribute to the presence of radionuclides in the SRW groundwater are not well understood at this point. If private well users are concerned about radionuclides in their well, they can pay to have their 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 MPCA'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 (VOCs). The Ambient Groundwater Network currently consists of approximately 270 sites that represent a mix of deep 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 sampled annually. In addition to the annual ambient groundwater samples, MPCA staff collect approximately 40 contaminants of emerging concern (CEC) samples that are analyzed for over 267 analytes, such as pharmaceuticals, personal care products and fire retardants.

From 2004 to 2017, 24 ambient network wells were sampled within the SRW annually for the ambient groundwater suite. The wells were located in agricultural areas (62.5%), SSTS (septic systems) or sewered residential (29.2%), and commercial/industrial (8.3%) areas. The majority of wells were monitoring or observation wells, while almost 30 percent of the wells were utilized as drinking water sources. Wells with less than five years of data were not included in this summary, leaving eight wells (33%) for data analysis.

Results indicate that the majority of detections were within the human health guidelines set by either the United States Environmental Protection Agency (USEPA) or MDH. There were some exceedances to these limits, making the most important groundwater quality issues for this watershed arsenic, beryllium, cadmium, inorganic nitrogen (nitrate and nitrite), iron, manganese, and vanadium.

- **Arsenic** was detected in four of the eight wells. Exceedances to the SDWA standard of 10 µg/L occurred in 8.4 percent of the samples. The human health risks associated with arsenic is referenced in the Arsenic section of the report.
- **Beryllium** was found in four of the eight wells, exceeding the MDH advised 0.8 µg/L health risk limit (HRL) 8.3 percent of the time. Beryllium is an inorganic chemical (also referred to as an alkaline earth metal) that can be found naturally in silicate minerals. However, the primary source of beryllium in water can be linked to its release during anthropogenic processes, such as coal burning and other industries using beryllium (i.e. aerospace, weapons, nuclear, electronics and mechanical industries) (WHO, 2009). The end point health issue associated with this contaminant is cancer.
- **Cadmium** detections were identified in six of the eight wells with 2.6 percent of samples exceeding the HRL for short-term, subchronic, and chronic exposure. For chronic non-cancer HRL, the concentration is 0.5 µg/L, which affects the renal (kidney) system and the skeletal system. For the subchronic or short-term non-cancer HRL, the HRL is 1 µg/L, which also affects the renal system, skeletal system, and can cause developmental issues. For more information on Cadmium (www.health.state.mn.us/divs/eh/risk/guidance/gw/cadmiuminfo.pdf).
- **Nitrate** was detected at seven of the wells and in 71.2 percent of all samples, only 6.1 percent of the detections exceeded the SDWA of 10 mg/L; two of which were nonpublic water supply wells whereas the others were monitoring wells.

- **Manganese** was detected in 53.5 percent of samples, concentrated in six of the eight wells. It has a Risk Assessment Advice (RAA) of 100 ug/L for infants and 300 ug/L for children and adults. There were eight instances (17.4%) when concentrations exceeded the RAA for infants, four of which exceeded the RAA for children and adults. Exceedances to the RAA were primarily identified in monitoring wells, with one instance in a nonpublic water supply well. For more information on Manganese (www.health.state.mn.us/divs/eh/water/contaminants/manganese.html#Protect)
- **Vanadium** is a trace metal associated with iron, occurring naturally in soil, water and air, as well as from man-made industrial sources (oil refineries and power plants). It was detected in six of the wells analyzed with a detection frequency of 23.1 percent and one exceedance to the chronic HRL of 50 µg/L. This HRL has no known health endpoints at this time and more research needs to be complete to understand the full effects of vanadium on human health.
- **Chloride** occurs naturally in groundwater, is commonly detected in the watershed, and was identified in all eight wells 100 percent of the sampling. The concentrations all well below the EPA Secondary Maximum Contaminant Level of 250 mg/L in drinking water. Chloride has become an increasing concern due to salt being used as a deicing agent on roads. Elevated chloride concentrations can affect the taste of drinking water (Kroening & Ferrey, 2013).

MPCA staff also collected 40 samples for CECs. These samples were collected at 11 of the 24 wells throughout 2000 to 2017. There were sixteen detections of these chemicals. The most commonly detected CECs were bisphenol A (BPA) and DEET, which is a common occurrence in water quality sampling. There were no exceedances to applicable water quality guidelines.

Perfluorinated chemicals (PFCs) were also sampled at five of the wells within the watershed during 2006, 2013 and 2017. Samples were tested for 13 contaminants, such as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanoic acid (PFBA). There were detections of PFBA identified in two monitoring wells located in agricultural areas. These detections were well below the HBV for PFBA. PFCs are chemicals that are manmade for products that resist heat, oil, stains, grease and water, such as nonstick cookware, coatings on some food packaging, and fire-fighting foam. Exposure to elevated levels of PFCs may cause higher cholesterol, changes to liver function, reduced immune response, thyroid disease, and increased risk of kidney and testicular cancer.

MDH hosts information on a List of Contaminants in Water (www.health.state.mn.us/divs/eh/water/contaminants/index.html), as well as CECs (www.health.state.mn.us/divs/eh/risk/guidance/dwec/index.html).

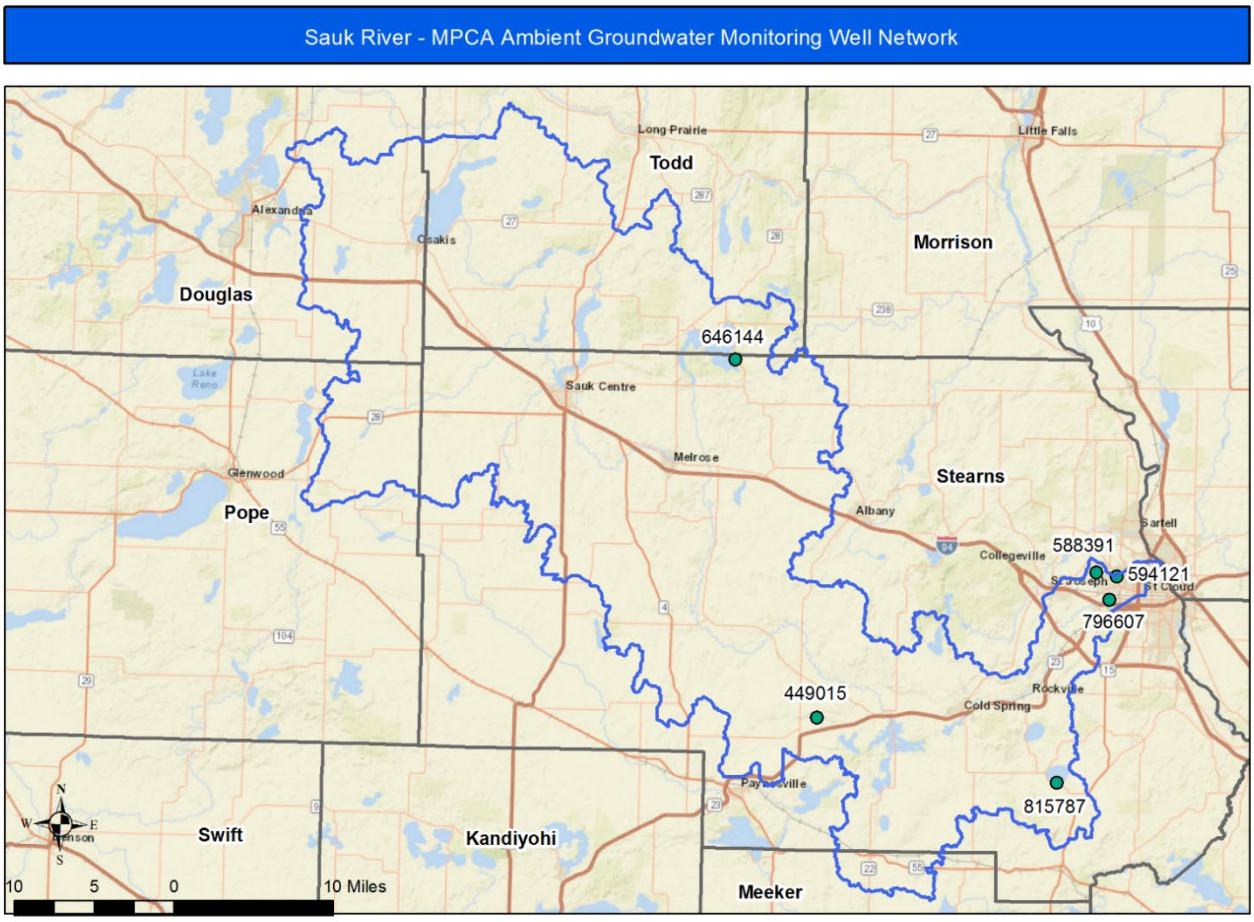

Figure 22: Sauk River Watershed - MPCA Ambient Groundwater Monitoring Well Network

Potential Contaminant Sources

Some land use practices make it easier for contaminants to get into groundwater. Key land uses that are potential contaminant sources in the SRW 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 management of manure, especially in places with high pollution sensitivity, can contaminate 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/local-ordinances-regulating-livestock-minnesota).

MDA developed a new tool in collaboration with the National Weather Service called the Minnesota Runoff Risk Advisory Forecast (RRAF) system (www.mda.state.mn.us/protecting/cleanwaterfund/toolstechnology/runoffrisk). RRAF is designed to help farmers and commercial applicators determine the best time to apply manure to reduce the probability of off target movement of valuable nutrients and protect water resources.

Where Are Animal Feedlots in Sauk River Watershed?

The SRW has 1670 active feedlots. The watershed is a leading producer of dairy in the state, followed by cattle, and poultry. 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. All counties are delegated entities within the SRW.

Table 10 outlines the number of registered feedlots in the SRW for each county. Figure 23 contains a grid that depicts the number of active feedlots in each six by six-mile section of the watershed. Darker colors correspond to a higher concentration of active feedlots.

Table 10: Number of registered feedlots and the delegated counties

Counties	Number of Registered Feedlots per County
Douglas	70
Pope	41
Todd	240
Stearns	1306
Meeker	13

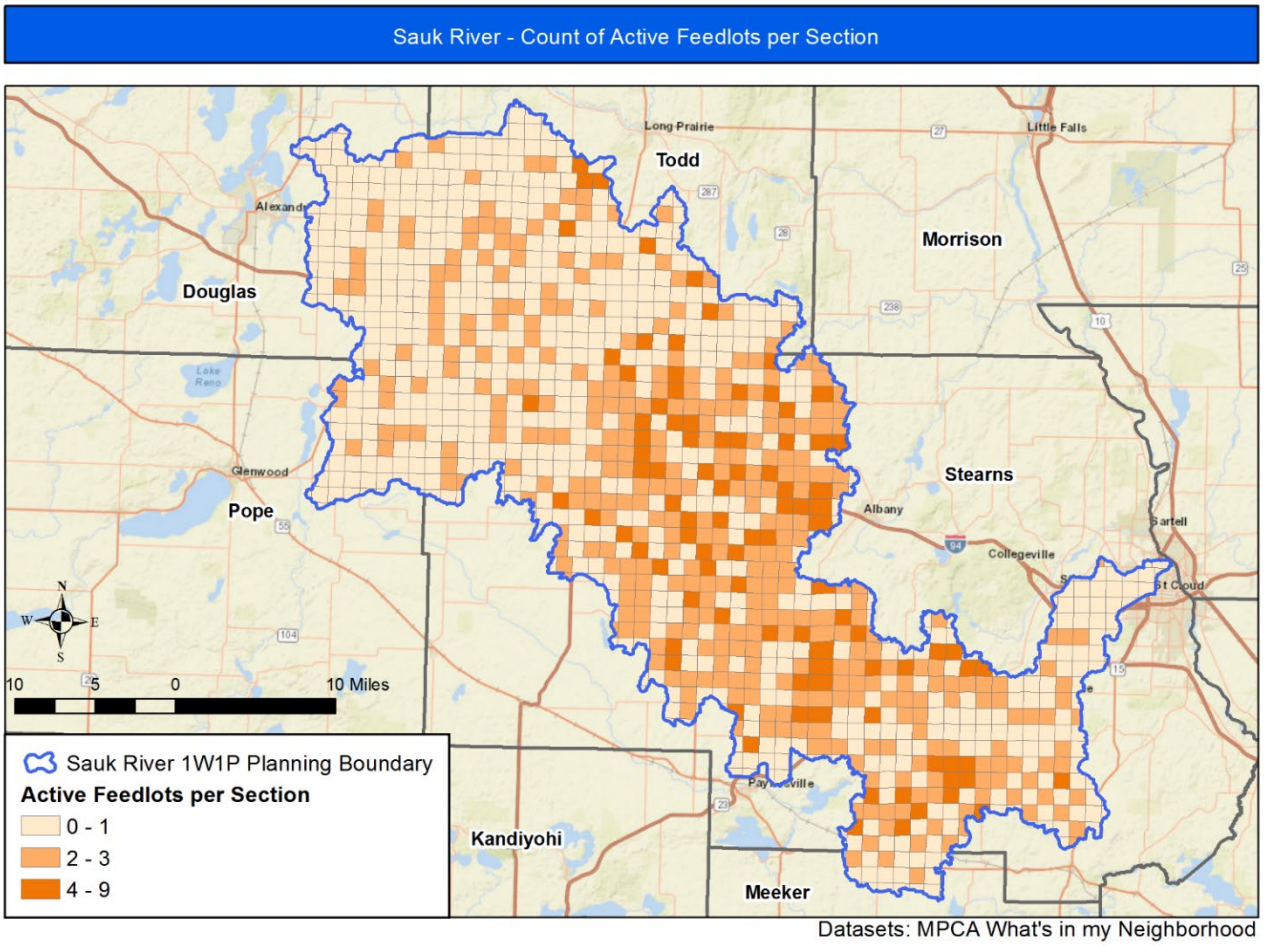

Figure 23: Sauk River Watershed - Active Feedlots

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. It is important to prioritize activities in the areas most sensitive to groundwater first. Table 13 provides a more comprehensive list of specific actions partners in can take to protect groundwater from nitrate and pathogen contamination.

Row Crop Agriculture

Row crop agriculture or cultivated crops (Figure 3) is the largest land cover within the SRW at nearly 50 percent. Impacts from row crop production to water resources include nitrogen loss in the form of nitrate to groundwater, which can move downward to aquifers or be laterally dispersed to lakes and rivers. Tile drainage is another pathway for nitrogen to reach surface water systems, however this is not a focus of the GRAPS report being the TMDL and WRAPS reports assess impacts. Agricultural chemicals, including pesticides, are another risk for groundwater contamination from row crop agriculture. Both nitrate and pesticides are addressed in the **Groundwater Quality Issues and Concerns** section of this report.

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 drain field and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients, and some chemicals. SSTS infiltrate treated sewage into the ground, which ultimately travels to groundwater.

Where Are SSTS in the Sauk River Watershed?

SSTS are found in all five counties in the SRW. Information reported by counties indicate a relatively small to high number of failing SSTS in the watershed (Table 11). State regulations require each county to adopt a local SSTS ordinance and that eminent health threats 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 records on treatment system age, type or function, known unsewered communities, and lack of a point of sale requirement triggering an inspection through a property sale.

Table 11: Reported number of failing SSTS in each county within the Sauk River Watershed

County	Estimated number of failing SSTS per 1,000 acres
Douglas	1 – 2
Pope	1 – 2
Todd	1 – 2
Stearns	1 – 2
Meeker	2 – 3

How to Protect Groundwater from SSTS Contamination

SSTS must be properly sited, designed, constructed and maintained to minimize the potential for disease transmission and groundwater contamination. Each county carries out permitting, inspections and operation of the SSTS program locally. Table 13 provides a more comprehensive list of specific actions the SRW can take 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 identified 222 active tank sites, 63 leak sites, and two closed landfills in the SRW. 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 the Sauk River Watershed?

Figure 24, maps active tank and leak sites compared to pollution sensitivity of near-surface materials in the SRW. Figure 25 provides a map of the closed landfills in the SRW. 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.

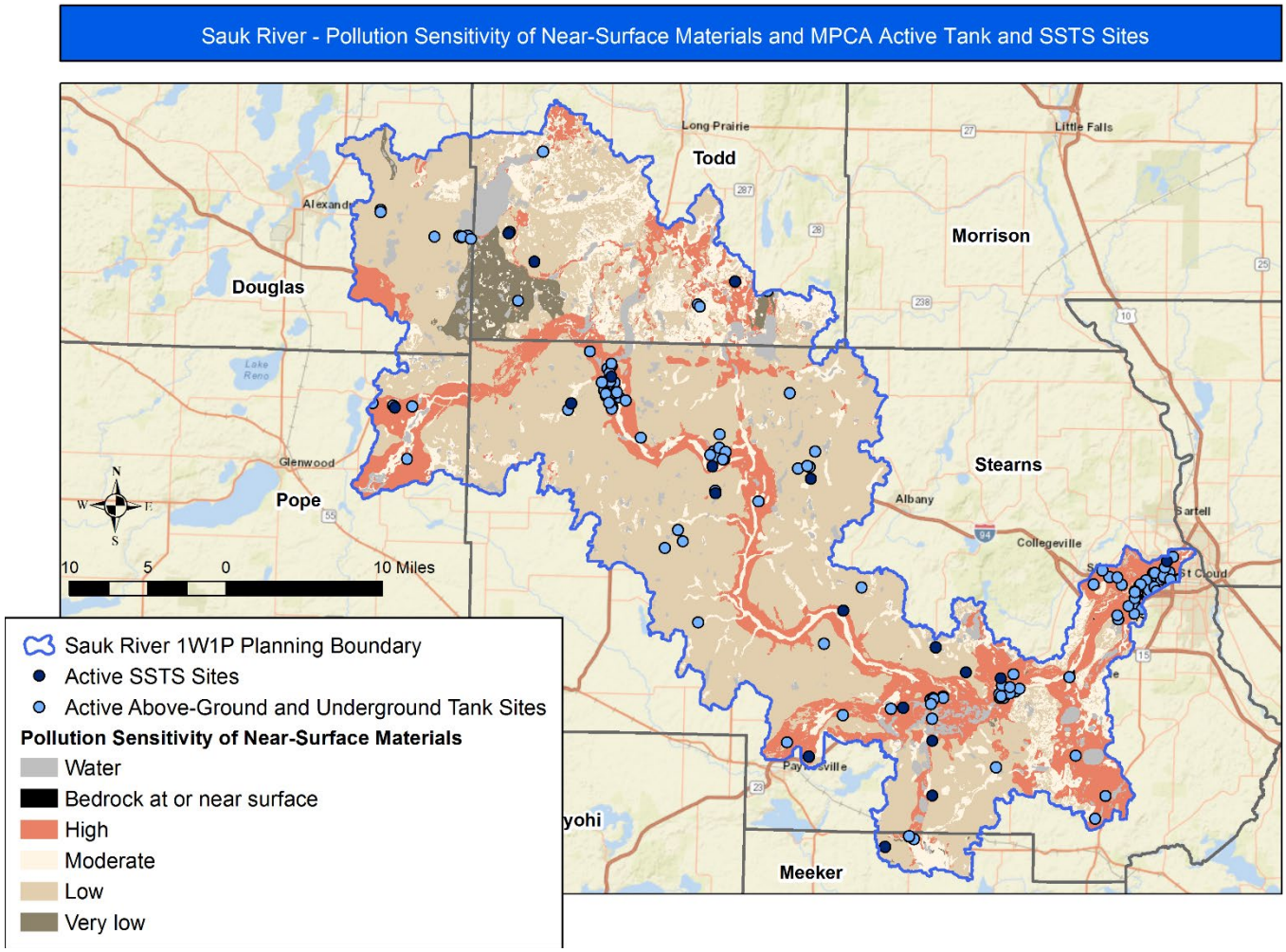

Figure 24: Sauk River Watershed - MPCA Active Tank and SSTS Sites and Pollution Sensitivity of Near-Surface Materials

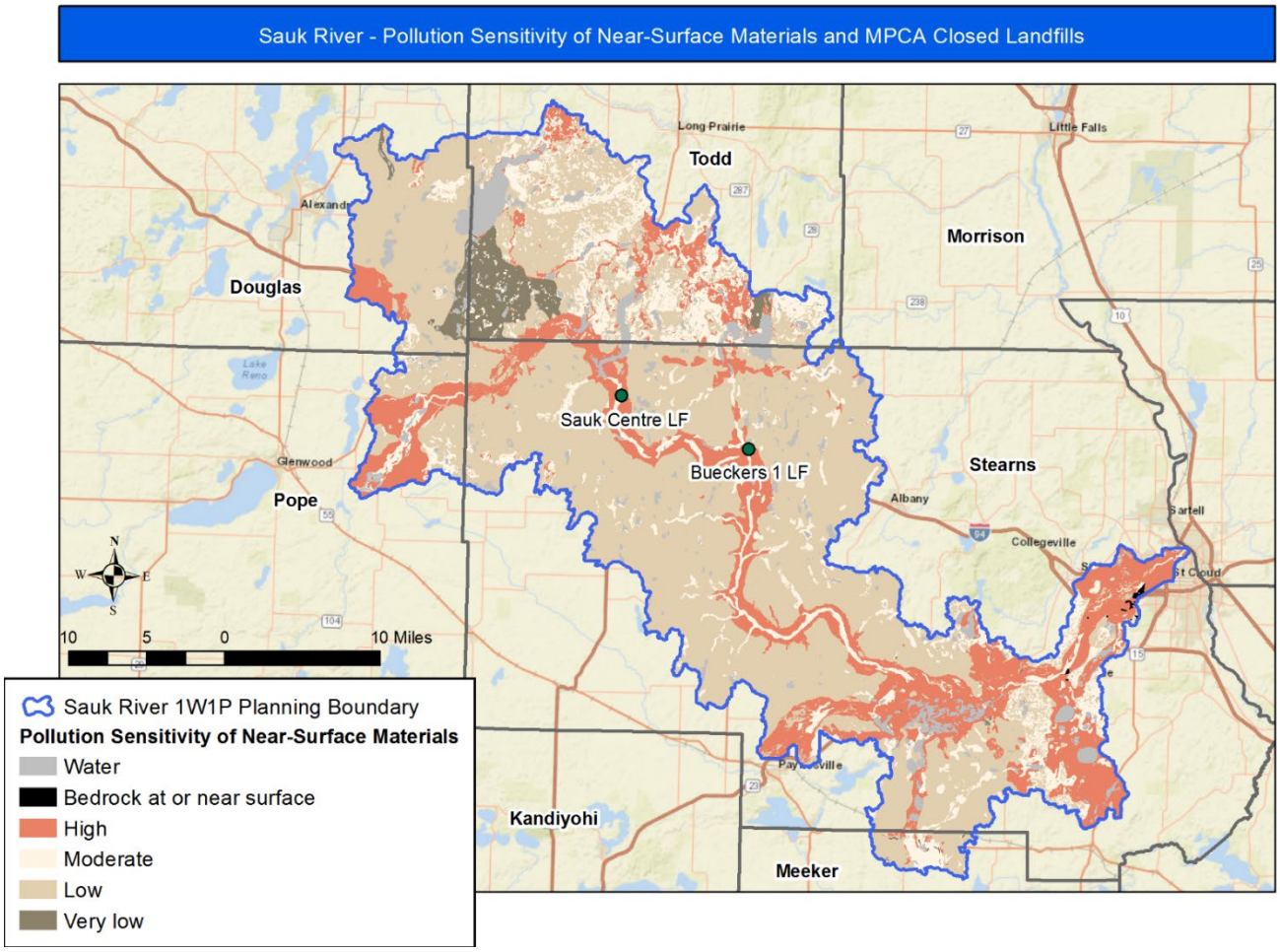

Figure 25: Sauk River Watershed - MPCA Closed Landfills

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 13 provides a more comprehensive list of specific actions the SRW 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. All MS4 permitted systems are located on the eastern edge of the SRW, including Stearns County, St. Cloud, and Waite Park. Entities with an MS4 permit require 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.

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. Table 13 provides a more comprehensive list of additional actions the SRW 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 about HHW 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, MDA partners 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, mobile collection 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 13 provides a more comprehensive list of specific actions the SRW can take to assure consumer products do not contaminate groundwater.

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)*.

Groundwater Quantity Issues and Concerns

The SRW depends on sand and gravel aquifers, both surficial (water table) and buried (confined). The crystalline bedrock in this area is generally not a good aquifer. Groundwater levels generally follow multiyear cycles that are correlated with precipitation. There is also a seasonal variation in water levels that is likely due to pumping. The surficial sand (water table) aquifer water levels vary over approximately a 5-foot range and the buried sand aquifer water levels vary over a 10-foot range.

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 storm water flow.

To understand whether there are groundwater quantity concerns in the SRW, 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 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 SRW, 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, interpreting impacts of pumping and climate, planning for water conservation, evaluating water use conflicts, and inform other water management decisions.

Data over a multiple decade period of record are needed 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 forty or more years. Additional 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.

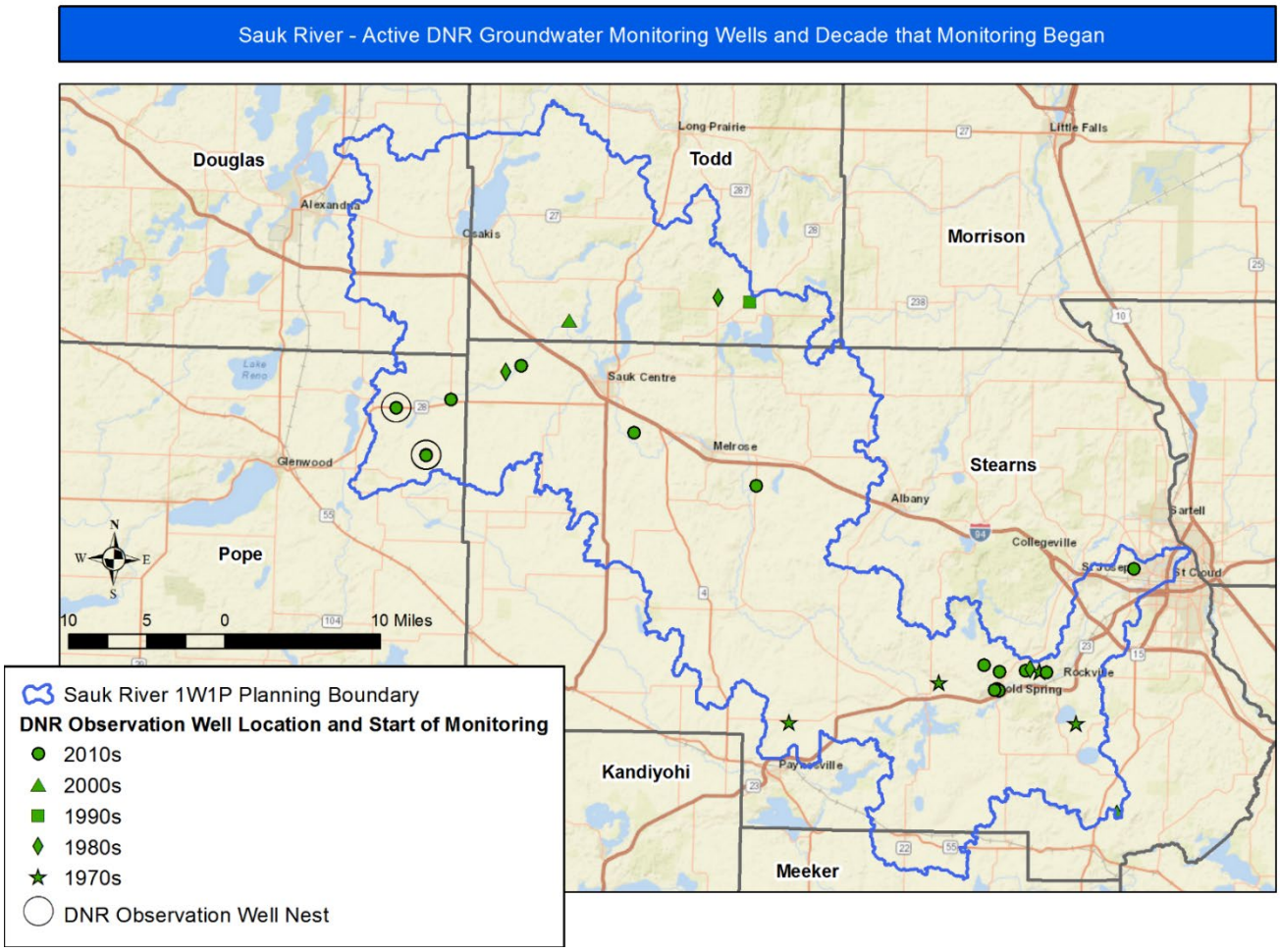

Figure 26: Sauk River Watershed - Location of Active DNR Groundwater Monitoring Wells

Seven observation wells with greater than 20 years of record were analyzed for water level trends by the Mann-Kendall non-parametric statistical method (Figure 26). The period from 1989 to 2018 was used for trend analysis in each well. Six wells are completed in the surficial sand (water table) aquifer and one well is completed in the buried sand and gravel 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 27. The Mann-Kendall method can indicate an upward trend, a downward trend or no trend. All calculated trends from observation wells in the SRW were no trend. A downward trend can result from changes in precipitation and groundwater recharge, or increases in nearby pumping, or both. The location of wells with hydrographs showing water elevation over time are shown in Figure 28. The hydrographs are shown in Figure 29 a-h.

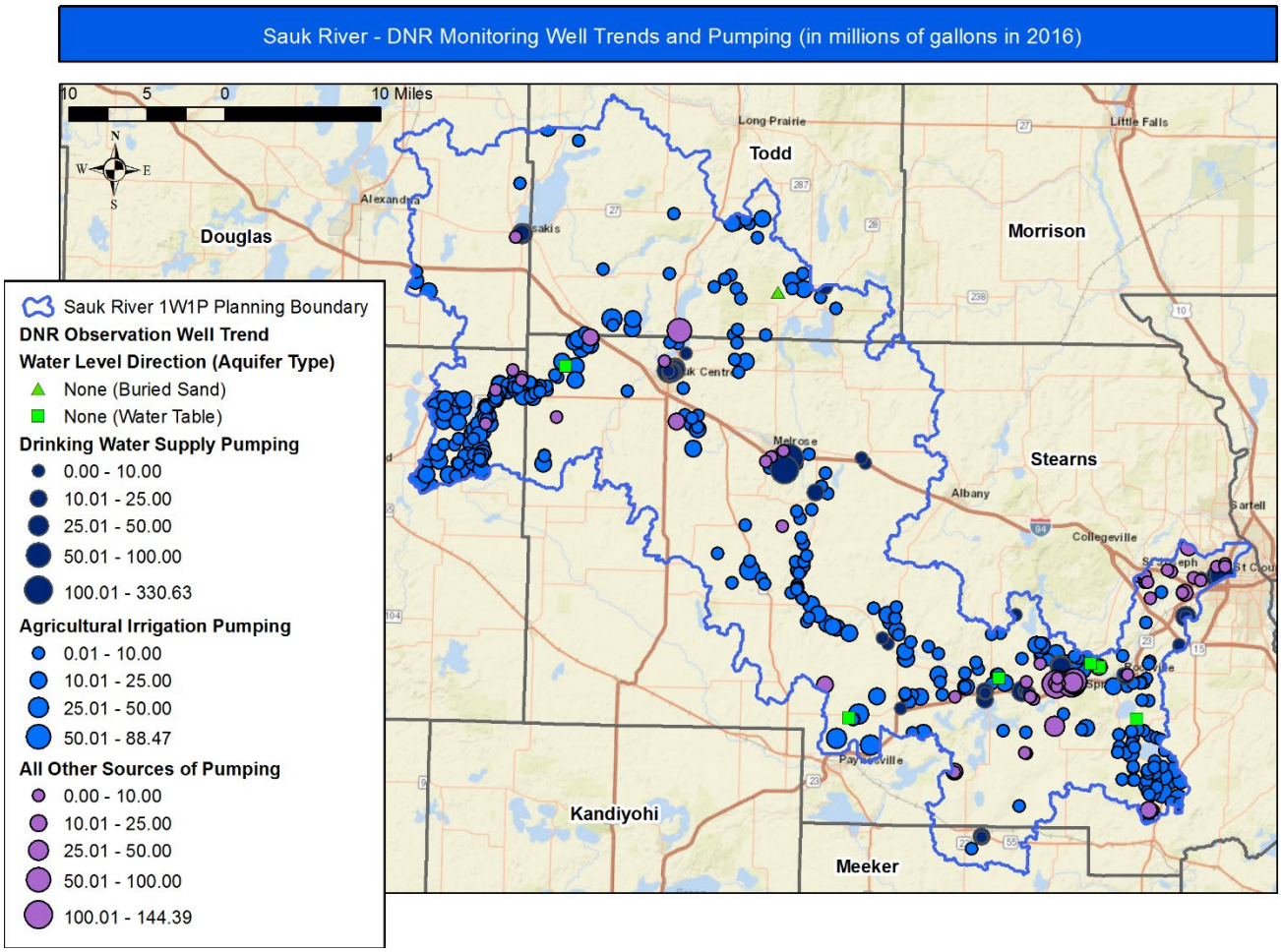

Figure 27: Sauk River Watershed - Location of Long-Term DNR Groundwater Level Monitoring Wells with enough water level measures to do a statistical trend analysis.

Figure 27, the circles represent water use data. The colors of circles correspond to water use permits issued for agricultural irrigation, public water supply, and all remaining sources of water use. The size of the symbol indicates how many millions of gallons were reported as pumped in 2016.

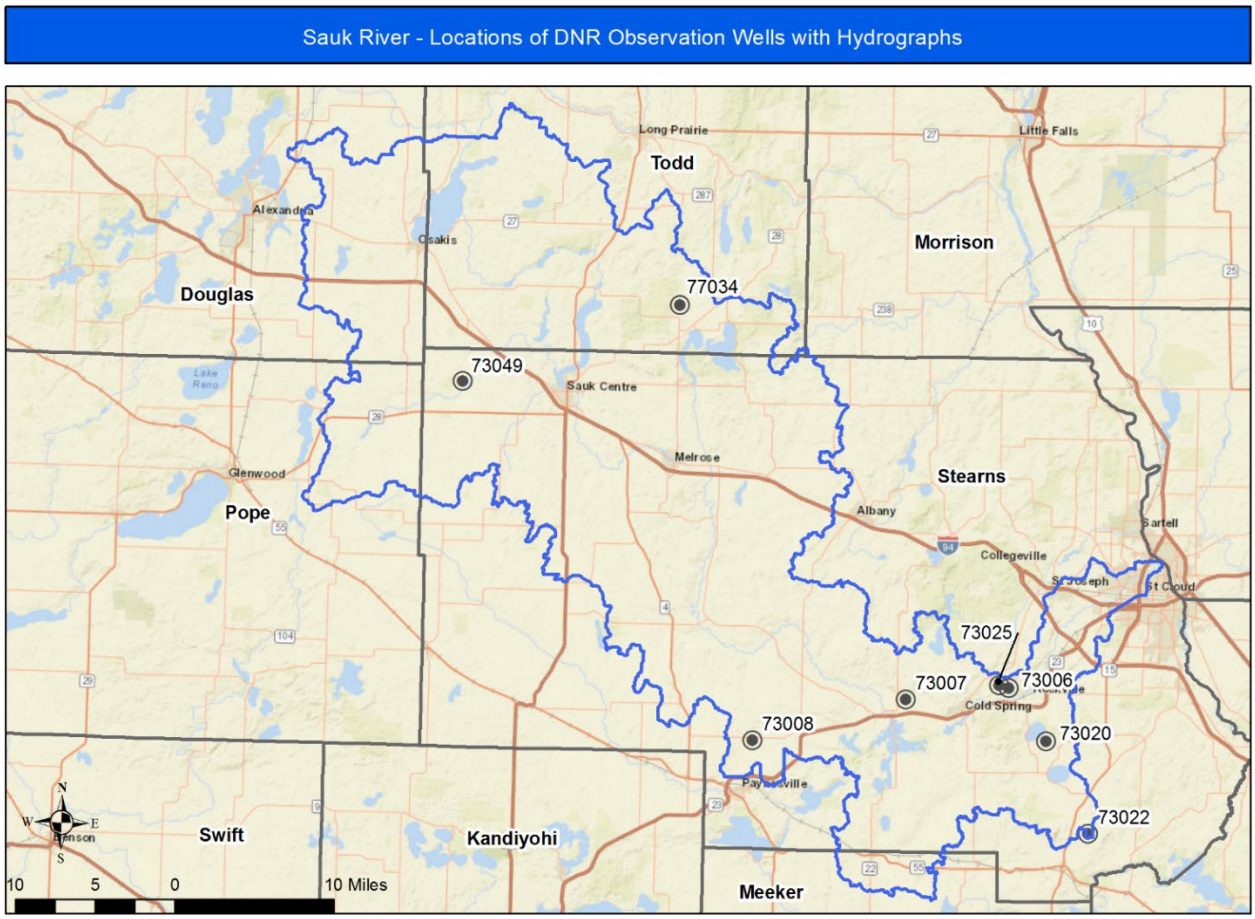

Figure 28: Sauk River Watershed - DNR Observation Wells with Hydrographs

Water levels in both the water table and buried sand aquifers are primarily correlated with long-term precipitation cycles. Seasonal changes in water levels are related to nearby pumping.

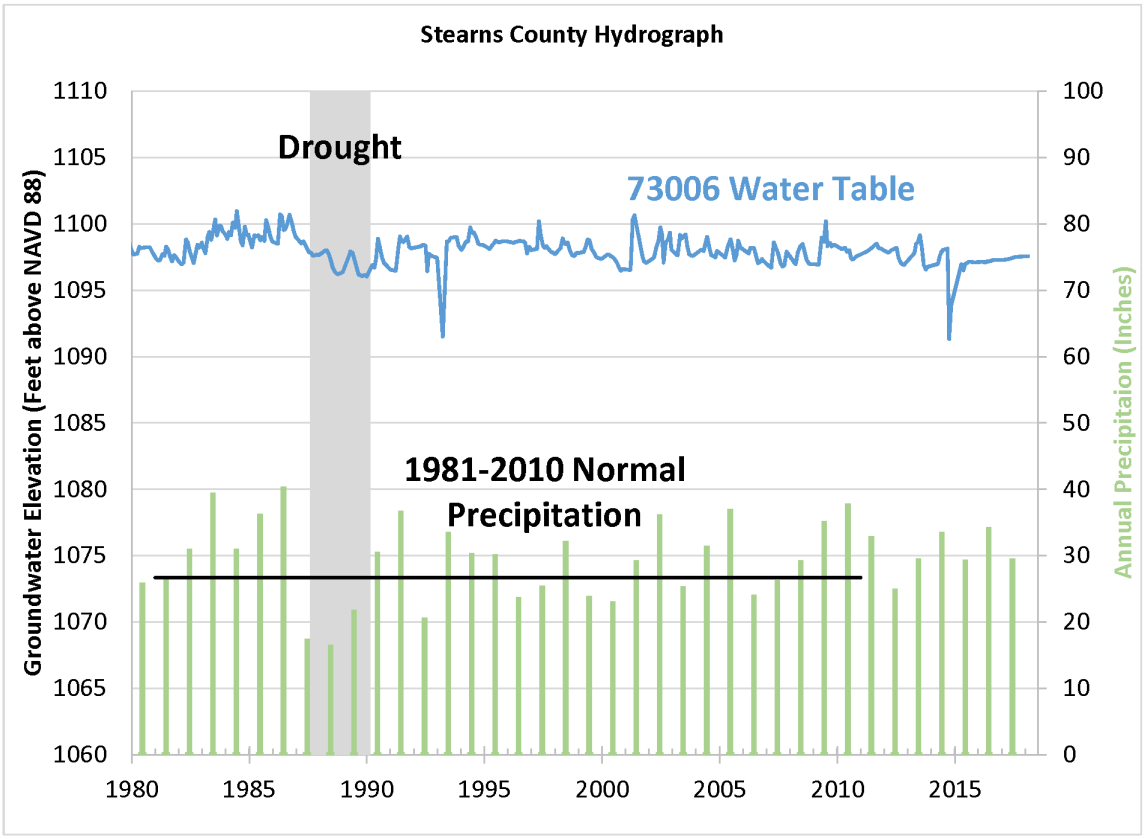

Figure 29a: Sauk River Watershed - Hydrographs from observation well nest 73006.

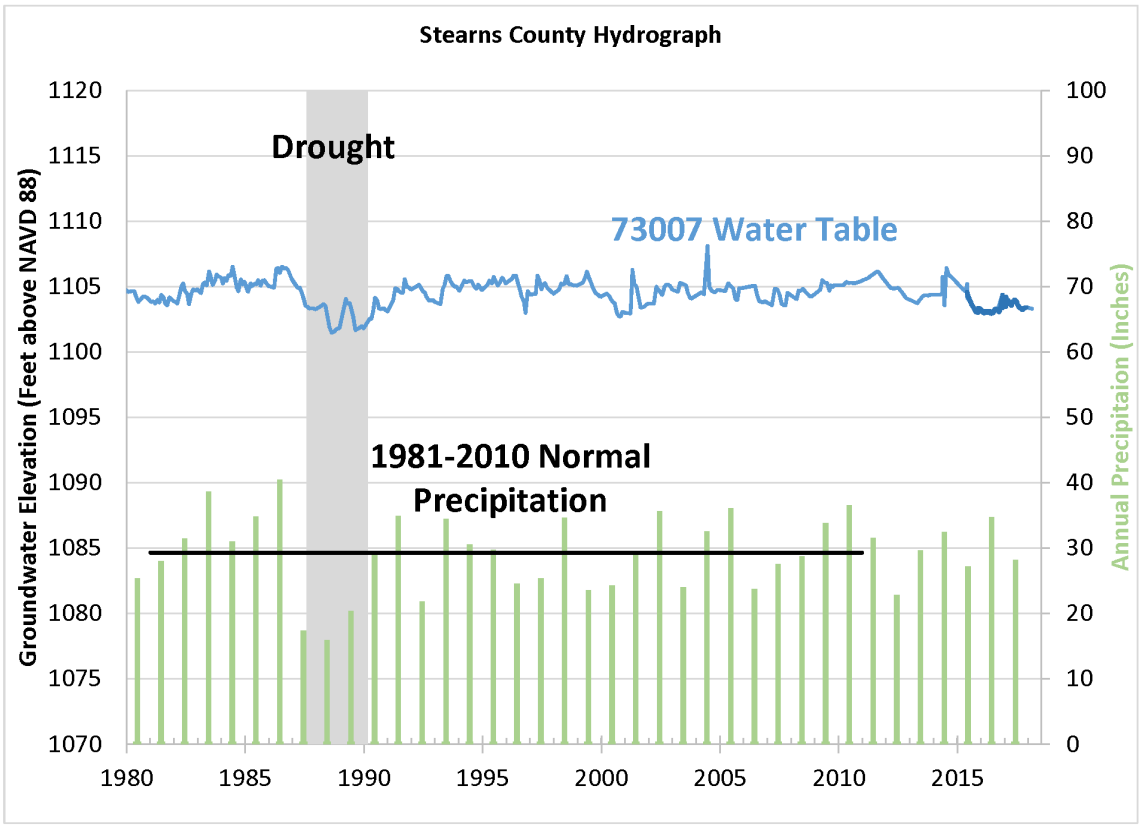

Figure 29b: Sauk River Watershed - Hydrographs from observation well 73007.

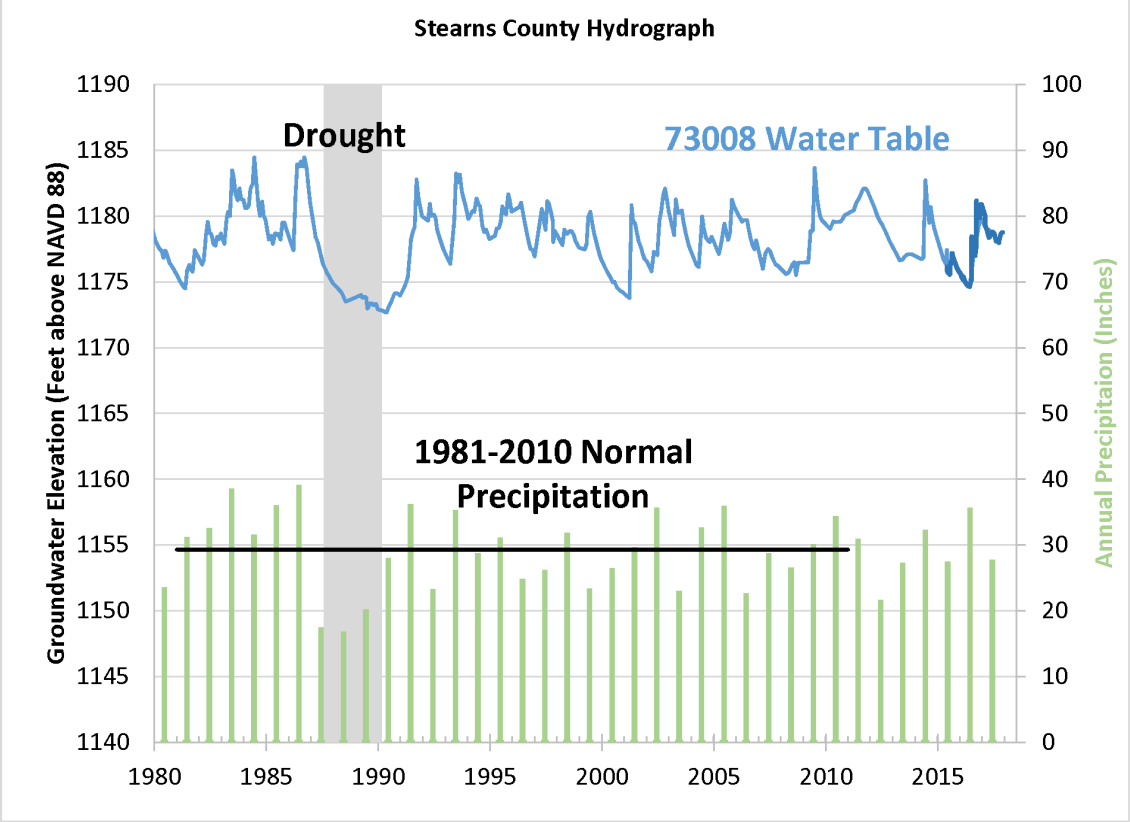

Figure 29c: Sauk River Watershed - Hydrographs from observation well 73008.

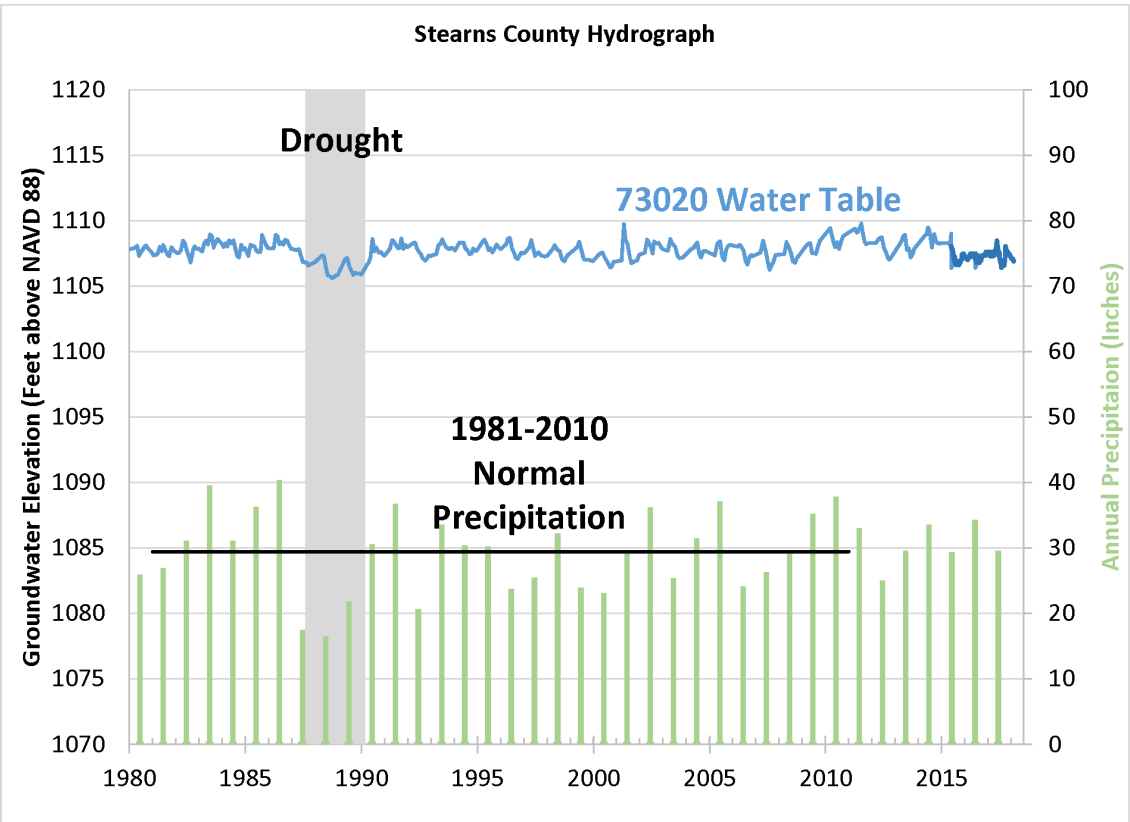

Figure 29d: Sauk River Watershed - Hydrograph from observation well 73020.

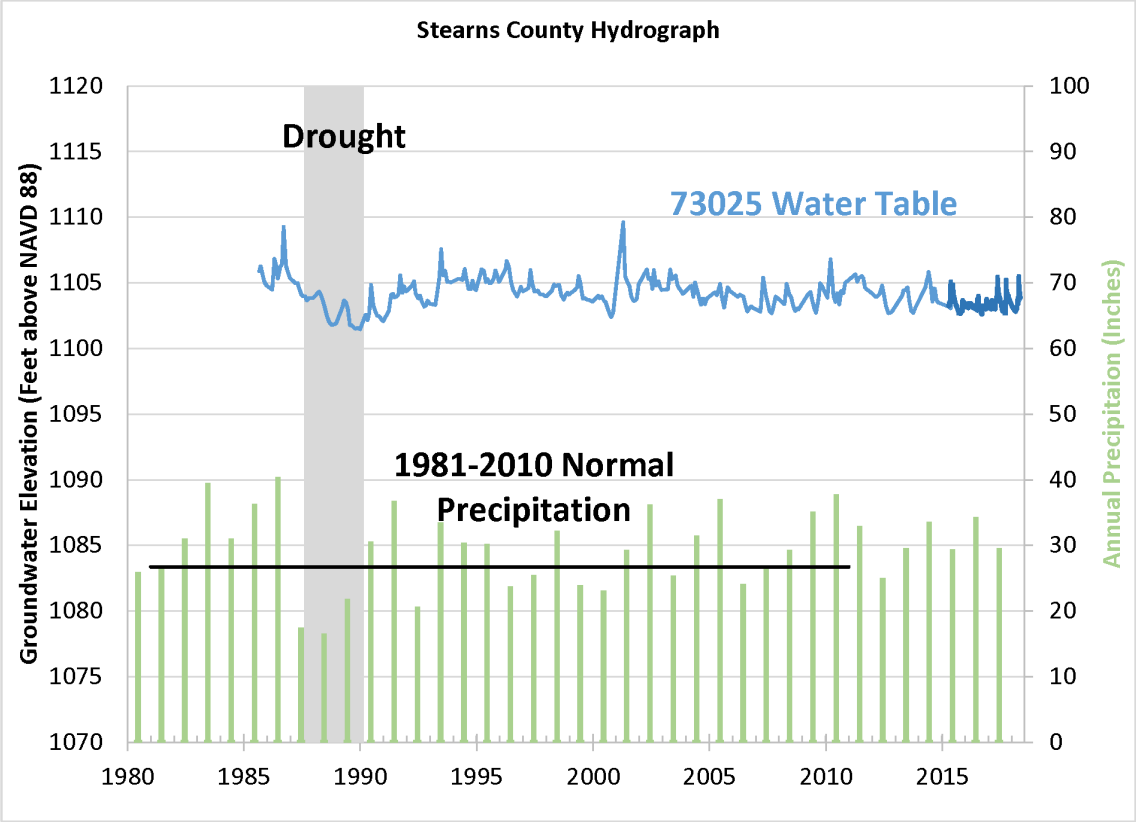

Figure 29e: Sauk River Watershed – Hydrograph from observation well 73025.

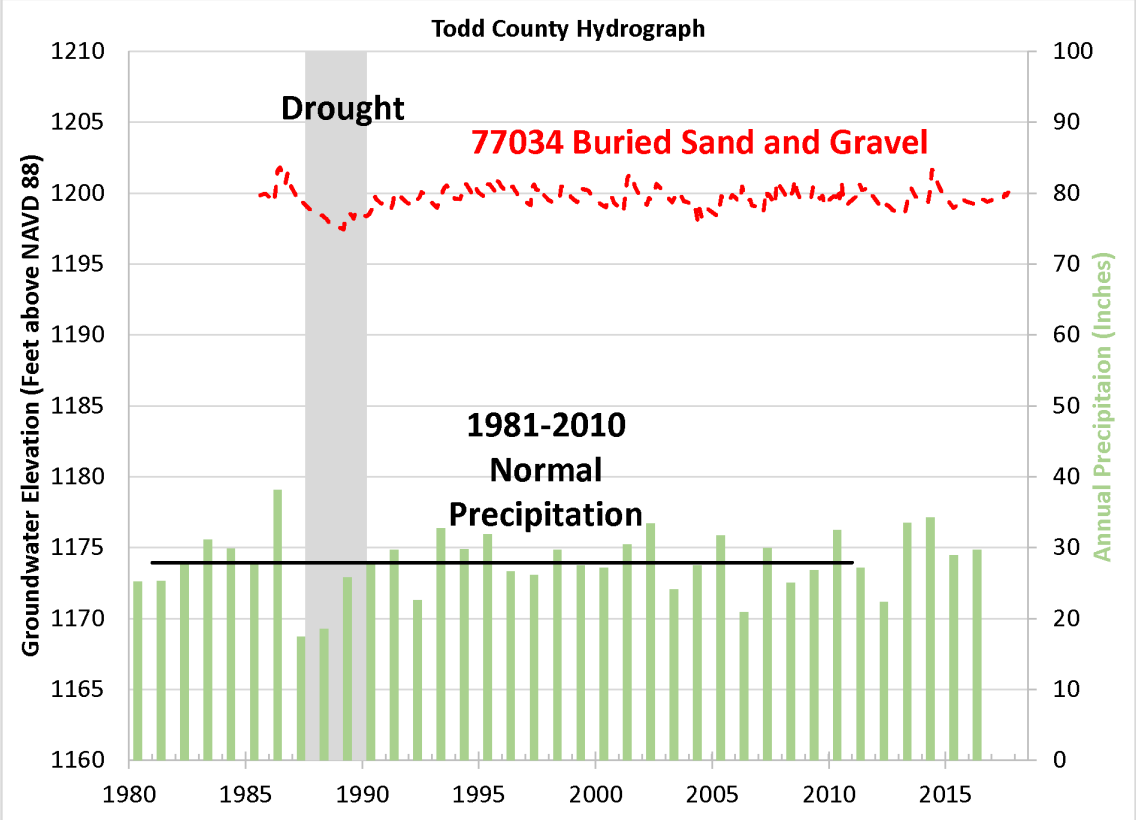

Figure 29f: Sauk River Watershed – Hydrographs from observation well 77034.

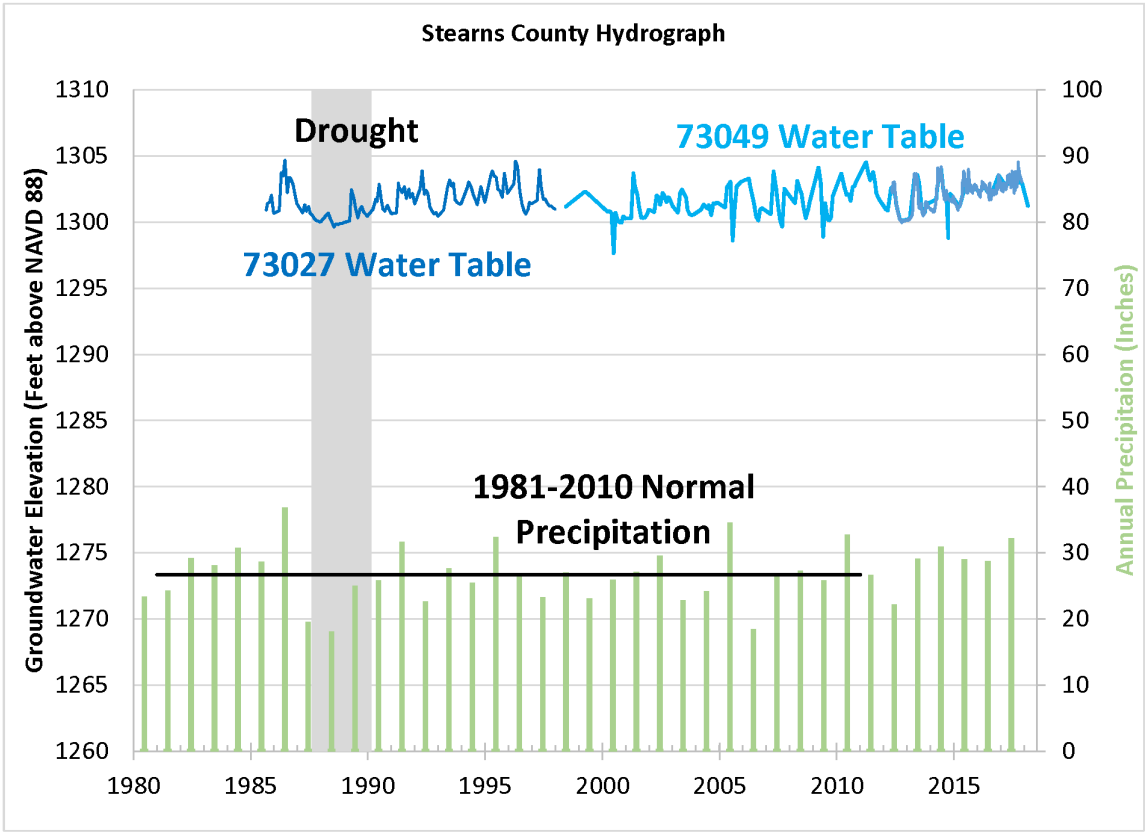

Figure 29g: Sauk River Watershed – Hydrograph from observation well 73027 are 73049. Although the two wells are 1065 feet apart, they are both constructed in the water table aquifer and have similar water levels. Connecting the water level records from both wells to form one hydrograph creates a long-term hydrograph that shows the water levels have changed little from 1985 to 2017.

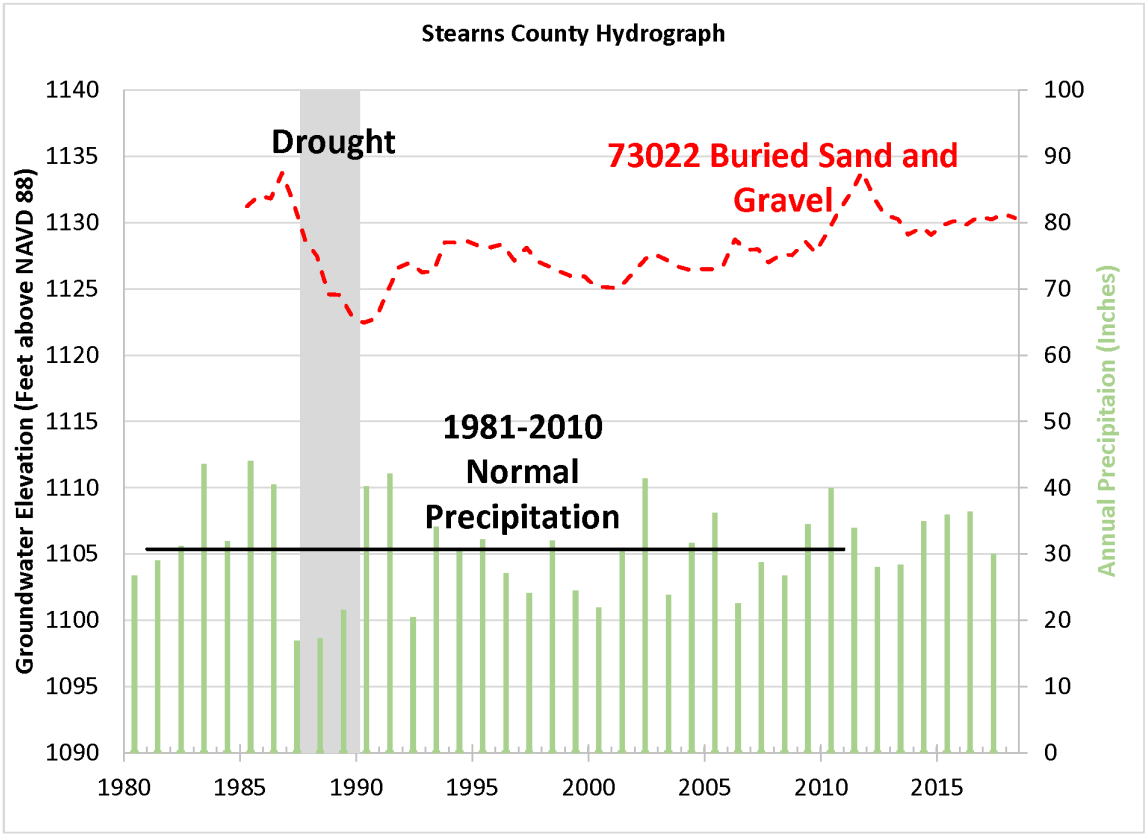

Figure 29h: Sauk River Watershed – Hydrograph from observation well 73022.

Data from observation wells measure how water levels in an aquifer change over time. In aquifers connected to the land surface water levels 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 connected features.

Groundwater Connected Natural Features at Risk

The SRW boundary includes significant natural features, including surface waters that depend on groundwater to sustain them (Figure 30 through 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 SRW:

- Three designated calcareous fens: Spring Hill Fen, Big Lake SW, and Roscoe North
- Five designated trout streams
- Wetland complexes across the entire area
- Lakes that may be susceptible to changing aquifer levels
- Twenty-three kinds of native plant communities connected to groundwater
- Eleven rare plant and animal species connected with groundwater that are listed as threatened or special concern. This list includes state listed species.

Rare Natural Features Connected with Groundwater in the Sauk River Watershed

Rare natural features (Figure 30 and Figure 31) 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 three designated calcareous fens in the SRW (Spring Hill Fen, Big Lake SW, and Roscoe North). Calcareous fens are very rare prairie wetlands that only occur in 10 states and are fed by a constant supply of cool, calcium rich groundwater that supports a unique set of plants and animals. Calcareous fens support three of the rare plants and zero of the rare animals found in the SRW. These fens are protected from harm under Minnesota Statute (103G.223). When they decline it is a signal to us that some element or process of our groundwater system is not functioning well. Once lost, these communities cannot be replaced. The Perch Creek WMA is one such example of a calcareous fen that has been lost. It was impacted by a change in groundwater supply and land use that led to periodic flooding, which contributed to its decline to the point that it is no longer recognizable as a viable calcareous fen community—in essence, it no longer exists on the landscape.

There are five designated trout streams in the SRW, listed below. 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).

- Cold Springs Creek (M-074-004)
- Little Sauk Creek (M-074-066)
- Kinzer Creek (M-074-005)

- Trout Creek (M-074-053-005-002)
- Cold Spring Creek (M-074-004-001)

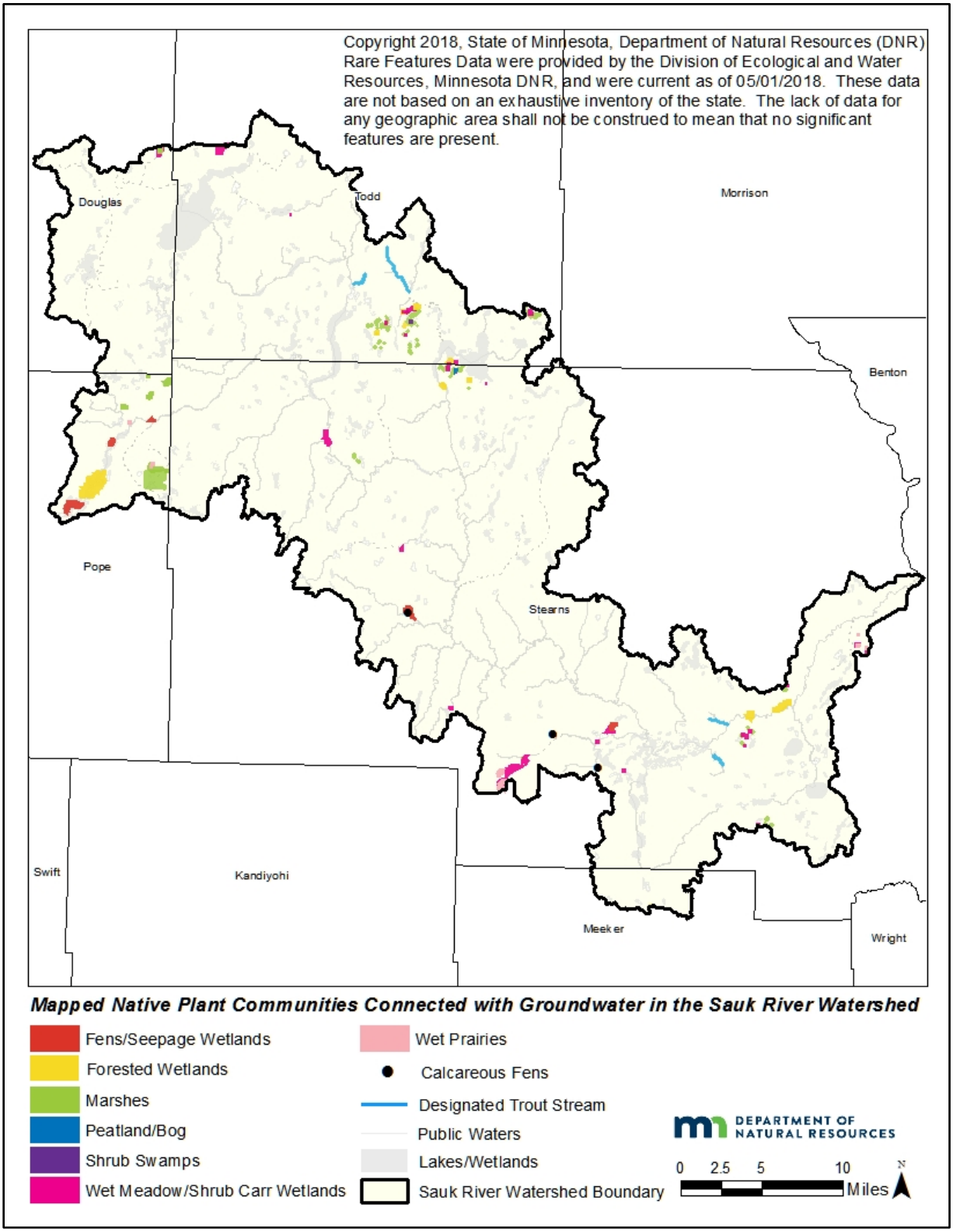

Figure 30: Sauk River Watershed - Native Plant Communities Connected with Groundwater

There are 28 kinds of native plant communities associated or dependent on groundwater in the SRW. They range from forested communities such as rich tamarack swamps and floodplain forests, to open communities such as wet prairies and rich fens. Seven of the these communities are considered

critically imperiled or imperiled and four are considered vulnerable status. Twelve of the 28 native plant communities associated with or dependent on groundwater are considered apparently secure or secure.

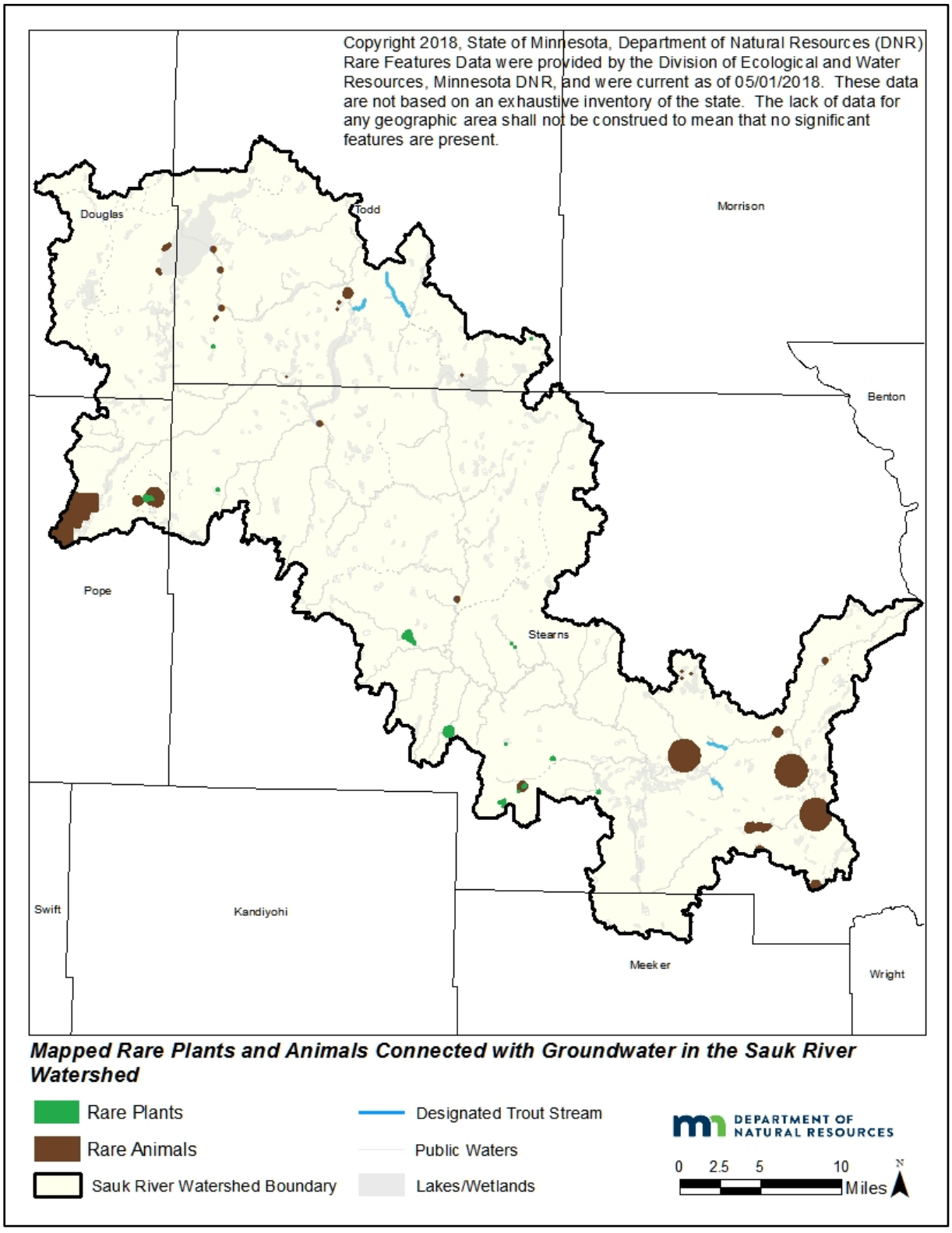

Figure 31: Sauk River Watershed - Rare Plants, Animals, and Native Plant Communities Connected with Groundwater

There are 12 species of animals and plants that are either threatened, special concern, or a state listed "Species In Greatest Conservation Need," that are dependent on habitats with groundwater or

groundwater seepage areas in the SRW. 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 14 through Table 17.

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

All lakes are connected to groundwater, but the specific interaction between lake water and groundwater depends on the geology, topography, and volume of surface-water inflow and outflow associated with the lake. There are three basic lake types (Petersen and Solstad, 2007):

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 for the purposes of this GRAPS report, the lake level versus outlet elevation has not been studied. 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 32). Two-hundred-six of the 423 lakes in the SRW have a watershed to lake area ratio of 10 or less and are considered groundwater-dependent lakes. Large-scale groundwater pumping near a lake will likely have more impact on groundwater-dominated lakes than on surface water dominant lakes.

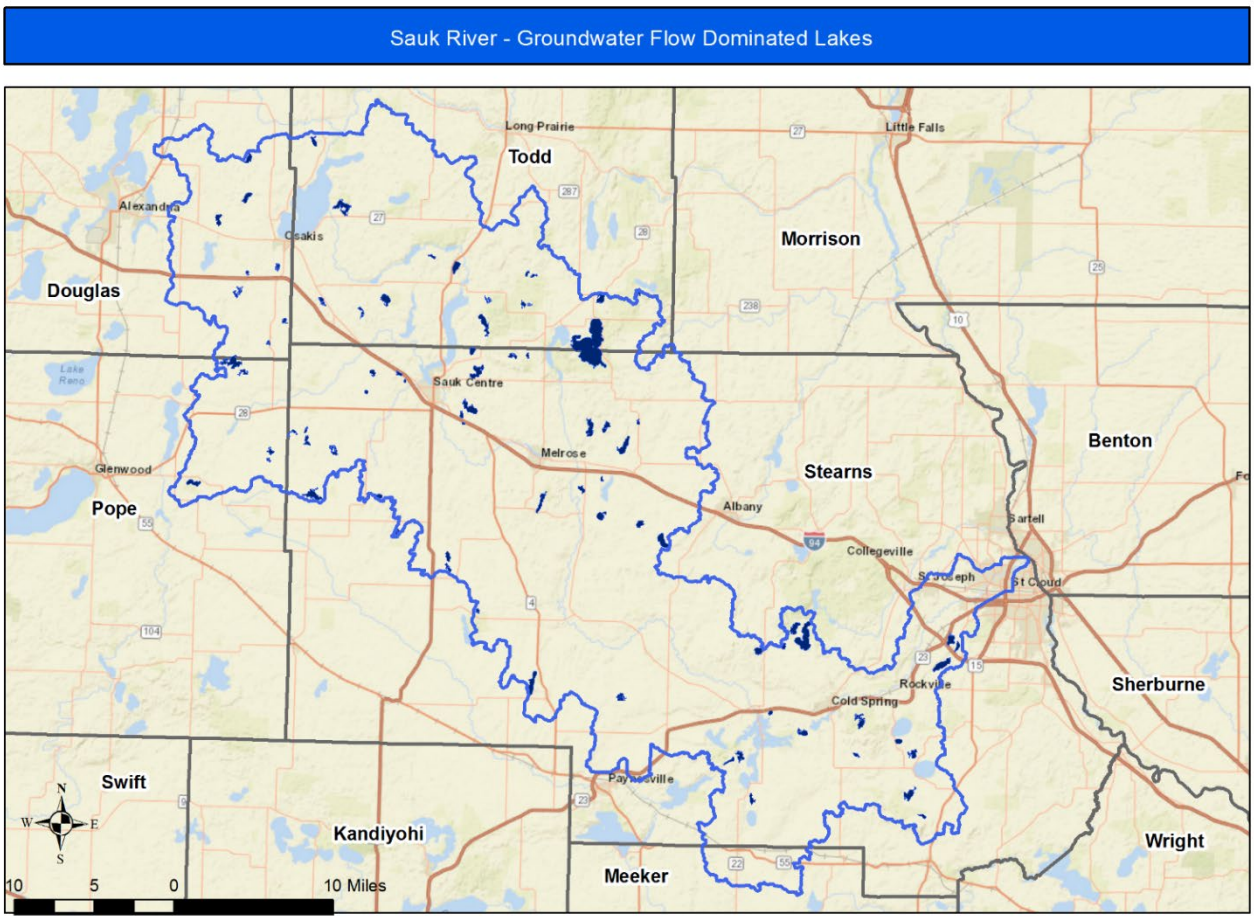

Figure 32: Sauk River Watershed - Groundwater Dominated Lakes

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 13) provides a more comprehensive list of specific actions the SRW can take to conserve water and promote recharge.

Sauk River Watershed 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 subwatershed (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 13) will 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 13) 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 6). 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 material than an area with low sensitivity that has a protective clay 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 13) 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 the SRW 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 13) 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 of remediating already-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 cost 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 are focused 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 Sauk River Watershed

This section provides a table of strategies and actions local partners in the SRW 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 key approaches to achieving the goal.
- **Recommended Groundwater Actions** are specific actions prescribed to a specific county or HUC-10 within the watershed that will help achieve the goal and pertains to the supporting strategy.

Figure 33 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.

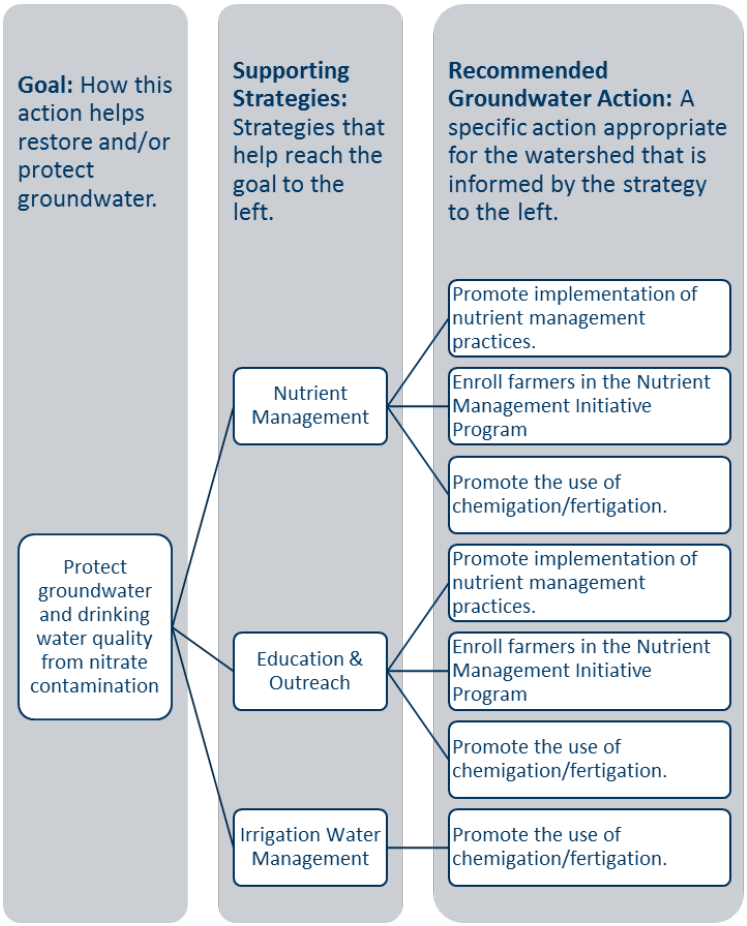

Figure 33: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 13) 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; and
- 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 13 represent:

- **Goal:** How the action in this row helps restore and/or protect groundwater. The goals have been sorted alphabetically as much as possible. Each goal identifies the main objective—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 you 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's' 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 subwatershed to a specific geographic area. For example, many of the subwatersheds 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 you work.
- **HUC-8s Involved**: This column denotes which HUC-8 major watershed(s) within the SRW to consider using the action described in the corresponding row. There are four HUC-8s within the watershed. Table 12 provides the name and the HUC-8 number assigned to each major watershed. Figure 2 is a map of the HUC-8s.
- **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-8s. 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-8 to target. The maps are listed in *italicized font.* You can click on the *blue text* that says the figure number for the map to hyperlink directly to the map being referenced.
- **Benefit:_____ [10]:** This series of 'X' marks whether the corresponding action may have additional benefits. An 'X' denotes the action could create the described additional benefit.

Table 12: HUC 10 subwatersheds within the Sauk River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Headwaters Sauk River	Headwaters	0701020201
Ashley Creek	Ashley Creek	0701020202
Upper Sauk River	Upper Sauk	0701020203
Adley Creek	Adley Creek	0701020204
Middle Sauk River	Middle Sauk	0701020205
Lower Sauk River	Lower Sauk	0701020206

Summary of Key Findings and Issues

Below is a summary of key groundwater quality and quantity findings found in the SRW. This summary can be used to help target groundwater actions during the 1W1P exercise.

[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; GWCF=Improve/Protect Groundwater Connected 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*).

Key Groundwater Quality Findings and Issues

- **Nitrate** – almost two percent of tested drinking water wells had levels at or above the SDWA standard of 10 mg/L. Shallow wells, less than 50 feet deep, had approximately 7 percent of samples exceed the SDWA standard.
  - MDA ambient monitoring wells recorded nitrate results ranging from 12.5 mg/L to 50.7 mg/L in the surficial aquifer. All samples exceeded the SDWA standard.
  - MDA TTP sampled almost 2700 drinking water wells for nitrate in 18 townships in the SRW. Nitrate exceedances were most prevalent in Stearns County where row crop production combined with vulnerable geology has resulted in samples exceeding the SDWA standard.
  - MPCA ambient monitoring wells detected nitrate at seven of the eight monitoring wells and in 71.2 percent of all samples. Six percent to the detections exceeded the SDWA standard.
- **Arsenic** – almost 32 percent of tested wells have elevated arsenic with approximately eight percent exceeding the SDWA standard of 10 µg/L. 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.
- **Pesticides** were detected in all nine MDA monitoring wells, but not at concentrations above human-health based drinking water standards or reference values.
- **DWSMAs** cover approximately 50,011 acres in the watershed. Thirteen of the 17 approved community wellhead protection plans exhibit a high vulnerability in all or part of their DWSMA and are considered vulnerable to contamination from the land surface.
- **Animal feedlots –** There are 1670 active feedlots in the watershed with the greatest concentration in Stearns County. All counties within the watershed are delegated counties and manage the feedlot program locally.
- **Row crop agriculture** accounts for nearly 50 percent of land cover in the watershed. In areas with high pollution sensitivity, agricultural inputs can contaminate the underlying aquifer.
- **SSTS** are found throughout the watershed. Information reported by counties indicate Meeker County has the highest number of failing SSTS at two to three per 1,000 acres, with all other counties estimating failing systems at one to two per 1,000 acres.
- **Contaminated sites –** Over one quarter of all registered tanks are leaking chemicals into the environment and have the potential to cause localized groundwater pollution.
  - Two closed landfills with known groundwater contamination plumes are found within the watershed.

Key Groundwater Quantity Findings and Issues

- The SRW depends on the sand and gravel aquifers, both surficial (water table) and buried (confined). The crystalline bedrock in this area is generally not a good aquifer.
- Groundwater levels generally follow multiyear cycles that correlated with precipitation. There is also seasonal variation that is likely due to pumping.
- The surficial sand (water table) aquifer water levels vary over approximately 5-foot range and the buried sand aquifer water levels very over a 10-foot range.
- All calculated trends from DNR observation wells in the SRW were no trend, indicating water use has remained consistent over the period of record.
- SRW has three designated calcareous fens (Spring Hill Fen, Big Lake SW, and Roscoe North) and five designated trout streams.
- Two-hundred-six of the 423 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes, susceptible to changing aquifer levels.
- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Twenty-three kinds of native plant communities and 11 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater that are at risk to changing aquifer levels and degraded groundwater quality.

Table of Actions and Strategies to Restore and Protect Groundwater

Table 13: Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*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	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 21)* *Drinking Water Wells Map (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 for: ▪ Coliform Bacteria (every year) ▪ Nitrate (every other year) ▪ Arsenic (at least once) ▪ Lead (at least once) ▪ Manganese (at least once)	X	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells, high pollution sensitivity, and/or where there are known groundwater contaminants. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *Arsenic Map (Figure 21)* *Drinking Water Wells Map (Figure 21)* *Nitrate Map (Figure 17)*						
Protect Private Well Users: Manage Wells **Protect Groundwater and Drinking Water**	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	All	MDH Well MGMT	Prioritize areas with a high density of private wells *Drinking Water Wells Map (Figure 21)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Quality: Manage Wells																
Protect Groundwater and Drinking Water Quality: Well Sealing	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	All	MDH Well MGMT	Prioritize areas with a high density of private wells and DWSMAs. *Drinking Water Wells Map (Figure 21)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Well Inventory	Land Use Planning and Management	To understand water quality trends, establish a well inventory to record baseline data or changes in groundwater quality. An example of a successful model is the Southeast MN Domestic Well Network.	X	X	X	X	X	All	MDH Well MGMT	*N/A*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management Land Use Planning and Management	▪ Identify MPCA closed landfill locations 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. ▪ 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				X		Upper Sauk Middle Sauk	MPCA CLP Land Manager	*Closed Landfill Map (Figure 25)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		be notified regarding any changes in the migration or movement of contaminants. ▪ Educate residents about the proper disposal of HHW, pharmaceuticals and personal care products that can contaminant landfills.														
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	All	MPCA Tanks Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Tank & Leak Site Map (Figure 24)*						
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	All	MPCA Feedlot Program	*Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs.* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Manure 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	All	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*			X	X		X
Protect Groundwater and Drinking Water Quality: Manure Management	Education and Outreach Nutrient Management Contaminant Planning and Management	Promote actions to prepare for field application of manure: ▪ Inspect equipment to ensure everything is functioning properly to avoid leaks or spills ▪ Get manure sampled and analyzed for nutrient availability ▪ Plan applications for each field ▪ Determine any setbacks needed in fields and mark locations of sensitive features to avoid	X	X	X	X	X	All	MPCA Feedlot Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*			X	X		X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Use the Minnesota Runoff Risk Advisory Forecast system tool to determine the best time to apply manure. ▪ Put together an emergency action plan that identifies leak and spill containment														
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 source, right rate, right timing, and right place) ▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen use in Minnesota ▪ 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	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)*						X
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	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program.						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
										Pollution Sensitivity Map (Figure 6) *Pollution Sensitivity Wells* (Figure 9) *DWSMA Map* (Figure 11) *Township Testing Map* (Figure 18)						
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach Cropland Management	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	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map* (Figure 6) *Pollution Sensitivity Wells* (Figure 9) *DWSMA Map* (Figure 11) *Township Testing Map* (Figure 18)	X		X		X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote the adoption of cover crops for scavenging nutrients under row crops.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, irrigated row crops, highly vulnerable DWSMAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map* (Figure 6) *Pollution Sensitivity Wells* (Figure 9) *DWSMA Map* (Figure 11) *Township Testing Map* (Figure 18) *Drinking Water Wells Map* (Figure 21)	X		X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	X	All	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 27)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water 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	X	All	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 27)*						X
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	All	NRCS Field Office	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*			X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
										Township Testing Map (Figure 18) *Nitrate in Wells Maps (Figure 17)*						
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient 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 alternative nitrogen management practices, soil health, and second crops.	X	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *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	Education and Outreach Cropland Management Integrated Pest Management	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	All	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)* *Pesticides Map (Figure 20)*		X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	Upper Sauk Middle Sauk Lower Sauk	UMN Lawns & Turfgrass MGMT Team	Focus in MS4 communities and residential developments with high pollution sensitivity, along with highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*			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	All	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						X
Protect Groundwater and Drinking Water	Education and Outreach	Promote to farmers and area businesses the Agricultural and Non-Agricultural Waste	X	X	X	X	X	All	MDA Pesticide &	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity,						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Quality: Pesticides		Pesticide Collection Program to dispose of unwanted and unusable pesticides.							Fertilizer Division	highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						
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	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 21)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
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	X	X	X	X	X	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 21)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
		▪ Financial options to repair or replace failing or non-compliant system								*Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
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	All	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 21)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection (WHP)	Education and Outreach Cropland Management Land Use Planning and Management	Serve on WHP planning teams to assist public water suppliers with planning and implementation activities to address land use planning concerns.	X	X	X	X	X	All	MDH SWP Unit	*Wellhead Protection Plan Development Status (Figure 10)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Land Use Planning and Management	Integrate WHP plan strategies into local plans, such as the 1W1P and land use plans.	X	X	X	X	X	All	MDH SWP Unit	*DWSMA Map (Figure 11)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water: Household Hazardous Waste (HHW)	Education and Outreach Land Use Planning and Management	▪ Educate the public about the risks of improperly disposing of HHW and promote community-supported collection sites. ▪ Make disposal of HHW easy for the public by expanding collection sites through mobile units by stopping in different communities throughout the summer for free drop off. ▪ Promote other recycling options of various products at area businesses throughout the year.	X	X	X	X	X	All	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
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	All	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
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	All	MDH CEC Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	All	DNR Ecological & Water Resources	Focus in areas with high pollution sensitivity. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)*						
Protect Groundwater and Drinking Water Quality Water Sustainability	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 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.	X	X	X	X	X	All	MDH Well MGMT & SWP Unit	N/A						
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 connected features from future land use impacts for their long-term sustainability and use.	X	X	X	X	X	All	MN Assoc. of Counties	Focus in areas with high sensitivity, highly vulnerable DWSMAs and groundwater connected natural features *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)*		X				

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
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	All	MDH SWP Unit	*Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *Tank & Leak Site Map (Figure 24)*						
Groundwater Sustainability: Water Conservation	Land Use Planning and Management	Plan for future population growth by reflecting drinking water quality and quantity issues in land use plans. Use planning tools such as setbacks, performance standards, conditional use permits, zoning districts, etc. that protect aquifer health and yield.				X	X	Upper Sauk Middle Sauk Lower Sauk	MN Assoc. of Counties	Prioritize highly vulnerable DWSMAs and areas of high water use: *DWSMA Map (Figure 11)* *Monitoring Wells/Pumping (Figure 27)*		X				
Protect Groundwater and Drinking Water Quality	Working Lands Initiative	Explore incentivizing the adoption of perennial crops for improved water quality.				X		Middle Sauk	BWSR	Target the piloted subwatersheds identified in the Working Lands Initiative final report.	X	X	X	X	X	X
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	All	BWSR	Prioritize areas of high pollution sensitivity, and highly vulnerable DWSMAs. Target areas of high water use, known groundwater connected	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Sustainability: Recharge										natural features. Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Monitoring Wells/Pumping (Figure 27)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *RIM Easements Map (Figure 34)*						
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	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 dependent features, areas of high pollution sensitivity, and highly vulnerable DWSMAs. *RIM Easements Map (Figure 34)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *Pollution Sensitivity Map (Figure 6)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
										DWSMA Map (Figure 11)							
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.				X	X	Upper Sauk Middle Sauk Lower Sauk	MPCA MS4 Program	Prioritize MS4 communities, target highly sensitive areas, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *DWSMA Map (Figure 11)*	X	X		X		X
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 beyond 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	X	All	MDA Pesticide & Fertilizer Division	Prioritize areas of high water use intensity by agricultural irrigators, highly sensitive areas, and highly vulnerable DWSMAs. *Monitoring Wells/Pumping (Figure 27)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*		X		X		X
Groundwater Sustainability:	Education and Outreach	Provide education on water conservation practices that can be adopted in people's	X	X	X	X	X	All	DNR Ecological & Water	N/A		X				

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Douglas Co.	Target Pope Co.	Target Todd Co.	Target Stearns Co.	Target Meeker Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Water Conservation		homes and businesses. Use the Met Council's Water Conservation Toolbox.							Resources							
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		Headwaters Upper Sauk Middle Sauk Lower Sauk	DNR Ecological & Water Resources	N/A		X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers with a water appropriation 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	X	All	DNR Ecological & Water Resources	Prioritize areas of high water use intensity by agricultural irrigators. *Monitoring Wells/Pumping (Figure 27)*		X				X
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		All	DNR Ecological & Water Resources	Target areas near sensitive features and groundwater fed lakes. *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* Groundwater Dominated Lakes Map *(Figure 32)*	X	X	X	X	X	X

Descriptions of Supporting Strategies

Working Lands Initiative

A BWSR initiative that explored incentivizing planting perennial crops to improve water quality. This initiative developed a detailed plan that identified pilot watersheds that are expected to result in the greatest water quality improvement and exhibit readiness to participate based on a number of criteria. The minor watershed of Getchell Creek was selected based on the high nutrient volumes it contributes to the Sauk River. The adjacent watershed of County Ditch 9 was included in the analysis in order to include the DWMSA for the cities of Meire Grove and Greenwald, both of which show moderate levels of vulnerability. Additionally, results of the MDA TTP indicate that Grove Township, where County Ditch 9 is located, over 10 percent of the private wells tested show nitrate levels above 10 mg/L.

Through the landowner surveys, over 30 percent of respondents indicated a very likely willingness to planting perennial or cover crops if higher payments were awarded. Additionally, tax benefits and compensation for lost crop production also ranked high. BWSR's Working Lands Watershed Restoration Program (www.bwsr.state.mn.us/planning/WLWRP/wlwrp.html) provides additional information on the program, including the final report.

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 land uses, such as row crop agriculture, will help protect groundwater quantity and quality.

Existing Programs and Resources

- MDA **Conservation Reserve Program** (http://www.mda.state.mn.us/protecting/conservation/programs/ccrp.aspx): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR **Conservation Reserve Enhancement Program - CREP** (http://www.bwsr.state.mn.us/crep/index.html): This project is a federal, state and local partnership and will voluntarily retire environmentally sensitive land using the nationally-recognized Reinvest in Minnesota (RIM) Reserve program. Figure 34 shows where RIM easements are in the watershed.

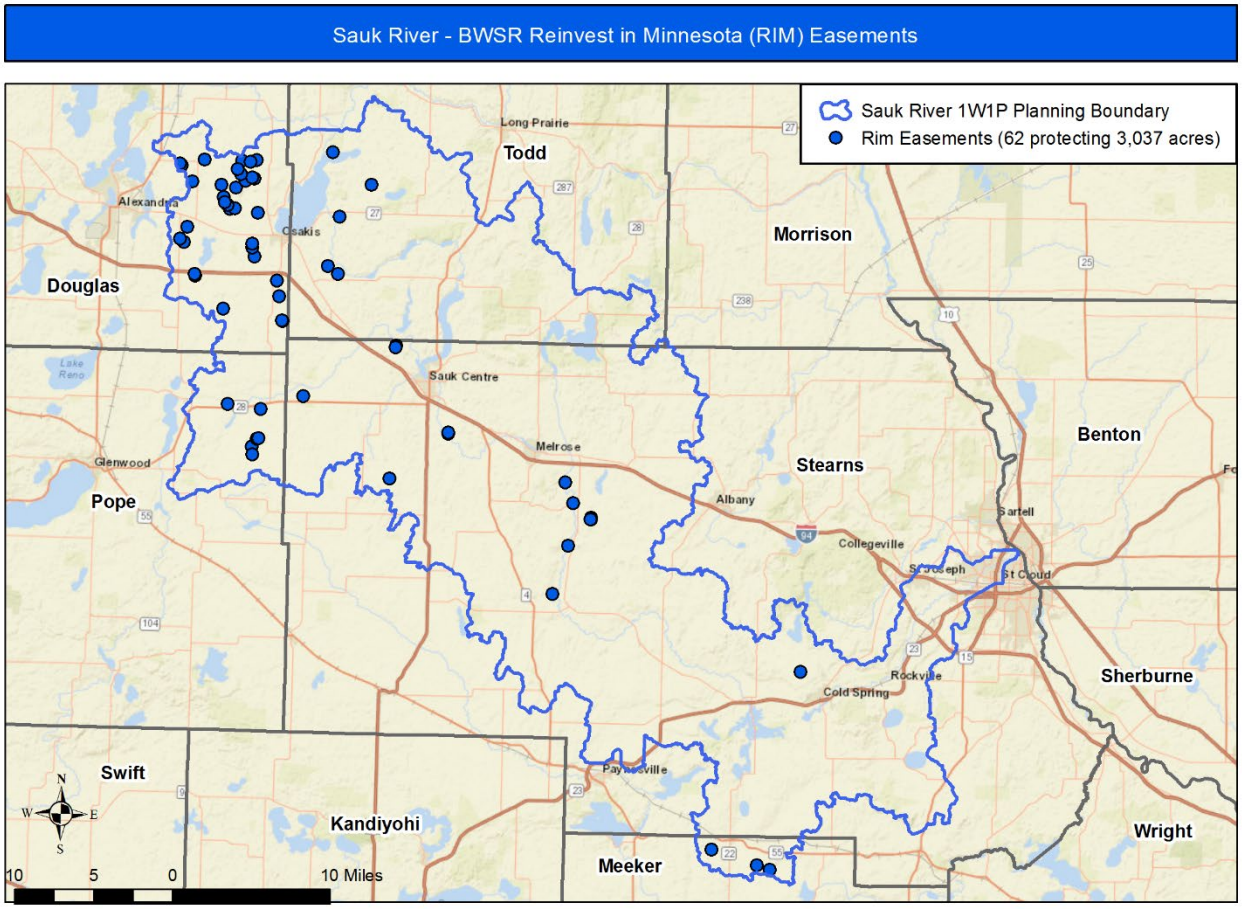

Figure 34: Sauk River Watershed – BWSR RIM easements

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 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 (CECs) 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 **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 at 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 **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.
- MDH **Water Treatment Units for Arsenic Reduction** (http://www.health.state.mn.us/divs/eh/wells/waterquality/arsenictreat.pdf)
- 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 which 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 **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, as well as 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** (https://www.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 **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** (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** (http://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 (PDF)** (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 35 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.

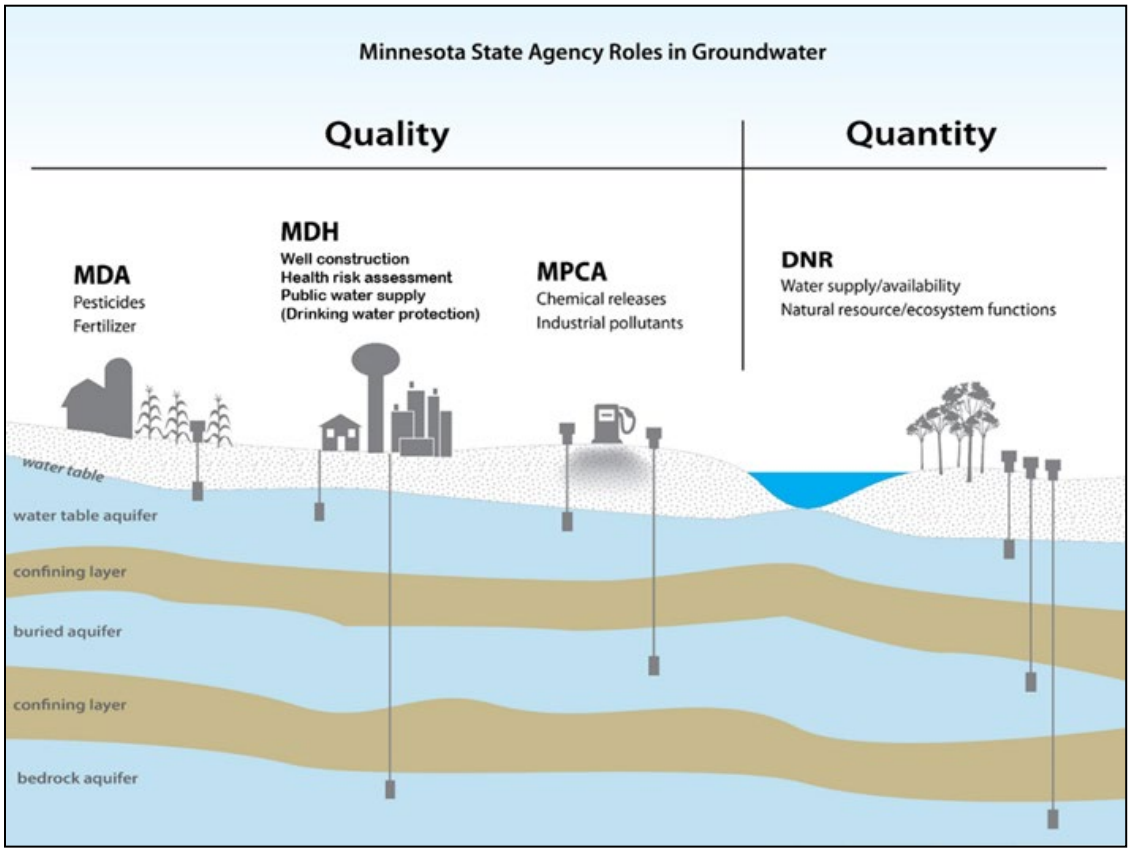

Figure 35: Minnesota State Agency Roles in Groundwater

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.

Figure 36 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.

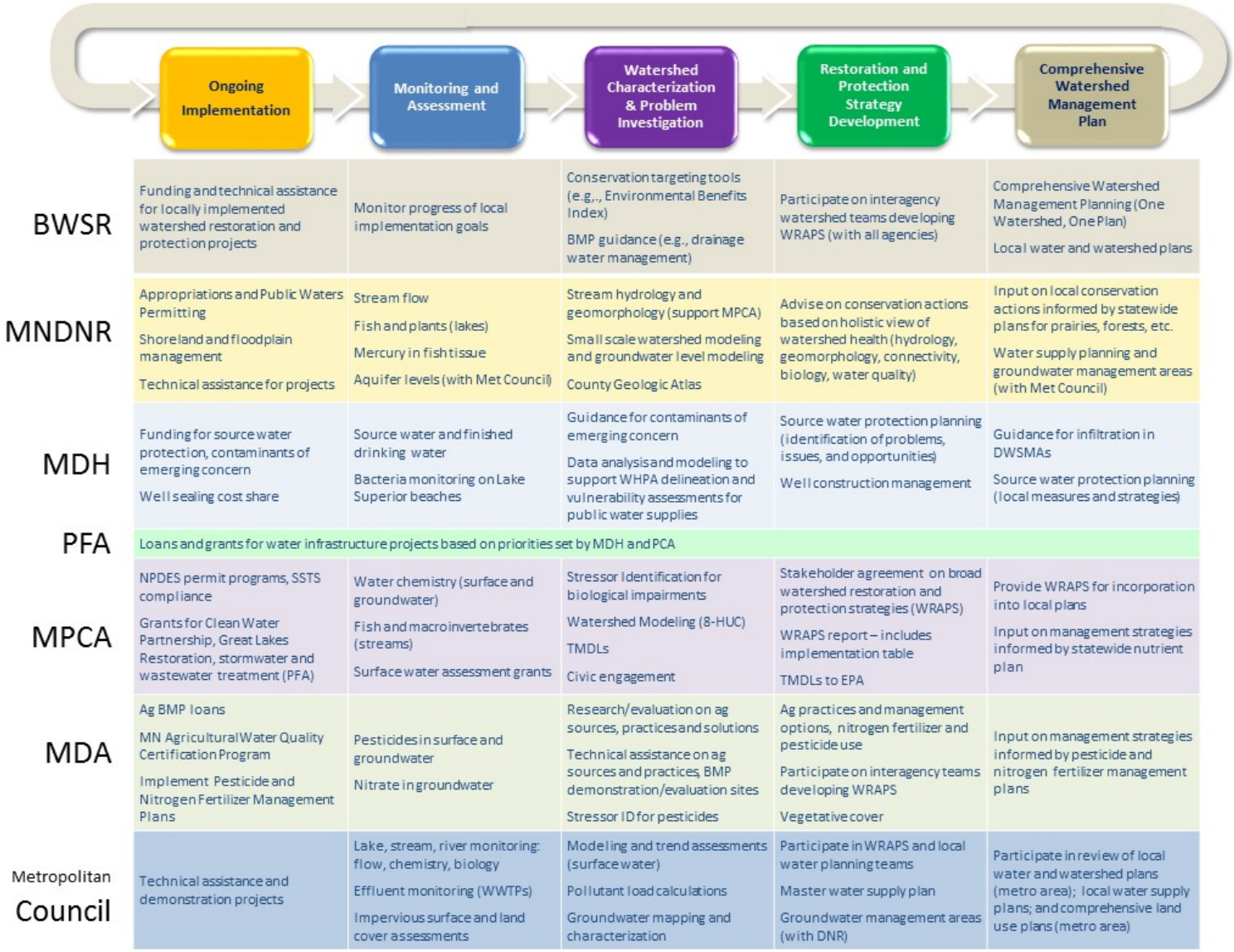

Figure 36: Roles agencies play within the Minnesota Water Management Framework

Appendices

List of Acronyms

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 Public Water Supply System

A public water supply system that serves at least 25 persons or 15 service connections year-round, which includes municipalities (cities), manufactured mobile home parks, nursing homes, etc.

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.

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).

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Additional Resources

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

Type of Information	Where you can get more information
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)
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

Type of Information	Where you can get more information
	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

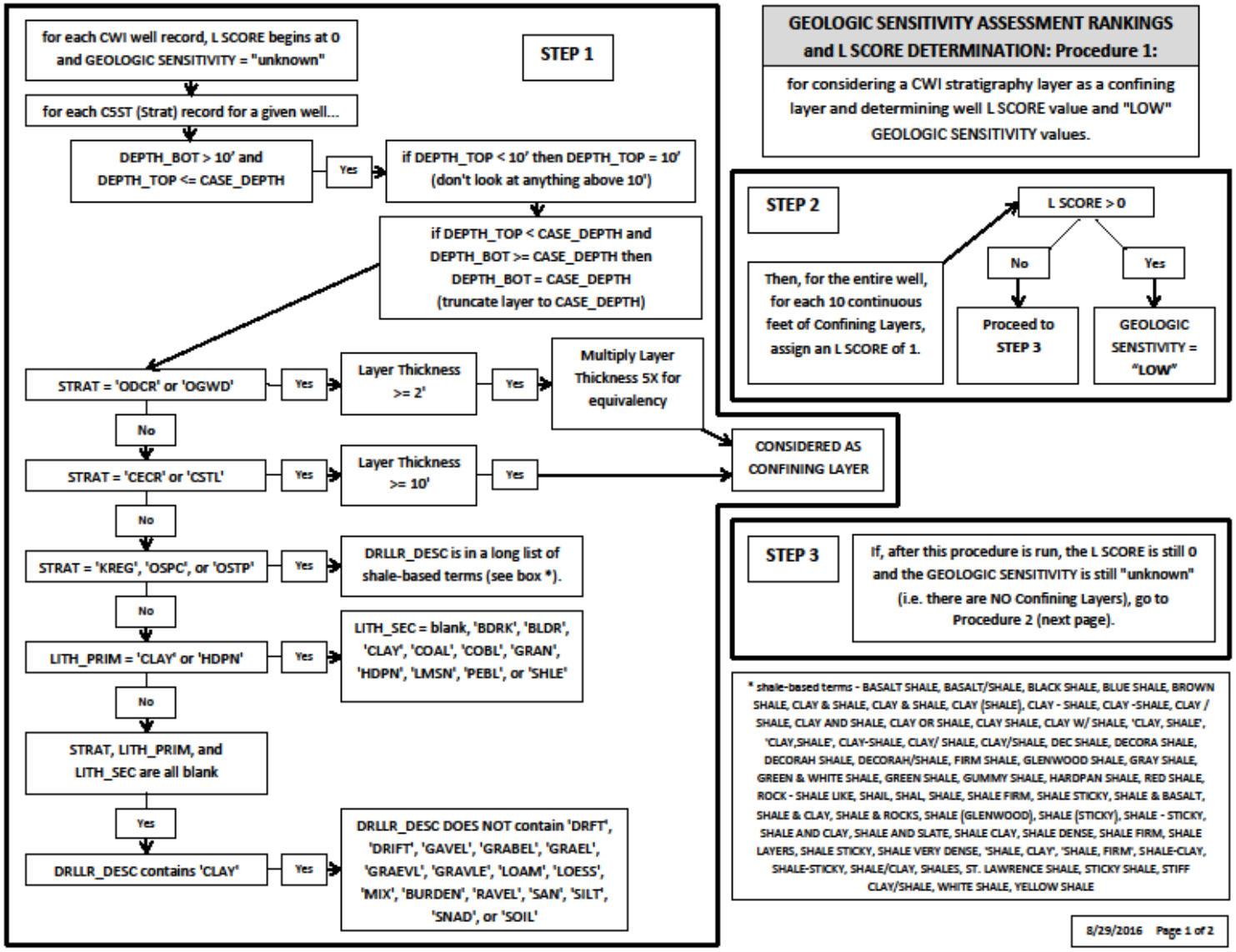

Figure 37: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9)

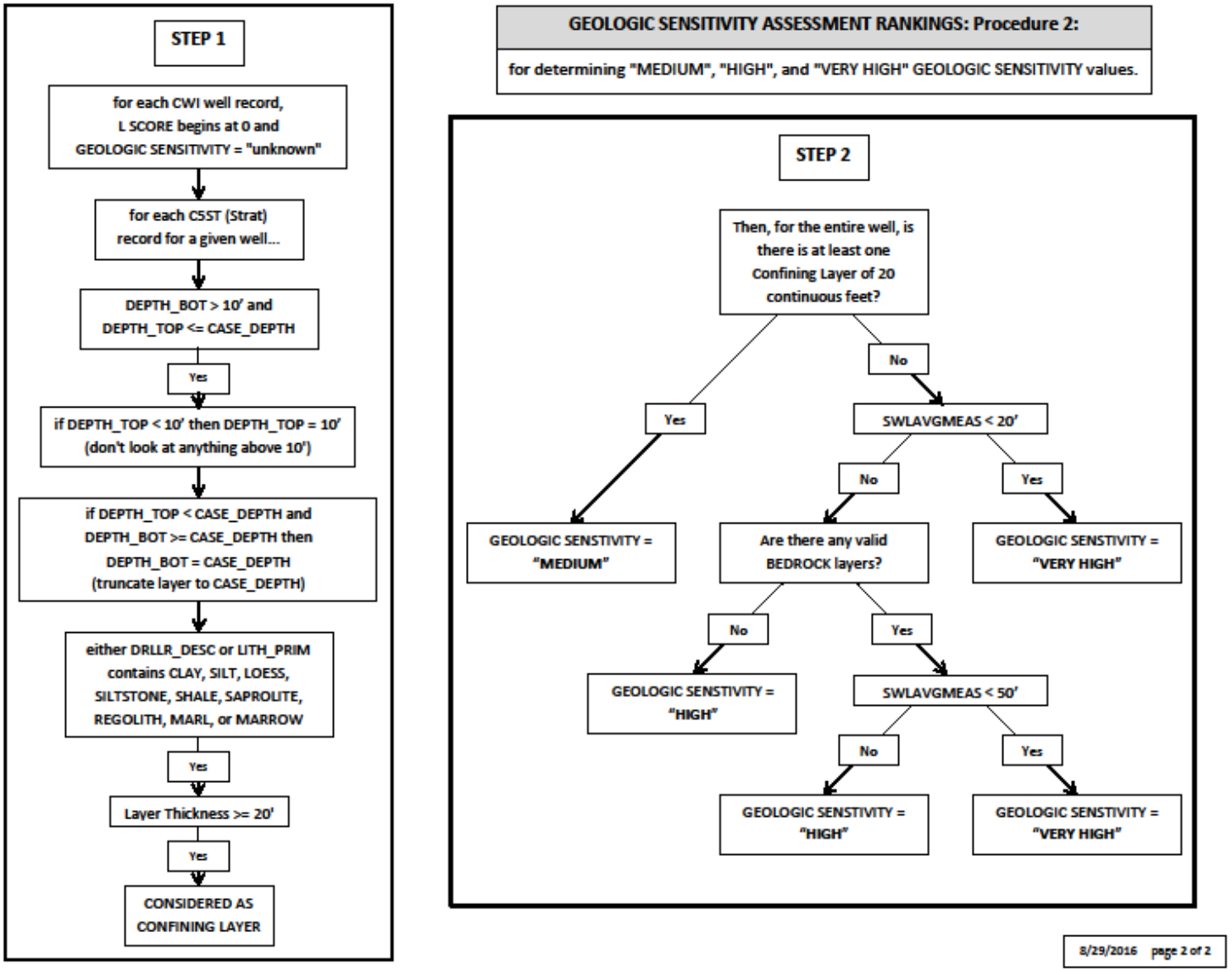

Figure 38: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9) continued

Table 14: Rare Species Connected with Groundwater in the Sauk River Watershed[11]

Scientific Name	Common Name	Species Class	Listing Status[12]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Plant: Carex sterilis	Sterile Sedge	Terrestrial Plant	THR	N	Y	Y	Calcareous fens that are mineral rich
Rare Plant: *Cypripedium candidum*	Small White Lady's-slipper	Terrestrial Plant	SPC	N	Y	Sometimes	Occurs in Calcareous fens, which are groundwater dependent; Calcareous seeps; wet prairie
Rare Plant: *Rhynchospora capillacea*	Hair-like Beak Rush	Terrestrial Plant	THR	N	Y	Y	Calcareous fens; spring fens
Rare Plant: *Rubus semisetosus*	Swamp Blackberry ("Half Bristly Bramble")	Terrestrial Plant	THR	N	Y	Y	Fens, meadows, swamps and prairie/savanna-like habitats. When occurring prairie/savanna-like habitat, often found near ecotone edge of wetland areas
Rare Amphibians: *Anaxyrus cognatus*	Great Plains Toad	Amphibian	SPC; SGCN	Y	Y	Likely	Flooded fields, temporary and semi-permanent wetlands provide breeding sites; relationship of groundwater to flooded fields within species ranges; Upland and lowland prairie
Rare Bird: *Botaurus lentiginosus*	American Bitten	Bird	Watch List; SGCN	N	Y	Sometimes	Marshes/wetlands
Rare Bird: *Grus canadensis*	Sandhill Crane	Bird	Watch List	N	Y	Sometimes	Open prairies, grasslands, and wetlands
Rare Bird: *Phalaropus tricolor*	Wilson's Phalarope	Bird	THR; SGCN	N	Y	Maybe	Wet prairie or rich fen habitats; Or grass or sedge-dominated wetlands; requires very shallow water associated with prairies, open rich peatlands, or other open habitats

[11] Last Updated 0/23/2018

[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]	AQUATIC (Y OR N)	WETLAND (Y OR N)	GROUNDWATER DEPENDENT (Y OR N)	General Habitat Type
Rare Fish: *Etheostoma microperca*	Least Darter	Fish	SPC; SGCN	Y	Sometimes	N?	Occupies areas of still water, possibly using wetlands which are permanently or seasonally connected to streams.
Rare Fish: *Notropis anogenus*	Pugnose Shiner	Fish	THR; SGCN	Y	N	N?	Prefers clear glacial lakes and streams with dense vegetation. Not much is known; glacial lakes and streams with good water clarity and an abundance of submerged vegetation
Rare Insects: *Marpissa grata*	A jumping spider	Insect	Watch List	N	Sometimes	Possibly	Wetlands, ponds, and rivers that contains sedges or emergent vegetation
Rare Insects: *Paradamoetas fontanus*	A jumping spider	Insect	SPC; SGCN	N	Y	Probably	Coffin and Pfannmuller 1988; Occurs in bogs, marsh edges, mesic prairie, and uplands prairie
Rare Mussel: *Pleurobema sintoxia*	Round Pigtoe	Mussel	SPC; SGCN	Y	N	Y	Medium to large rivers with sand, gravel, or mud substrates
Rare Reptile: *Emydoidea blandingii*	Blanding's Turtle	Reptile	THR; SGCN	Y	Y	Possibly	If groundwater levels impact wetland and/or river levels, then this species is groundwater dependent; known to use calcareous fens as part of their summer habitat in central Minnesota; Wetland complexes, small streams, and adjacent uplands, typically, but not always mapped as sandy soils.

Tables 15-17[13] show the documented wetland native plant communities connected to groundwater in the Sauk River Watershed.

Table 15: Sauk River Watershed – Documented wetland native plant communities dependent on sustained groundwater discharge

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Fens and Seepage Wetlands		
OPp91a	Rich Fen (Mineral Soil)	S4
OPp91c	Rich Fen (Prairie Seepage)	S3
OPp93c	Calcareous Fen (Southeastern)	S1
WMs83a	Seepage Meadow/Carr	S3

Table 16: Sauk 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		
FPn82a	Rich Tamarack - (Alder) Swamp	S5
FPs63a	Tamarack Swamp (Southern)	S2S3
WFn55b	Black Ash - Yellow Birch - Red Maple - Basswood Swamp (Eastcentral)	S3
WFs57a	Black Ash - (Red Maple) Seepage Swamp	S1S2
AFP_CX	Alder Swamp / Forested Peatland Complex	SNR
Shrub Swamps		
OPn81	Northern Shrub Shore Fen	S5
SS_CX	Shrub Swamp Complex	SNR
Wet Meadow/Shrub Carr Wetlands		
OPn92	Northern Rich Fen (Basin)	S4
OPn92a	Graminoid Rich Fen (Basin)	S4
OPn92b	Graminoid – Sphagnum Rich Fen (Basin)	S4
Peatland/Bog		

[13] Updated 05/01/2018

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
APn91a	Low Shrub Poor Fen	S5
Marshes		
MRn83a	Cattail – Sedge Marsh (Northern)	S2
MRn83b	Cattail Marsh (Northern)	S2
MRp83b	Cattail Marsh (Prairie)	S1
MMS_CX	Meadow – Marsh – Fen – Swamp Complex	SNR
MOW_CX	Marsh – Open Water Complex	SNR
PWL_CX	Prairie Wetland Complex	SNR

Table 17: Sauk River Watershed documented wetland native plant communities dependent on groundwater associated with water tables that are high for some portion of the growing season

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
FFs59a	Silver Maple - Green Ash - Cottonwood Terrace Forest	S3 - Vulnerable to Extirpation
WFs55a	Lowland Aspen Forest	S4 - Apparently Secure; Uncommon but not Rare
Wet Meadow/Shrub Carr Wetlands		
WMn82	Northern Wet Meadow/Carr	Between S4 (Apparently Secure) and S5 (Secure, Common, Widespread, and Abundant)
WMn82a	Willow - Dogwood Shrub Swamp	S5 - Secure, Common, Widespread, and Abundant
WMn82b	Sedge Meadow	S4 or S5 - Subtype S-Ranks are either S4 or S5
WMn82b4	Sedge Meadow, Lake Sedge Subtype	S5 - Secure, Common, Widespread, and Abundant
Wet Prairies		
WPs54b	Wet Prairie (Southern)	S2 - Imperiled

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