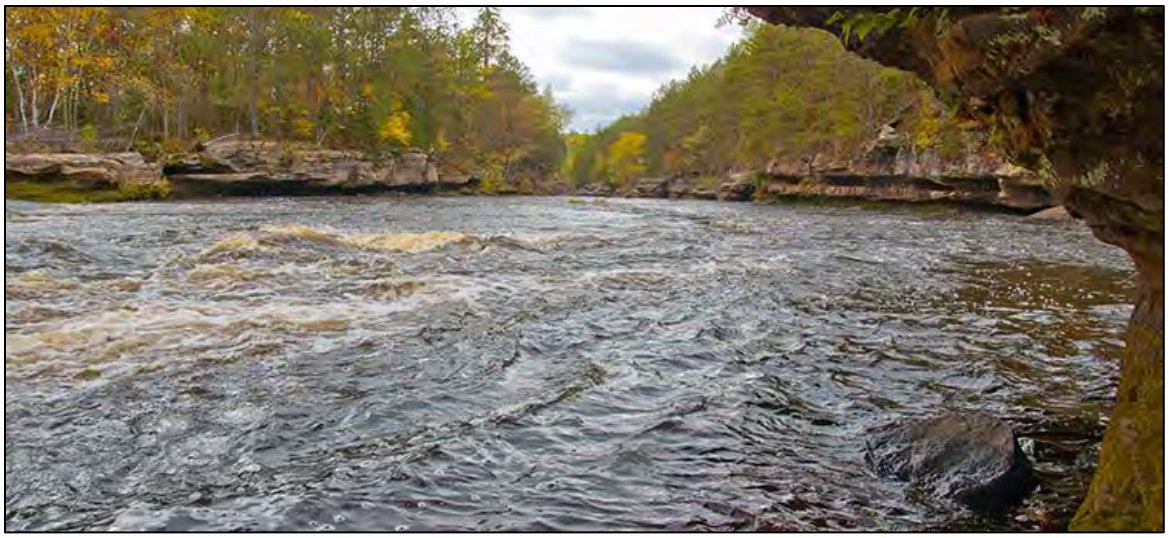
Kettle and Upper St. Croix River Watersheds (KUSCRW)

Groundwater Restoration and Protection Strategies Report



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Kettle and Upper St. Croix River Watersheds Groundwater Restoration and Protection Strategies Report

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Contributors

The following agencies dedicated staff time and resources toward the development of the Kettle and Upper St. Croix River Watersheds 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 the Kettle River Watershed, courtesy of the DNR.

Summary

Groundwater is an important resource in the Kettle and Upper St. Croix River Watersheds (KUSCRW) One Watershed One Plan (1W1P) planning effort[1]. Permitted annual groundwater use in the KUSCRW had been 375 and 531 million gallons per year over the period 1988-2021. Approximately 85.2 percent of permitted groundwater use is for water supply and 7.5 percent is used for non-crop irrigation. In addition, groundwater accounts for most of the region's drinking water. It is important to ensure adequate supplies of high-quality groundwater remain available for the region's residents, businesses, and natural resources.

Buried glacial aquifers (32% of wells), fractured crystalline bedrock (29%), and the Hinckley sandstone bedrock (24%) are the main sources of drinking water in the KUSCRW.

Groundwater has a greater risk to contamination in areas of high pollution sensitivity[2]. The KUSCRW has areas of high pollution sensitivity, especially through an area in northern Pine County running roughly parallel to MN Highway 23, where the Hinckley sandstone bedrock exhibits karst-like features. Understanding pollution sensitivity is a key consideration to prevent groundwater pollution. Many land-use activities (including 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:

- **Nitrate** – less than one percent of the 1,803 tested drinking water wells had nitrate levels at or above the SDWA standard of 10 mg/L.
- **Arsenic** – over three percent of the 215 tested drinking water wells had arsenic levels exceeding the 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.
- **Contaminated sites –** there are 201 active tanks at 75 unique sites that could leak chemicals into the environment and 10 leak sites that may cause localized groundwater pollution if not properly managed. The risk to groundwater is greatest in areas of high pollution sensitivity.
- One closed landfill with known groundwater contamination is found within the watershed, in addition to a Superfund site at the Kettle River Company's former creosote plant in Sandstone.

[1] For this report, the boundary of the KUSCRW is comprised of the HUC 8 major watersheds of the Kettle River and Minnesota portion of the Upper St. Croix River.

[2] 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. Karst is considered to be very highly sensitive to pollution.

These contaminants can affect both private wells and public water systems when levels exceed drinking water standards. About 42 percent of the people living in the watershed get their drinking water from a community public water supply system. Wellhead Protection Plans have been completed for 11 of the 13 community public water systems in the KUSCRW and identify land use protections strategies for the almost 4,000 acres in Drinking Water Supply Management Areas (DWSMAs).

Permitted groundwater is primarily sourced from buried sand/gravel (34.9 percent) and bedrock sandstone aquifers (48.9 percent). The DNR has 18 active groundwater-level monitoring wells in the KUSCRW. Eight wells had sufficient water-level data to calculate a long-term trend over the period 1990-2020: all nine wells had no trend.

Activities on the land surface can affect groundwater levels by reducing infiltration (groundwater recharge) especially in the southern portion of the watershed; these activities include changes in vegetation, increased areas of impervious surface, and changing surface water or stormwater flow.

The KUSCRW includes 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:

- There are 56 groundwater-flow dominated lakes in the KUSCRW. Of these lakes, 33 have a watershed area to lake area ratio between 5 and 10, and 23 have a watershed to lake area ratio of less than 5. These lakes may be groundwater dominated. Lake specific data should be collected before making a final determination on the amount of influence groundwater has on a particular lake.
- There are seven kinds of native plant communities associated with groundwater in the watersheds and one native plant community complex.

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. Areas of higher pollution sensitivity is 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.[3]

[3] 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 (https://bwsr.state.mn.us/sites/default/files/2019-09/1W1P_guidebook.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 80 major watersheds[4]. 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).

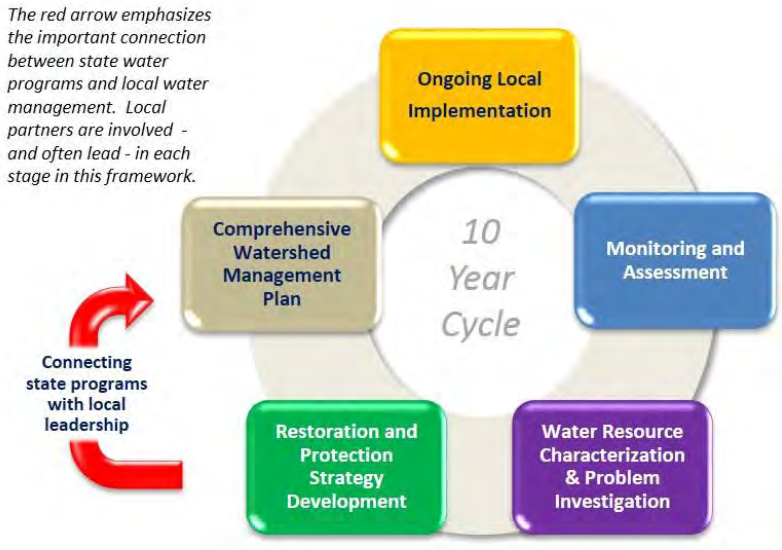

Figure 1: Watershed Approach Framework

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.

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

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 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 five 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

Kettle and Upper St. Croix River Watersheds 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 Kettle and Upper St. Croix River Watershed (KUSCRW) 1W1P planning boundary groundwater quality and quantity. You can find more detailed information about the KUSCRW and groundwater through the following resources:

Restoration and Protection Plans

- MPCA Kettle River watershed reports (www.pca.state.mn.us/water/watersheds/kettle-river)
- MPCA Upper St. Croix River watershed reports (www.pca.state.mn.us/water/watersheds/upper-st-croix-river)

The KUSCRW covers over 1 million acres of the St. Croix River Basin. The Kettle River covers 673,000 acres in Aitkin, Carlton, Kanabec, and Pine counties. The Upper St. Croix River covers 348,000 acres in Pine County (Figure 2). The watersheds experienced very little population change between the 2010 and 2020 census. The largest cities in the watersheds are Sandstone and Moose Lake in the Kettle River watershed and Askov in the Upper St. Croix River watershed.

Of the roughly 25,900 people living in the watershed, approximately 10,900 (42 percent) utilize community public water and the remaining 58 percent obtain their drinking water from private wells.

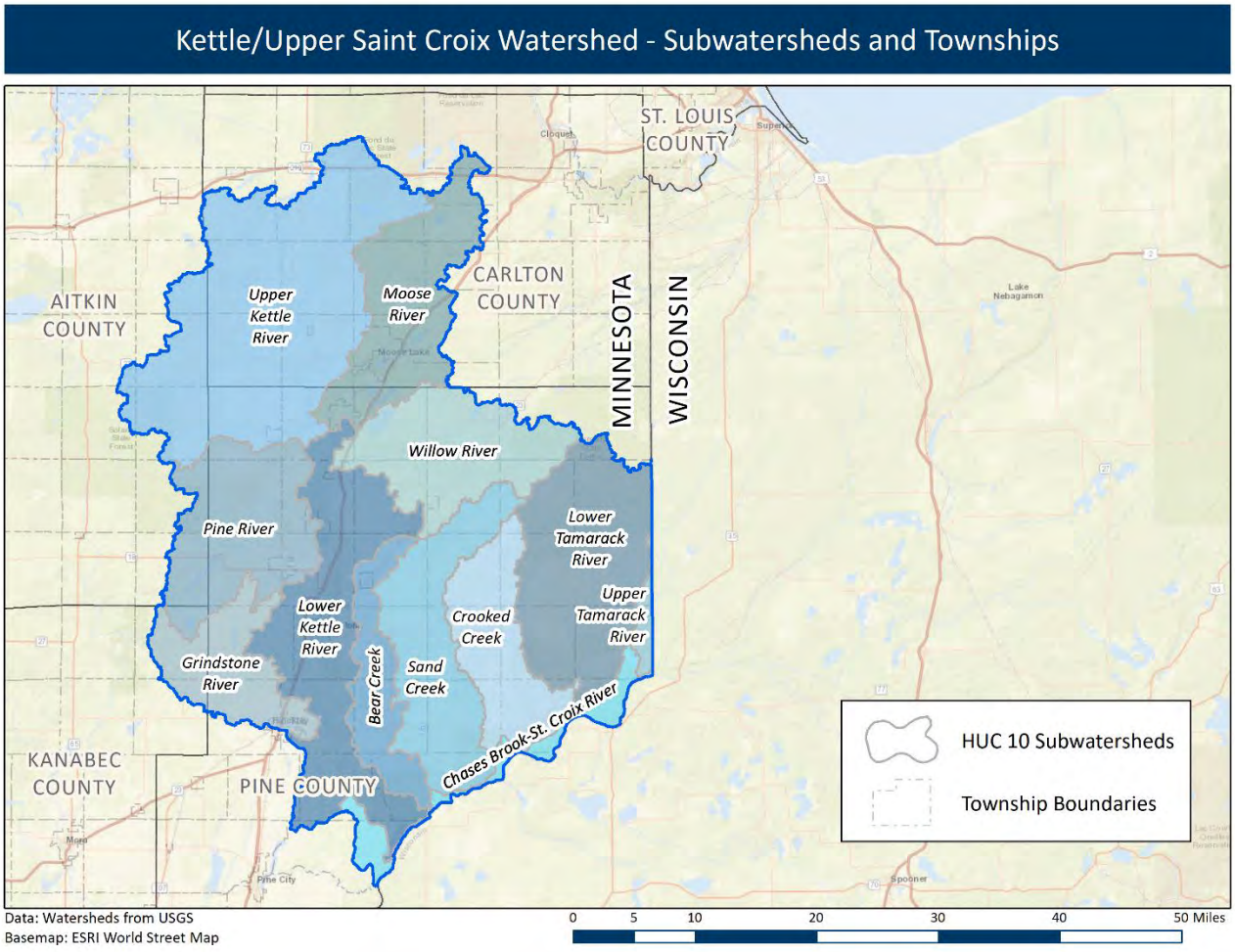

Figure 2: Kettle and Upper St. Croix River Watersheds are comprised of twelve subwatersheds (HUC-10).

Land Use

The majority of the KUSCRW is in the Northern Lakes and Forest Ecoregion. Nearly 40 percent of the Kettle River watershed and over 50 percent of the Upper St. Croix River watershed is covered in forest/shrubland, followed by wetlands covering over 30 percent in both watersheds, Figure 3. The watersheds have experienced minimal disturbances in landcover with only two percent in cultivated cropland.

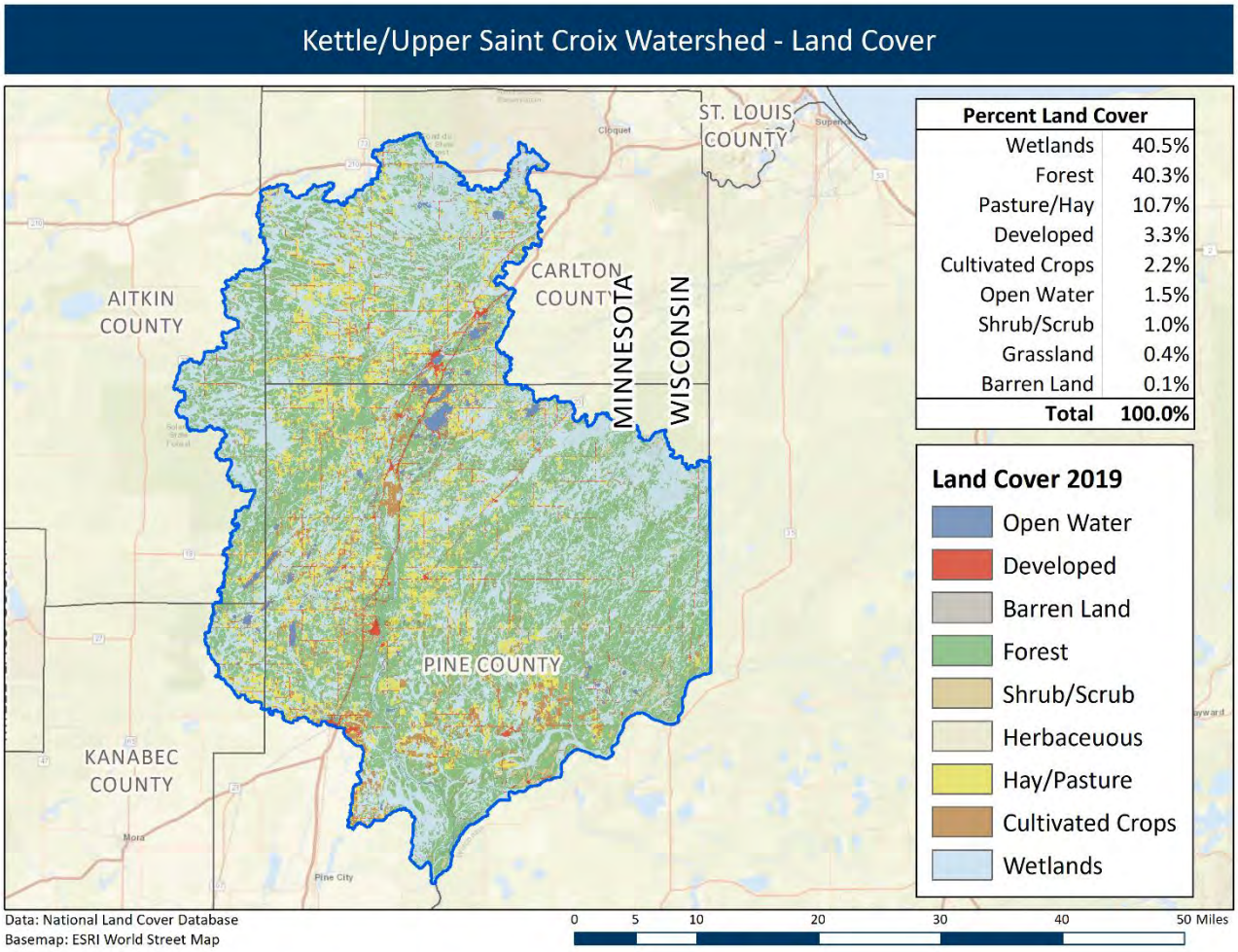

Figure 3: Kettle and Upper St. Croix River Watersheds - Land Cover. Wetlands and forests are the predominant land cover in the watershed, followed by pasture/hay and developed land.

Geology and Hydrogeology

Groundwater sources within the KUSCRW vary according to the underlying geology, which is the result of igneous, metamorphic, sedimentary, and glacial processes that have taken place in the region over billions of years.

The region's bedrock includes a base of metamorphosed igneous and sedimentary rocks. These are overlain by sandstone bedrock, including the important Hinckley sandstone aquifer, and some basaltic volcanic sequences. For the most part, the igneous and metamorphic bedrock is impermeable to water except for groundwater moving through fractures in the rock. The Hinckley sandstone has solution-enhanced fractures in addition to primary porosity, but is also well-cemented, limiting its primary porosity. The Fond du Lac and other Mesoproterozoic sandstones have fairly low hydraulic conductivity due to the presence of siltstone and shale beds.

Above the bedrock is sediment deposited by the advance and retreat of glaciers during the last ice age. The uppermost glacial deposits are mostly moraine sediments ranging in texture from "sandy" to

“clayey”. Sediments with a higher proportion of clay are less easily permeated by water and generally prevent these deposits from being used as water supplies. Coarser-grained glacial outwash deposits are found around the Kettle, Moose Horn, and St. Croix Rivers, as these modern waterways echo the paths of glacial meltwater.

Glacial geology is complex and multilayered. Some aquifers are protected beneath less penetrable layers of sediment ("buried"), while others lack these barriers ("surficial" or "water table" aquifers). To add to the complexity, buried aquifers are commonly directly connected to surficial aquifers.

Among the drinking water wells that have interpreted aquifer codes in the state database, most draw water from either sedimentary bedrock aquifers (36% of wells) or buried glacial aquifers (32%). About 16% of drinking water wells use igneous or metamorphic bedrock as a water source.

Figure 4 depicts a generalized map of aquifers in the watershed. The sandstone bedrock aquifers in the area share some important characteristics with crystalline bedrock aquifers—namely, these sandstones are well-cemented and fractured, in contrast to a typical porous media sandstone aquifer—so they have been categorized together in the figure. More information on the bedrock and surficial geology can be found in the Geologic Atlases for Pine and Carlton Counties.

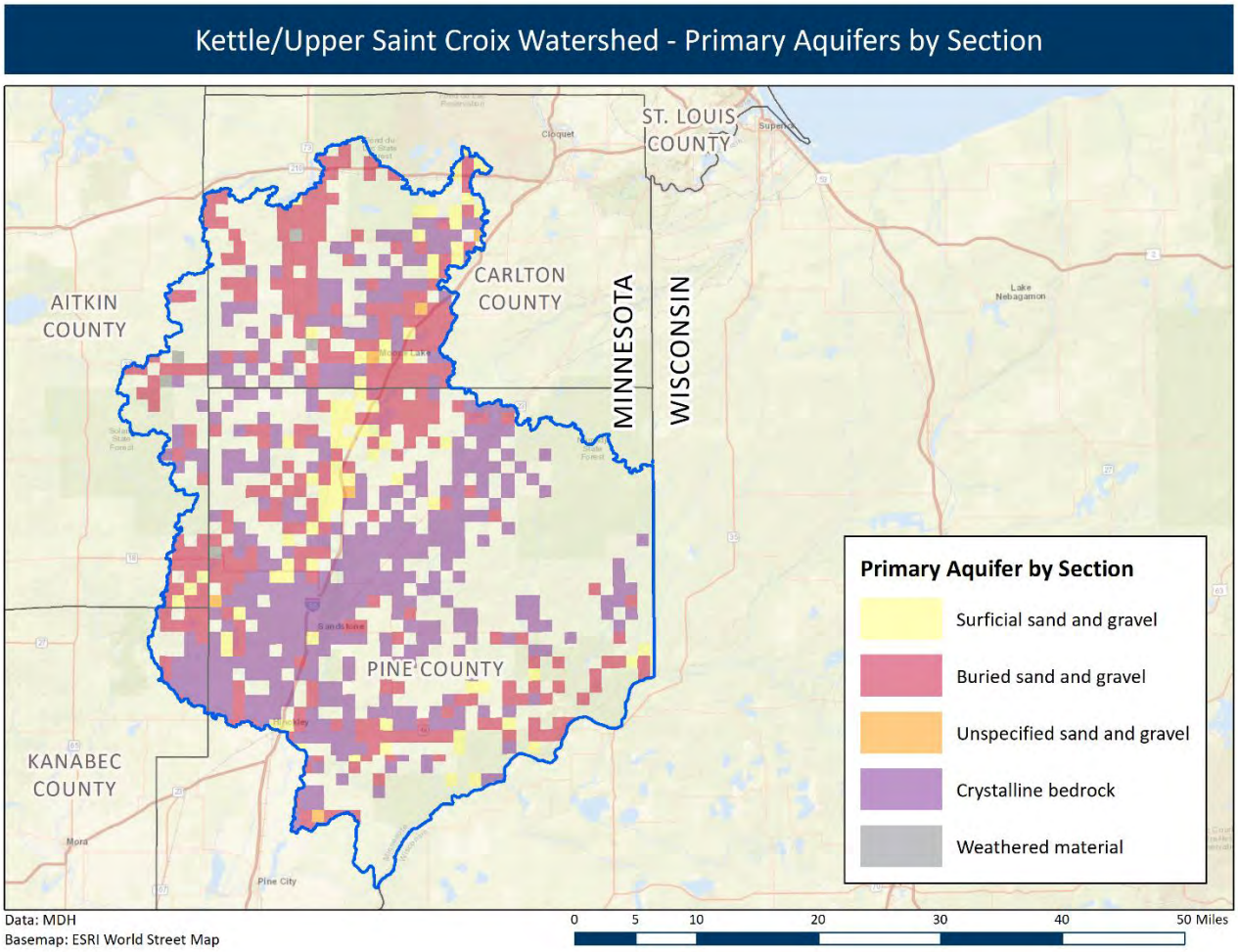

Figure 4: Kettle and Upper St. Croix River Watersheds – Primary Aquifers by Section. Crystalline bedrock is the primary drinking water source for the watersheds, followed by buried sand and gravel aquifers.

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 for groundwater to recharge and for 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 others in a given area. Figure 5 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. The pollution sensitivity map for the Kettle/Upper St. Croix River Watershed ranges from “very high” (karst) to “very low”. Karst features such as sinkholes typically develop in environments with carbonate (i.e., limestone) bedrock, but similar conditions exist in this watershed in locations where there is only a thin layer (<50 feet) of glacial sediment overlying the unsaturated Hinckley sandstone bedrock. This occurs throughout northern Pine County, over a broad area roughly parallel to MN Highway 23. In these areas water can be rapidly

transported downward through cracks and fractures, meaning that an aquifer could become easily contaminated by surface pollutants. In other areas of the watershed, the higher clay content of surficial sediments means that water generally takes longer to travel downward and there would likely be more time to respond to pollution incidents before contamination occurs.

More information on this dataset is available 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 7. This figure 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. More information on the geologic sensitivity calculations used to make this figure is included in the references section of this report as Figure 38 and Figure 39.

It is also important to understand how recharge travel time ratings (Figure 6 and Figure 8) 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 5); whereas, for deeper aquifers more commonly used for drinking water, a rating of 'moderate' reflects travel times of years to decades (Figure 8). 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.

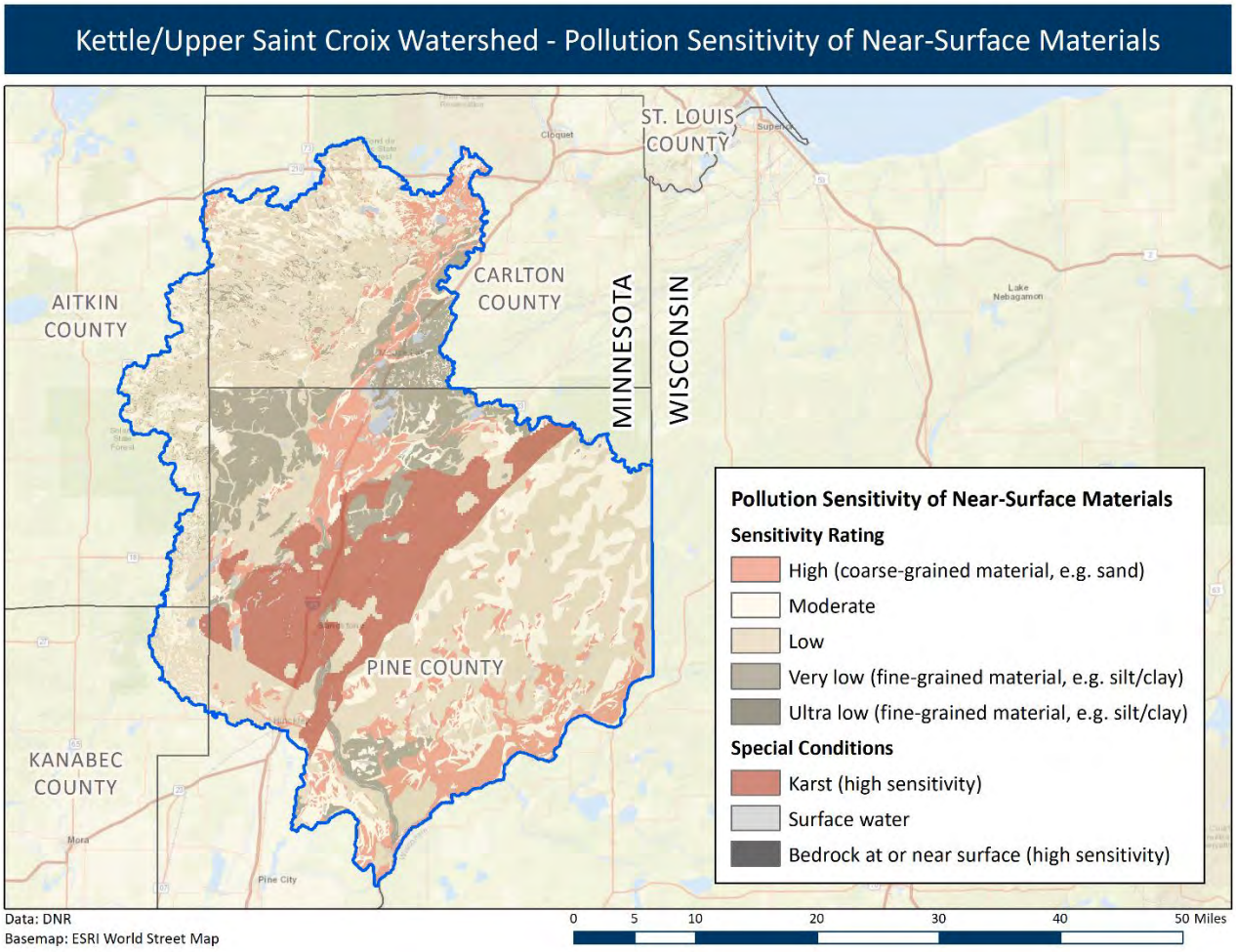

Figure 5: Kettle and Upper St. Croix River Watersheds - Pollution Sensitivity of Near Surface Materials

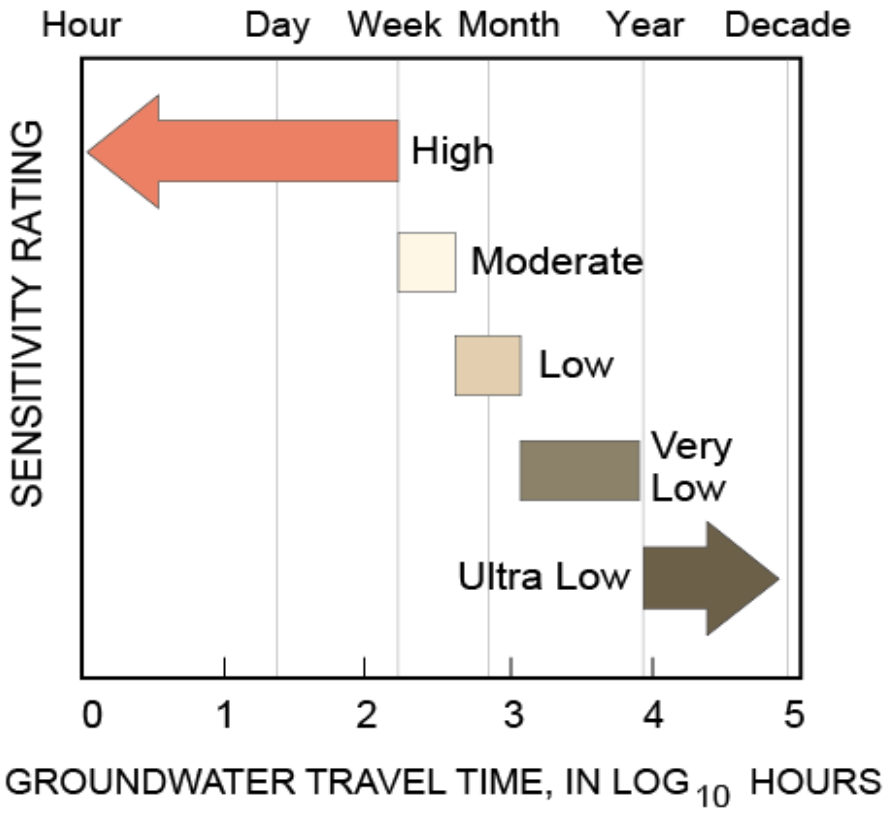

Figure 6: Recharge Travel Time for Near-Surface Materials

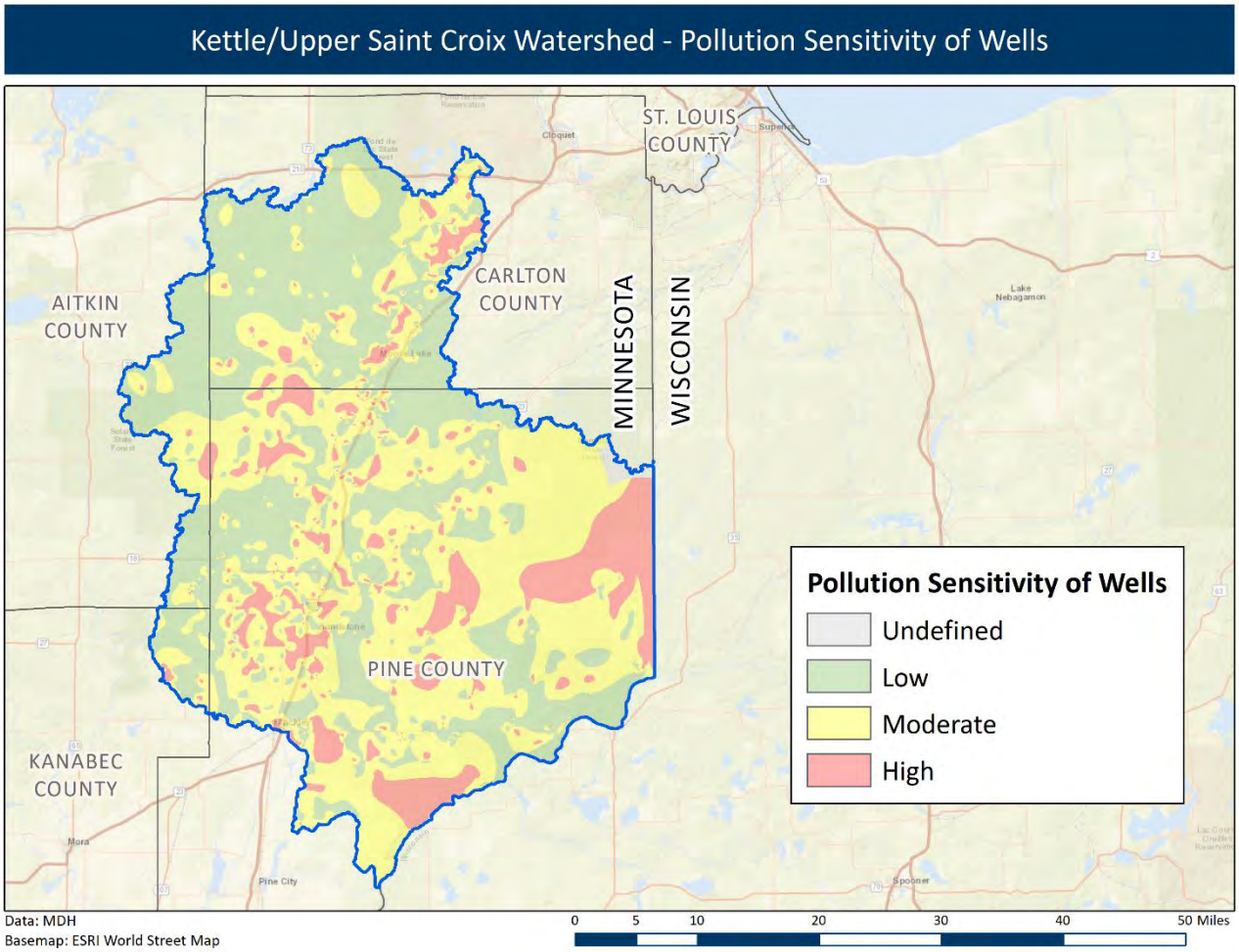

Figure 7: Kettle and Upper St. Croix River Watersheds - Pollution Sensitivity of Wells.

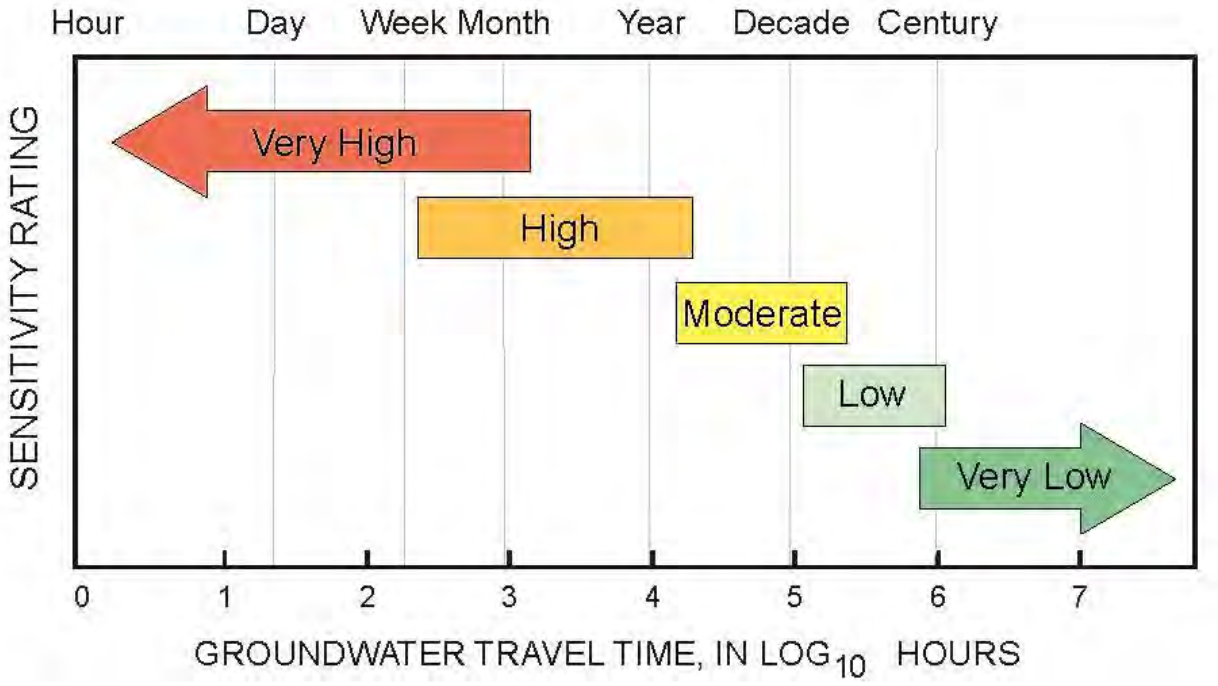

Figure 8: Recharge Travel Time for Buried Aquifers

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

Pollution Sensitivity Rating	Aquifer Recharge Time Period[5] 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

[5] 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 (WHP) 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 supplies[6], 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 to manage the groundwater below. Learn more about MDH Source Water Protection (www.health.state.mn.us/communities/environment/water/swp/index.htm).

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 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 the vulnerability assessments. Highly vulnerable WHPAs require a greater level of management to prevent potential contaminants at the ground surface from entering the aquifer. For WHPAs with low vulnerability, the primary focus is on sealing unused/unsealed wells since this is the main pathway for contaminants to reach the aquifer.

All community public water systems within the KUSCRW are engaged in the wellhead protection planning process or are implementing their plans. The DWSMA vulnerabilities range from "low" to "very high", with many demonstrating moderate and high vulnerability. Figure 9 shows the status of wellhead protection planning for the public water supply systems in the watershed. Figure 10 shows the DWSMAs delineated at the time the report was compiled, which covers over 3,985 acres in the watershed. It is important to note that WHP areas do not follow watershed boundaries and can extend into neighboring watersheds. The Hinckley DWSMA extends past the watershed boundary.

The KUSCRW has 13 community PWS that manage 29 wells. Not reflected in the report is the four non-community non-transient PWS wells and 154 transient non-community PWS wells.

[6] Community public water supplies serve at least 25 persons or 15 service connections year-round. Community public water supplies include municipalities (cities), manufactured mobile home parks, etc. Currently there are almost 1,000 community water supplies in Minnesota.

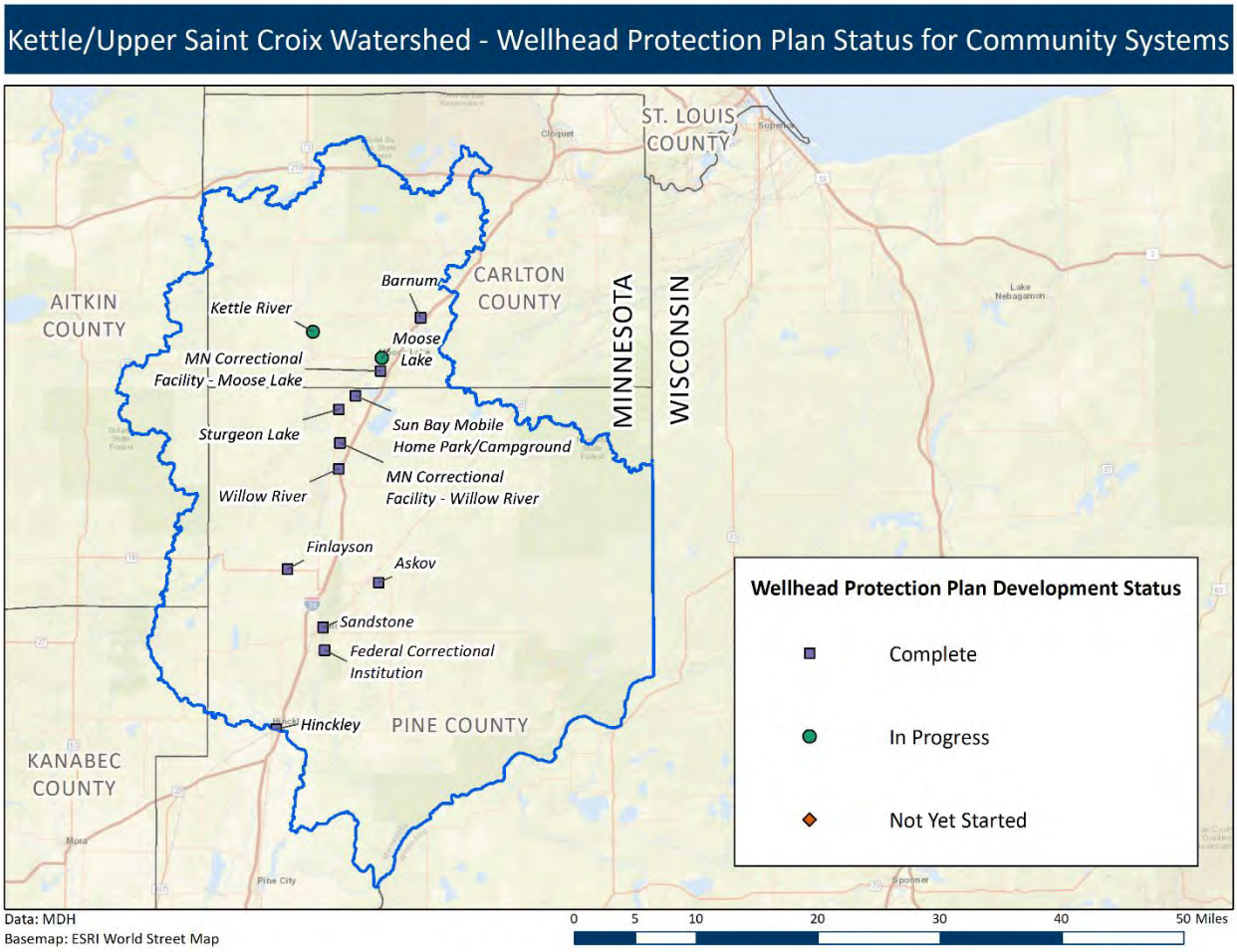

Figure 9: Kettle and Upper St. Croix River Watersheds - Wellhead Protection Plan Development Status for Community Public Water Systems. All *community public water supply systems are engaged in the wellhead protection planning process or are implementing their plans.*

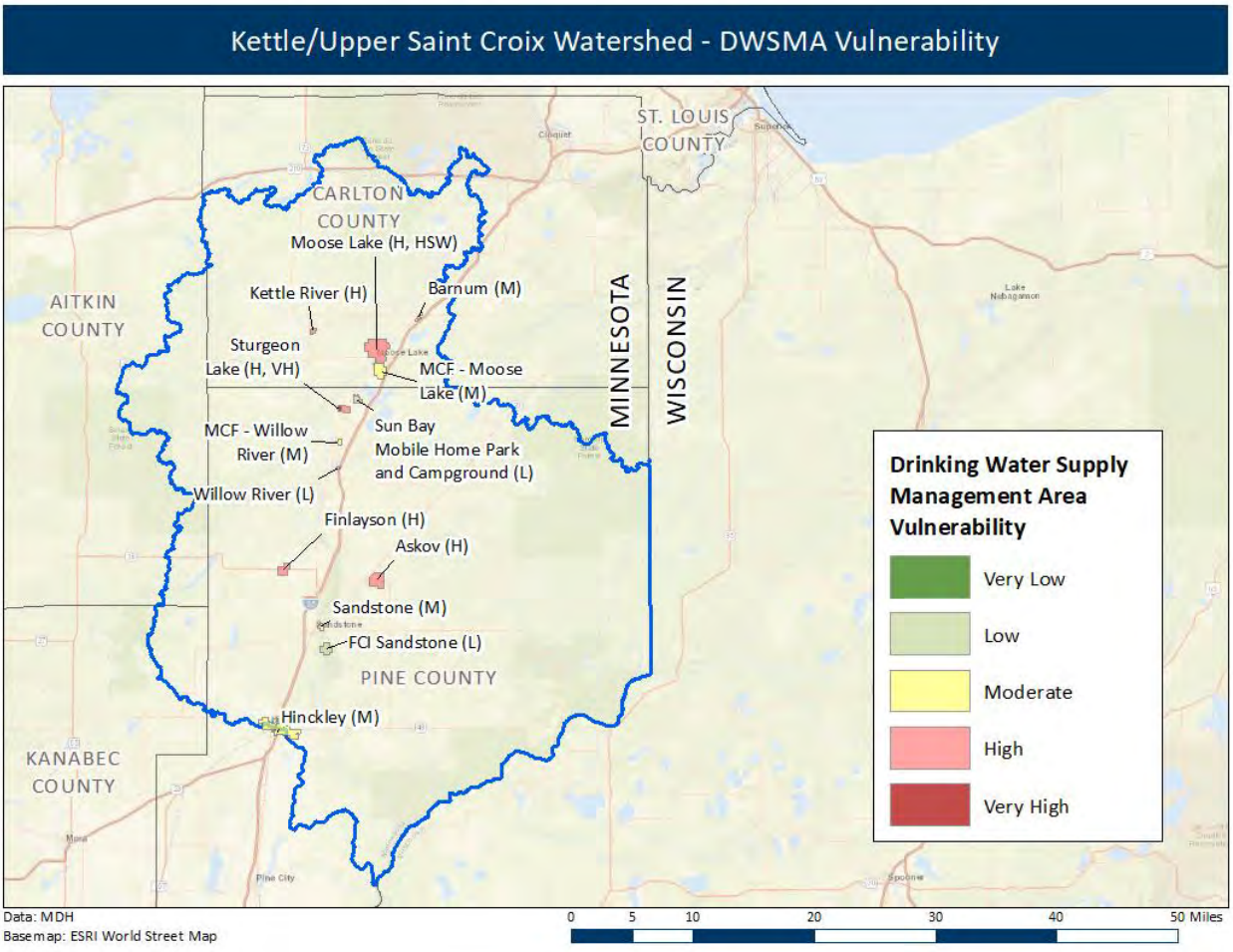

Figure 10: Kettle and Upper St. Croix River Watersheds - Drinking Water Supply Management Areas. There are 13 approved Drinking Water Supply Areas (DWSMA) for community public water systems in the watershed. The City of Moose Lake has a conjunctive WHPA delineation with a surface water contribution area in their DWSMA.

The city of Moose Lake in the KUSCRW has a conjunctive WHPA delineation. 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.

The management of conjunctive WHPAs can present challenges because of their large size relative to the more traditional WHPAs that are based solely on groundwater capture areas. In addition, management practices of potential contaminant sources can differ between groundwater capture areas and surface water capture areas (surface water contribution area). Within the groundwater capture area, the focus will be on those contaminants most likely to soak into the ground; whereas, the source water capture area, 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 PWS and associated surface water bodies.

Groundwater Protection Rule

The Groundwater Protection Rule minimizes potential sources of nitrate pollution to groundwater and protects drinking water. The rule restricts the application of nitrogen fertilizer in the fall and on frozen soils in areas vulnerable to contamination, and it outlines steps to reduce the severity of the problem in areas where nitrate in public water supply wells is already elevated.

The rule is intended to promote appropriate nitrogen fertilizer best management practices (www.mda.state.mn.us/pesticide-fertilizer/nitrogen-fertilizer-bmps-agricultural-lands) and to involve local farmers and agronomists in adopting the most current science-based and economically viable practices that can reduce nitrate in groundwater. These other practices are called alternative managment tools - AMTs (www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/nitrogenmgmt/amts).

The rule is implemented by MDA and contains two parts. Each part contains separate criteria and requirements.

Part 1 of the Rule

Part 1 of the Groundwater Protection Rule restricts the application of nitrogen fertilizer in the fall and on frozen soils on farmland in 1) an area with vulnerable groundwater or 2) those protection areas around a municipal public well (DWMSA) with high nitrate. Figure 11 shows the nitrogen fertilizer restrictions in the KUSCRW.

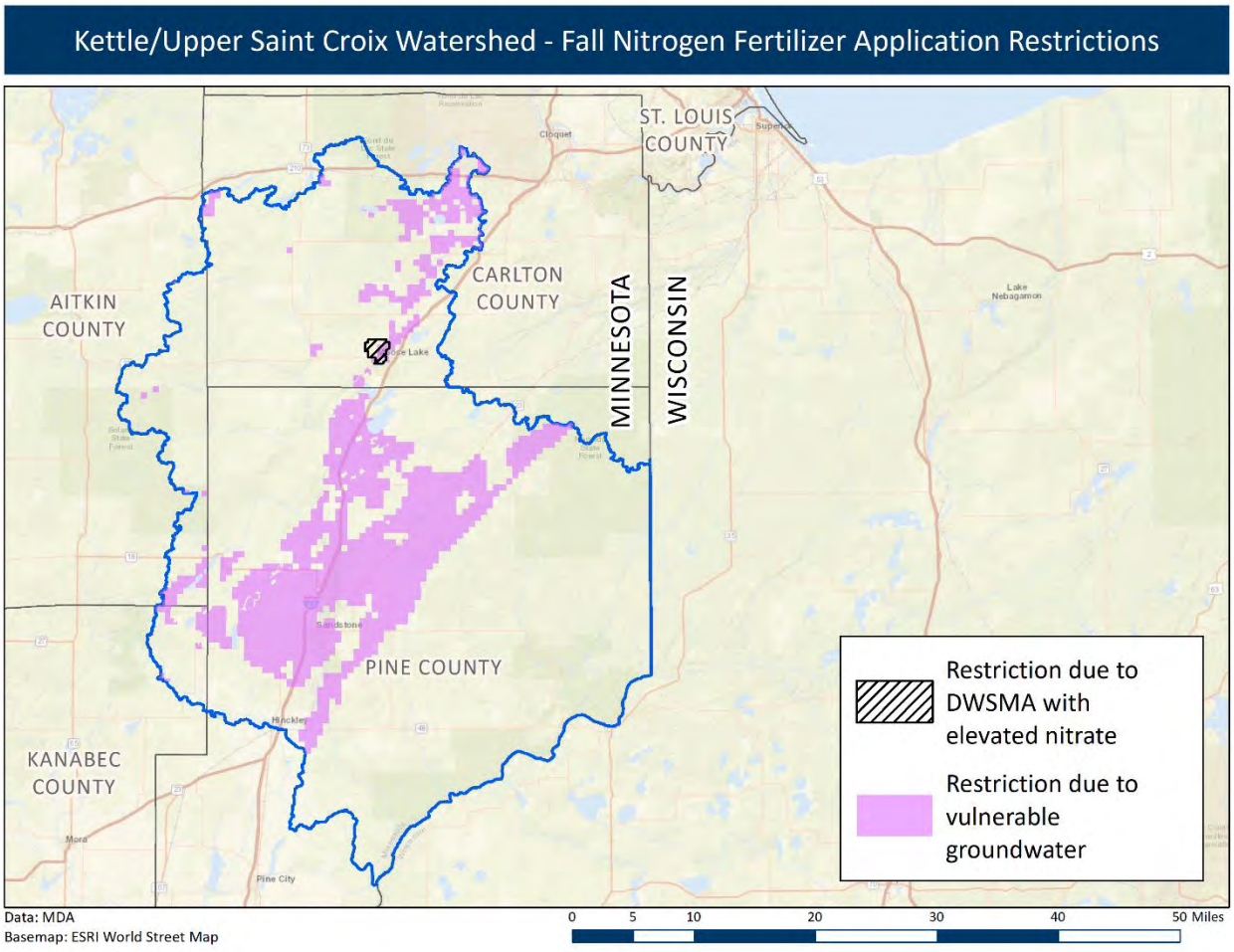

Figure 11: Kettle and Upper St. Croix River Watersheds – Fall Nitrogen Fertilizer Application Restrictions overlaid with the Groundwater Protection Rule DWSMA for the city of Moose Lake. More data needs to be collected before a mitigation level can be assigned to the city of Moose Lake.

Part 2 of the Rule

Part 2 of the rule responds to DWSMAs which already have elevated nitrate. The goal is to take action to reduce nitrate in groundwater before a public well exceeds the Safe Drinking Water Act (SDWA) standard for nitrate of 10 mg/L. The rule is structured using a sliding scale of voluntary and regulatory actions based on the concentration of nitrate in the well and the use of the BMPs.

There are four mitigation levels used to determine voluntary and regulatory actions, two voluntary levels and two regulatory levels. The MDA uses monitoring provided by MDH to determine mitigation levels. Wells that have nitrate levels greater than or equal to 5.4 mg/L but less than 8 mg/L at any point in the previous ten years fall within the guidelines for a Mitigation Level 1 determination. Wells with nitrate at or above 8 mg/L at any point in the last ten years or are projected to exceed 10 mg/L in the next ten years are within the guidelines for Mitigation Level 2.

Figure 11, shows the Groundwater Protection Rule DWSMA for the city of Moose Lake in the KUSCRW. More data is needed before a mitigation level can be assigned.

Private Wells

The KUSCRW has approximately 2,925 private wells with known locations, ranging from 13 feet to 610 feet deep with an average depth of 113 feet that provide drinking water to residents. Approximately 23 percent (about 668 wells) of private wells are in a highly vulnerable setting. Private well users are not afforded the same water quality safeguards as people who get their water from public water systems. While public water systems make sure water is safe for the end-user, private well users are responsible for making sure their water is safe for everyone in the household to drink.

The Minnesota Well Code ensures that private wells are properly located and constructed. However, once the well is put into service, private well users are responsible for properly maintaining their well, testing it regularly, and treating the water when necessary.

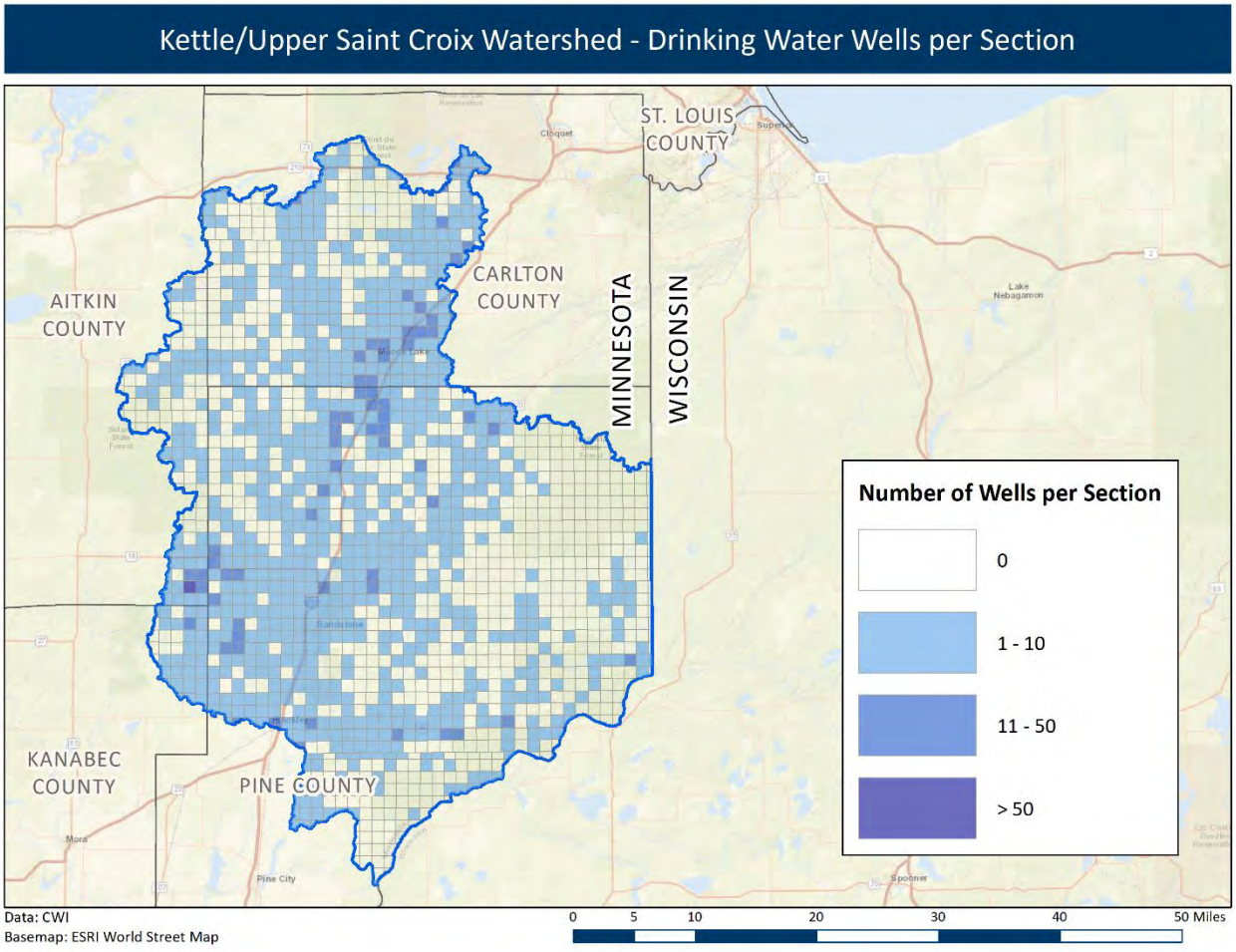

Figure 12: Kettle and Upper St. Croix River Watersheds - Density of drinking water wells per section. There are approximately 2,925 private wells identified.

Figure 12 illustrates well density and water use data in the KUSCRW. 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.

Extreme Weather

Climate records show that across Minnesota there has been an increase in average rainfall, as well as heavy precipitation events. As storms become more frequent and intense, flooding will be an ongoing challenge for public water systems and private wells. Flood events can threaten the safety and availability of drinking water by washing pathogens (bacteria, viruses, and parasites) and chemical contamination into source aquifers or by overwhelming the capacity of treatment systems to clean the water. The full extent of floodwater contamination depends on land use and associated infrastructure in the affected area. There is limited flood data for Aitkin, Carlton, and Kanabec counties to predict where drinking water wells are at risk to contamination from flood prone areas. Figure 13 displays drinking water wells and flood zone risk to contamination in the KUSCRW.

Extreme weather may also affect drought conditions by changing how and where precipitation falls. Increased rainfall over frozen ground and reduced snowpack from spring melt can decrease infiltration into groundwater when converted to runoff. The Groundwater Quantity Issues and Concerns section of the report assesses aquifer sustainability by evaluating long term monitoring well trends.

For more information on Climate and Health (www.health.state.mn.us/communities/environment/climate/) or visit the DNR's webpage Climate Change and Minnesota (www.dnr.state.mn.us/climate/climate_change_info/index.html).

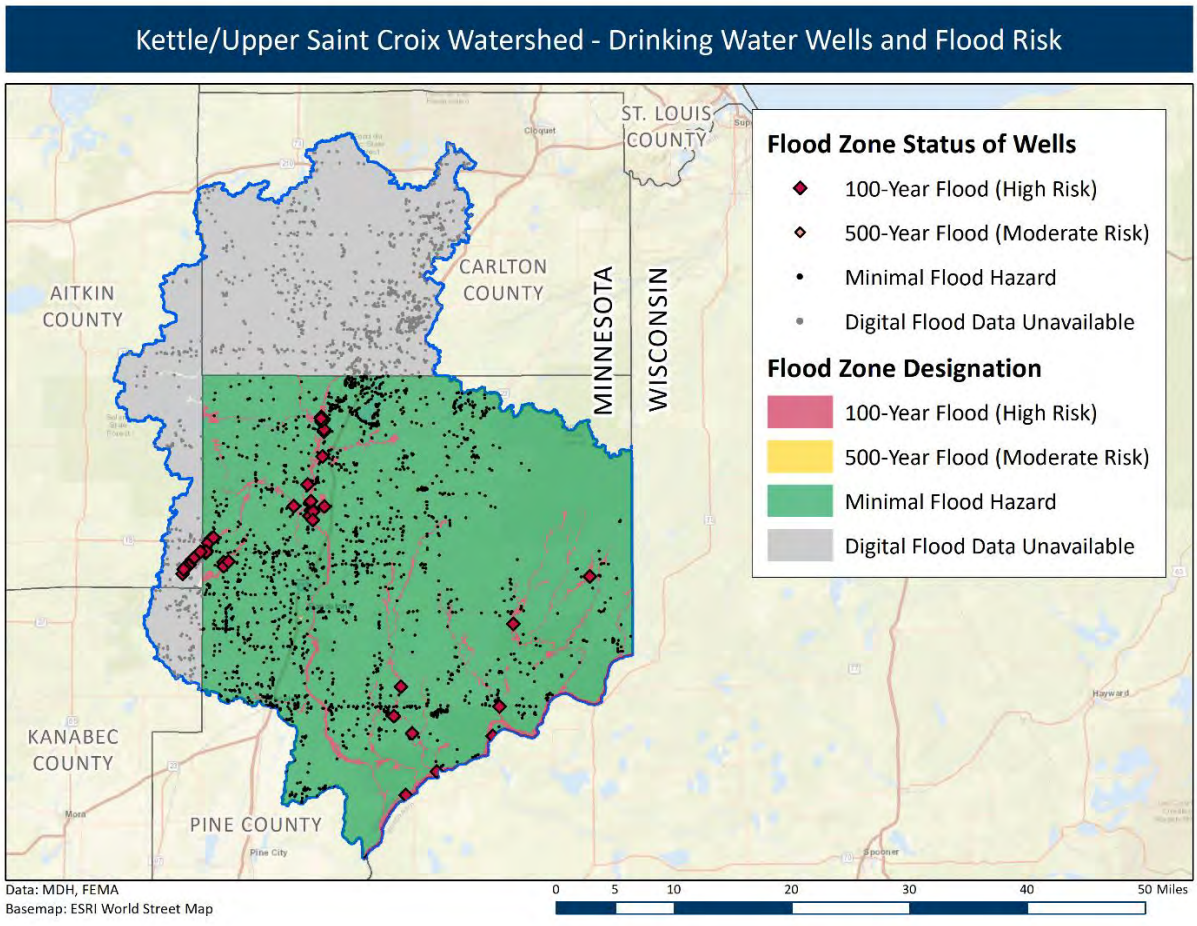

Figure 13: Kettle and Upper St. Croix River Watersheds – Drinking water wells and flood zone risk to contamination

Kettle and Upper St. Croix River Watersheds Groundwater Issues and Concerns

This section of the report describes the key groundwater quality and quantity issues for the KUSCRW. 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 KUSCRW 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 KUSCRW 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 KUSCRW. 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)[7] requirements for the quality of water served to their customers. However, some public water systems may have water quality issues in their untreated source water that requires either blending or treatment to meet SDWA standards.

Nitrate

Nitrate-nitrogen (referred to as nitrate) is a compound that occurs naturally and has many human-made sources. When nitrate levels are above 3 milligrams per liter (mg/L)[8] 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. Most of the samples taken from wells within the watersheds did not exceed the SDWA standard for nitrate. This dataset includes newly constructed wells, private wells, and other

[7] The Safe Drinking Water Act (SDWA) is the federal law that protects public drinking water supplies throughout the nation. Under the SDWA, EPA sets standards for drinking water quality; MDH is delegated to implement the program in MN to ensure drinking water safety.

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

drinking water supply wells. Sampling of newly constructed wells for nitrate began in 1974. Many older wells, pre-well code, are not included in this dataset. Table 2 shows nitrate test results for samples taken from these wells.

Table 2: Summary of nitrate results in drinking water wells of the Kettle and Upper St. Croix River Watersheds.

Depth Completed Range (feet)	Total samples (nitrate)	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	136	0	7.7	0.5	4.4	0
50 - 99	854	0	29.3	0.5	2.8	0.2
100 - 149	369	0	160	0.5	2.2	0.3
150 - 199	183	0	10.3	0.5	3.8	0.5
>= 200	261	0	3.12	0.5	0.4	0
Total	1,803	0	160	0.5	2.6	0.2

Where Is Nitrate in the Kettle and Upper St. Croix River Watersheds?

High levels of nitrate are present in areas where there are both human-caused sources of nitrate and high pollution sensitivity. The following image helps identify where nitrate is detected and at what levels in the watershed:

- Figure 14 shows the nitrate levels in wells in the KUSCRW. When compared with the areas with high pollution sensitivity (Figure 5) there is a correlation between pollution risk 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 2. 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).

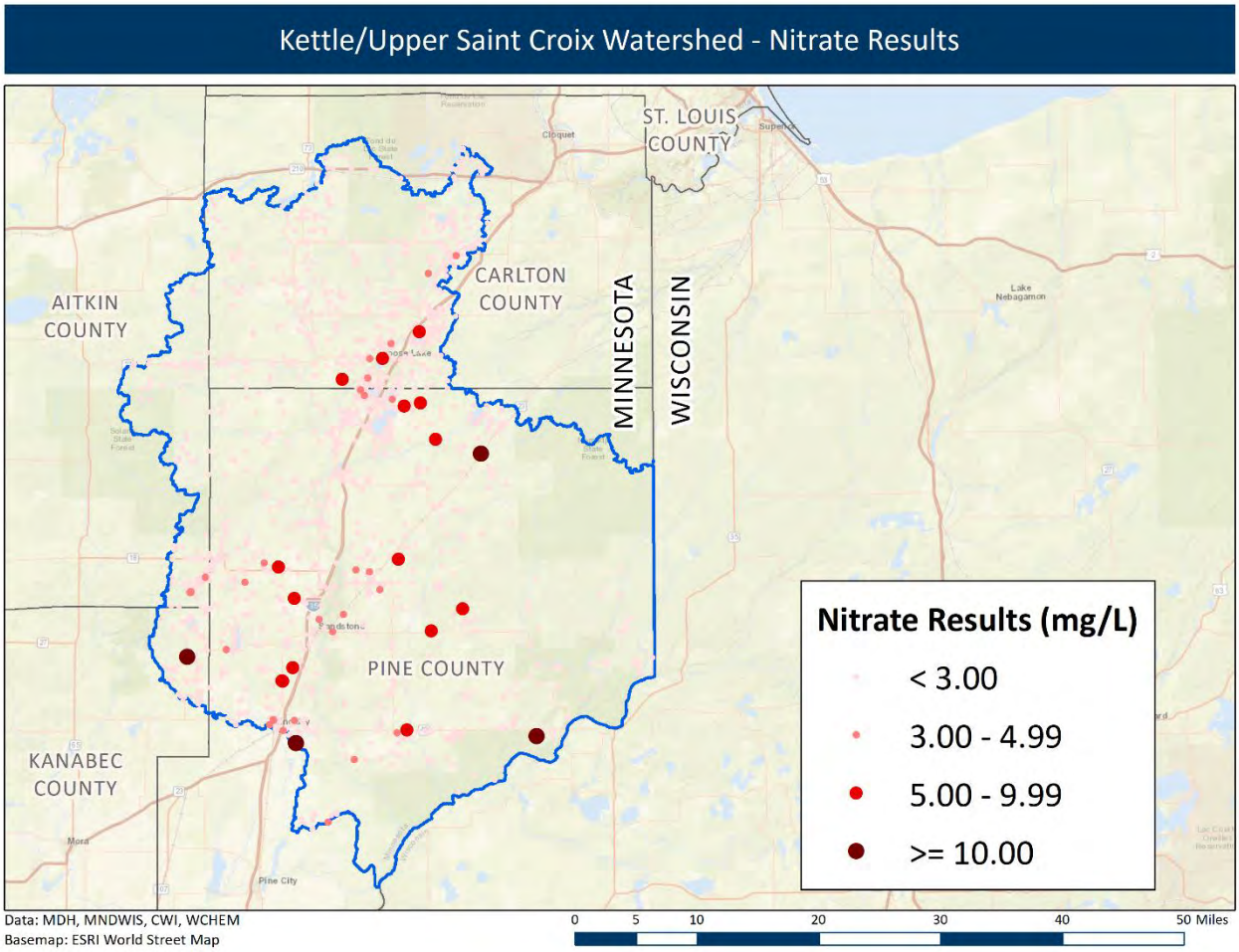

Figure 14: Kettle and Upper St. Croix River Watersheds - Nitrate results from drinking water wells.

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 3 provides a protection framework that identifies management priorities reflective of nitrate concentrations.

Table 3: 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)
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[9], 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 8 provides a more comprehensive list of specific actions counties and subwatersheds in the KUSCRW 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

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

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 Kettle and Upper St. Croix River Watersheds?

MDA does not have any ambient monitoring wells in the KUSCRW.

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

Arsenic

Over three percent of the 215 arsenic samples taken from located wells in the KUSCRW have levels of arsenic higher than the SDWA standard of 10 micrograms per liter (µg/L)[10]. 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; however, drinking water with arsenic at levels lower than the SDWA standard over many years can still increase the risk of cancer. The EPA has set a goal of 0 µg/L for arsenic in drinking water because there is no safe level of arsenic in drinking water.

Since 2008, the State of Minnesota has required that water from new water supply wells be tested for arsenic. Table 4 outlines the number of well water samples tested for arsenic in the KUSCRW, using the dataset from the Minnesota Well Index (MWI) and well for newly constructed private wells. The table shows the percentage of samples with arsenic levels over the SDWA standard. It is important to remember that arsenic concentrations can be drastically different from nearly identical wells installed on adjoining properties.

[10] One microgram per liter is the same as 1 part per billion (ppb).24.53.6

Table 4: Summary of arsenic (As) concentrations in wells of the Kettle and Upper St. Croix River Watersheds.

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	18	0.0019	12.8	1	27.8	11.1
50 - 99	110	0.00196	28.2	1.4	24.5	3.6
100 - 149	40	0.0005	9.6	1.7	10	0
150 - 199	17	0.0005	8.4	3.3	29.4	0
>= 200	30	0.0005	10	0.004235	23.3	3.3
Total	215	0.0005	28.2	1.01	22.3	3.3

Where Is Arsenic in the Kettle and Upper St. Croix River Watersheds?

Figure 15 shows that arsenic is found in elevated concentrations throughout the watershed. The dataset used to create Figure 15 is the same information displayed in Table 4. Theses samples were taken from newly constructed domestic wells.

There are elevated levels of arsenic above the drinking water standard of 10 ug/L in wells completed in the Hinckley Sandstone aquifer. Typically, elevated arsenic in Minnesota groundwater is associated with glacial lobes originating from northwest Canada. Elevated arsenic is correlated with clay layers and reducing geochemical conditions that release arsenic into the groundwater (Erickson and Barnes, 2004 and 2005). There is less information on the occurrence of elevated arsenic in bedrock aquifers. Well depths with elevated arsenic in the KUSCRW range from 45 to 305 feet. For wells with arsenic detected but below the drinking water standard, the wells were completed in the Hinckley Sandstone, Fond Du Lac Formation, and Quaternary Buried Artesian aquifers.

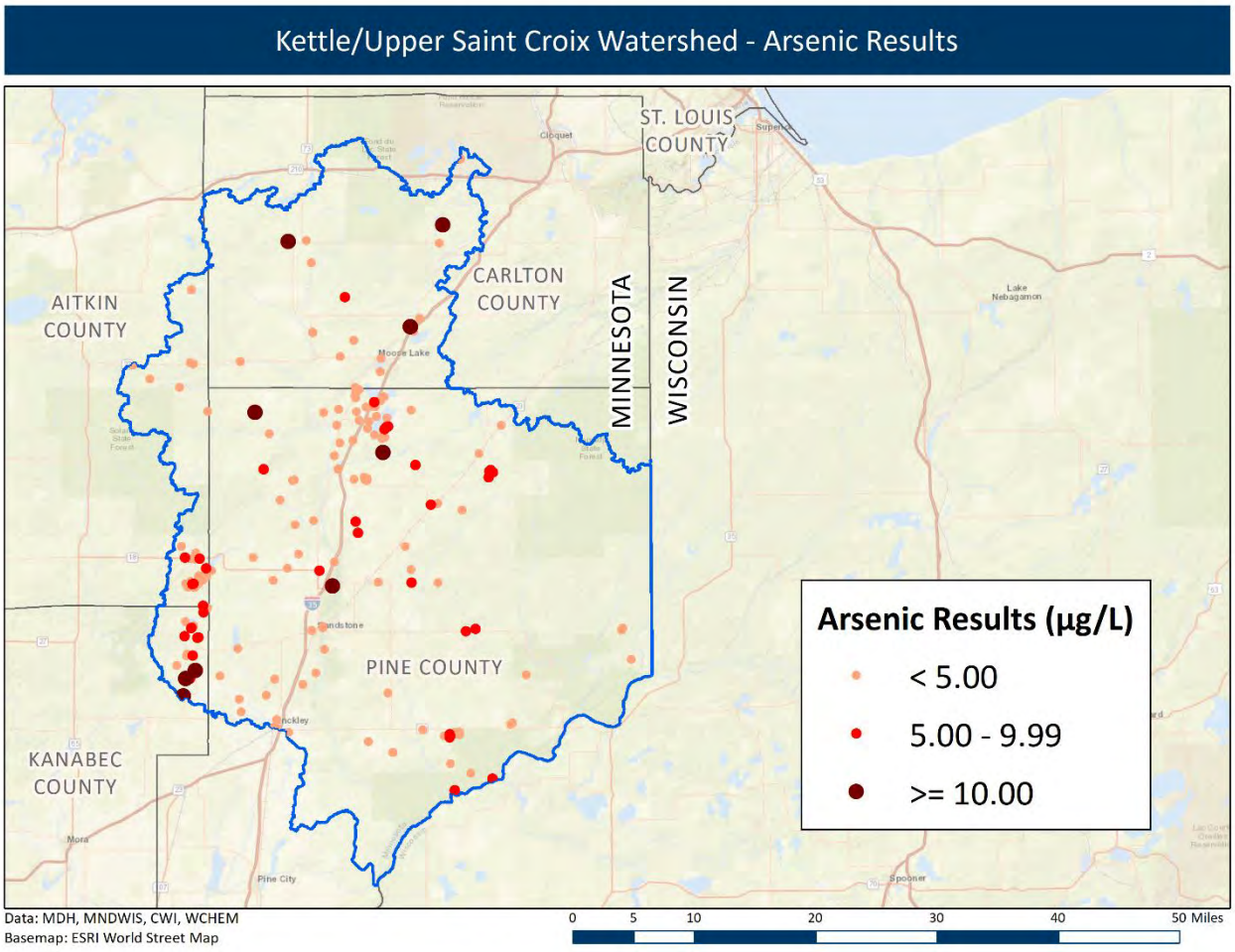

Figure 15: Kettle and Upper St. Croix River Watersheds - Arsenic Results

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 groundwater samples in the KUSCRW. There are elevated levels of combined radium 226/228 above the drinking water standard of 5 pCi/L in 9 public water supply wells, the highest level at 18 pCi/L. Wells with exceeding combined radium 226/228 range in well depth from 170 to 565 feet, completed in the bedrock Hinckley Sandstone, Fond Du Lac Formation, Hinckley-Fond Du Lac aquifers. 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 (Szabo, Z., Fischer, J. M., Hancock, T. C., 2012).

Where are Radionuclides in the Kettle and Upper St. Croix River Watersheds?

The few results indicate combined radium may be a problem in wells drilled in the bedrock Hinckley and Fond Du Lac and Hinckley-Fond Du Lac aquifers at this time.

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in the KUSCRW 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 KUSCRW 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. Water softeners and reverse osmosis are effective at removing radium from groundwater. Learn more at Radionuclides (Radium) in Drinking Water (https://www.health.state.mn.us/communities/environment/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. 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 is on shallow aquifers that underlie urban areas, due to the higher tendency of sensitivity to pollution, and are predominately located in sand and gravel and Prairie du Chien-Jordan aquifers.

In the period between 2008 and 2020, twelve ambient network wells were sampled in the KUSCRW. Of all the chemicals sampled for, nitrate and chloride are of particular concern due to the human health risks (nitrate) and ecological risks (chloride). Nitrate has a US EPA health risk limit of 10 mg/L (US EPA, 2022). No samples from any ambient wells in these watersheds exceeded that level. Chloride is naturally found in groundwater, but elevated levels can be caused by human activities like the usage of road salt and water softeners. It can also be damaging to plants and aquatic life but is a categorized as a nuisance chemical in drinking water. This means there are no established health risk limit for chloride in drinking water, but it can produce an unpleasant taste so, for it, the US EPA has set a secondary maximum contaminant level of 250 mg/L (US EPA, 2022b). Chloride levels at most of these sites were well below these levels. Two sites occasionally exceeded 250 mg/L but did not sustain those levels year-to-year.

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

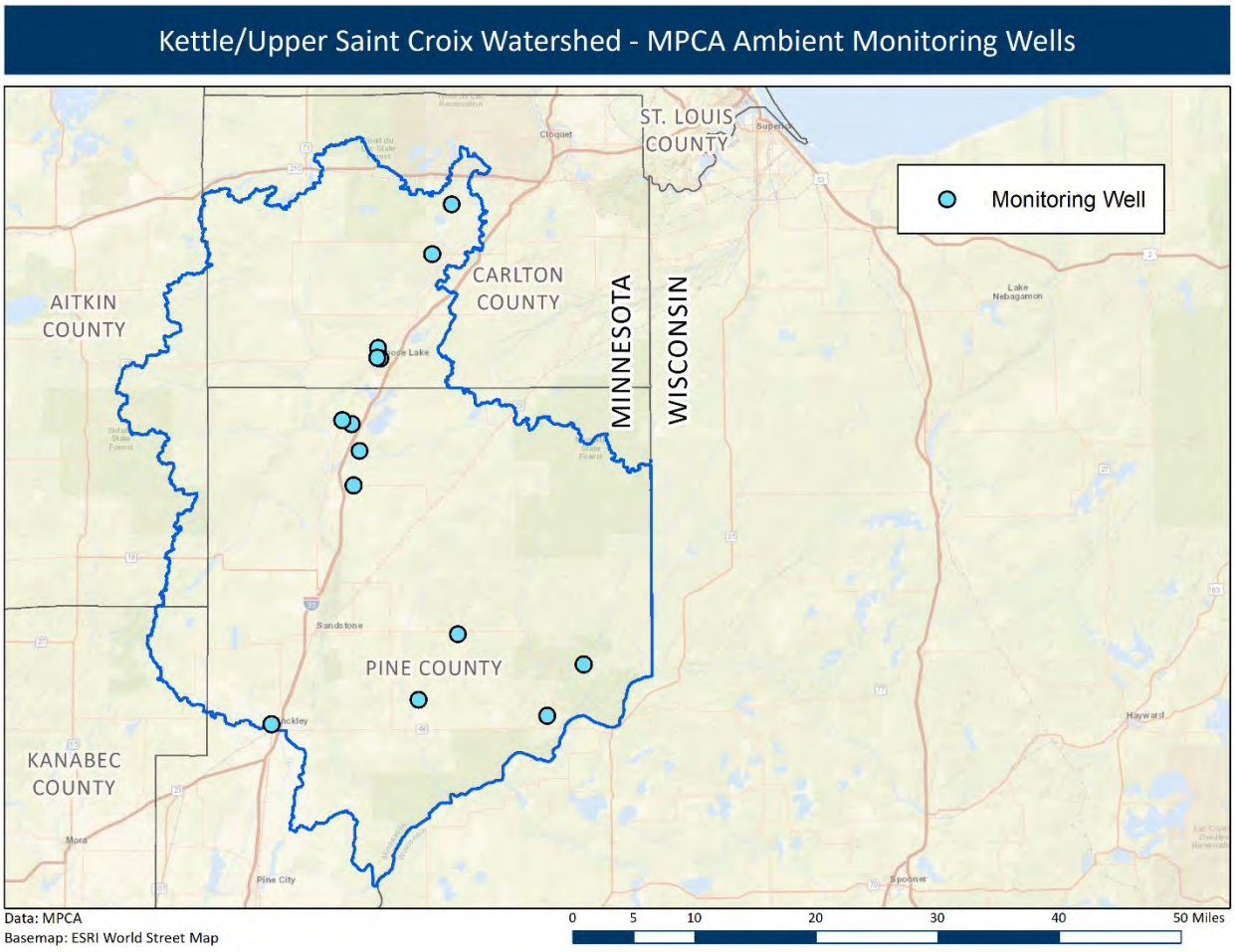

Figure 16: Kettle and Upper St. Croix River Watersheds – MPCA Ambient Groundwater Monitoring Well Network

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 KUSCRW 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 the Kettle and Upper St. Croix River Watersheds?

The KUSCRW has 429 active feedlots. 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 in the KUSCRW are not delegated counties and rely on the MPCA to execute the feedlot program within their jurisdiction.

Table 5: Number of registered feedlots and the delegated counties outlines the number of registered feedlots in the KUSCRW for each county. Figure 17 shows the active feedlots in the watersheds.

Table 5: Number of registered feedlots and the delegated counties

Counties	Number of Registered Feedlots per County	Delegated County
Aitkin	2	No
Carlton	35	No
Kanabec	3	No
Pine	79	No

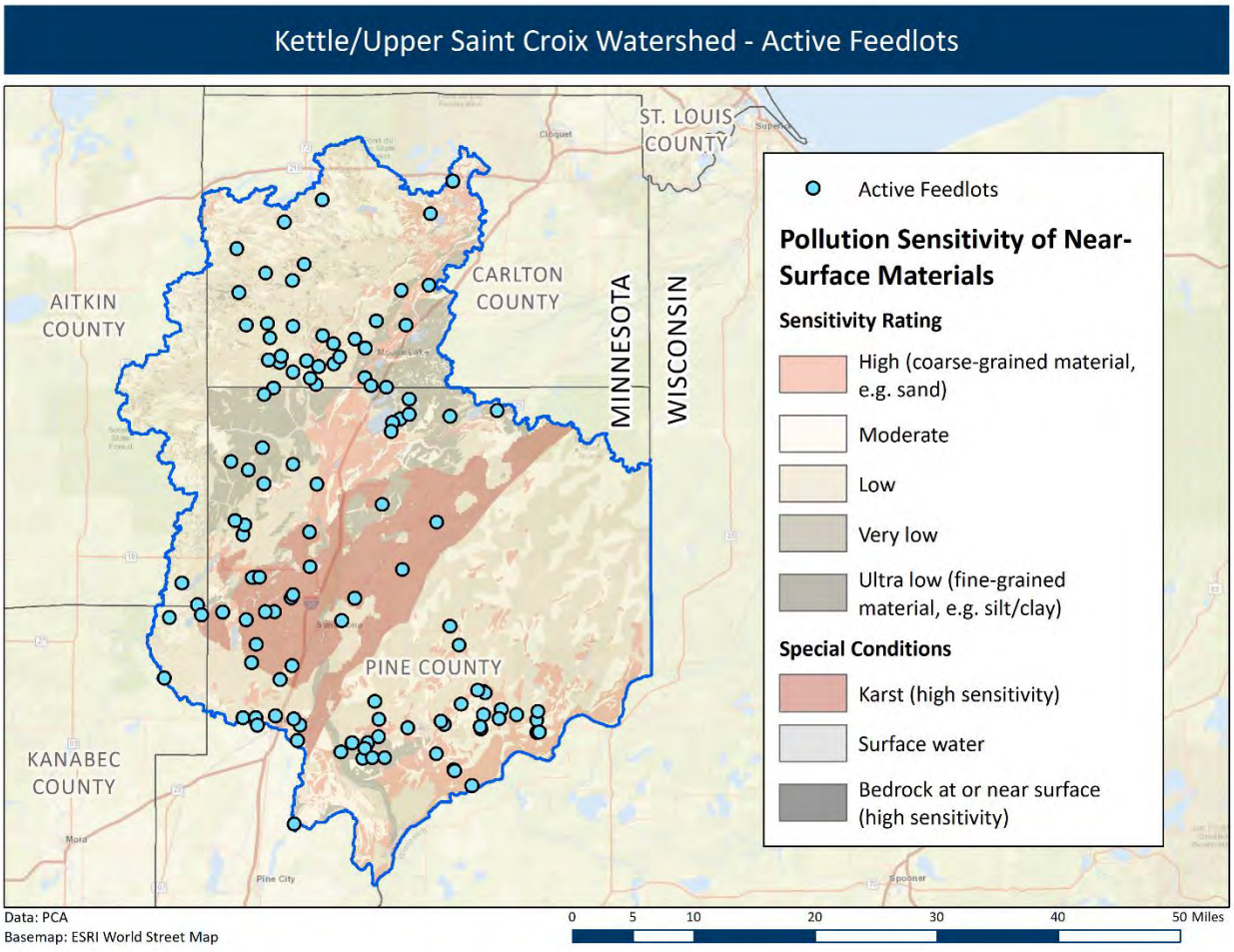

Figure 17: Kettle and Upper St. Croix River Watersheds – Active Feedlots. There are 119 active feedlots within the watersheds.

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 8 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) represent approximately two percent of the land cover within the KUSCRW. 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)

A total of 618,102 SSTS (commonly called septic systems) were reported across Minnesota in 2020, representing an estimated 42.3 billion gallons of wastewater treated by SSTS per year. The number of compliant SSTS has increased over the last ten years, from approximately 401,000 systems in 2011 to 505,300 systems in 2020. Trends observed from the MPCA 2020 SSTS Annual Report suggest continued improvements in subsurface wastewater treatment across the state.

While compliant SSTS have increased, failing SSTS still pose a risk to groundwater contamination. A failing SSTS lacks adequate separation between the bottom of the drain field and seasonally saturated soil. The wastewater in SSTS contain bacteria, viruses, parasites, nutrients, and some chemicals. SSTS infiltrate treated sewage into the ground, which ultimately travels to groundwater.

Where Are SSTS in the Kettle and Upper St. Croix River Watersheds?

SSTS are found in all counties of the KUSCRW. State regulations require each county to adopt a local SSTS ordinance to protect both ground and surface water. An imminent health threat or failing systems must 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. Carlton is the only county in the KUSCRW that does not require a point-of-sale requirement.

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 8 provides a more comprehensive list of specific actions the KUSCRW 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 201 active tanks at 75 unique sites, 10 leak sites, one closed landfill and one Superfund site in the watershed. 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 Kettle and Upper St. Croix River Watersheds?

Figure 18, maps active tank and leak sites compared to pollution sensitivity of near-surface materials in the KUSCRW. Figure 19 provides a map of the closed landfills and superfund site in the KUSCRW. 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 (http://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.

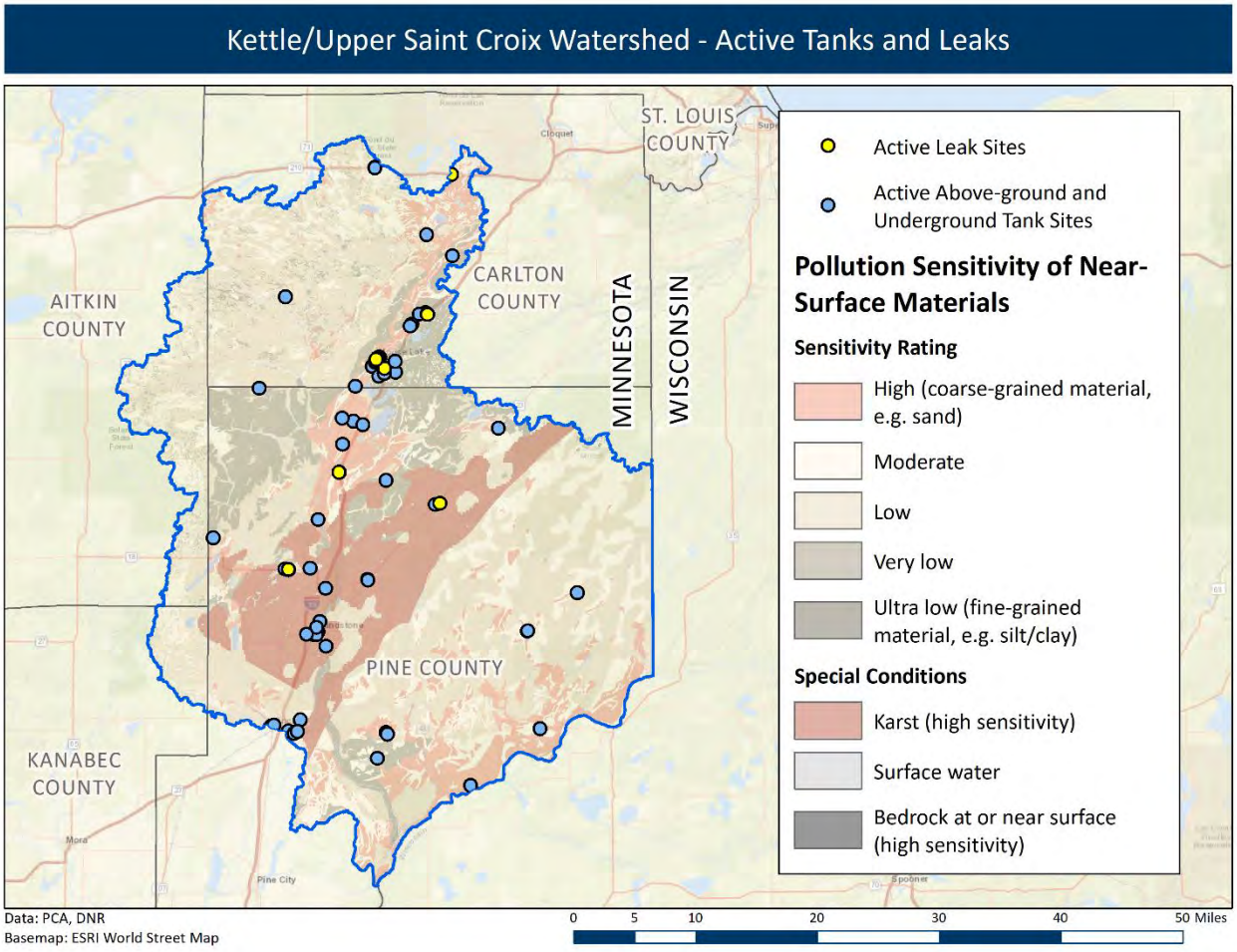

Figure 18: Kettle and Upper St. Croix River Watersheds - MPCA Active Tank and Leak Sites and Pollution Sensitivity of Near-Surface Materials

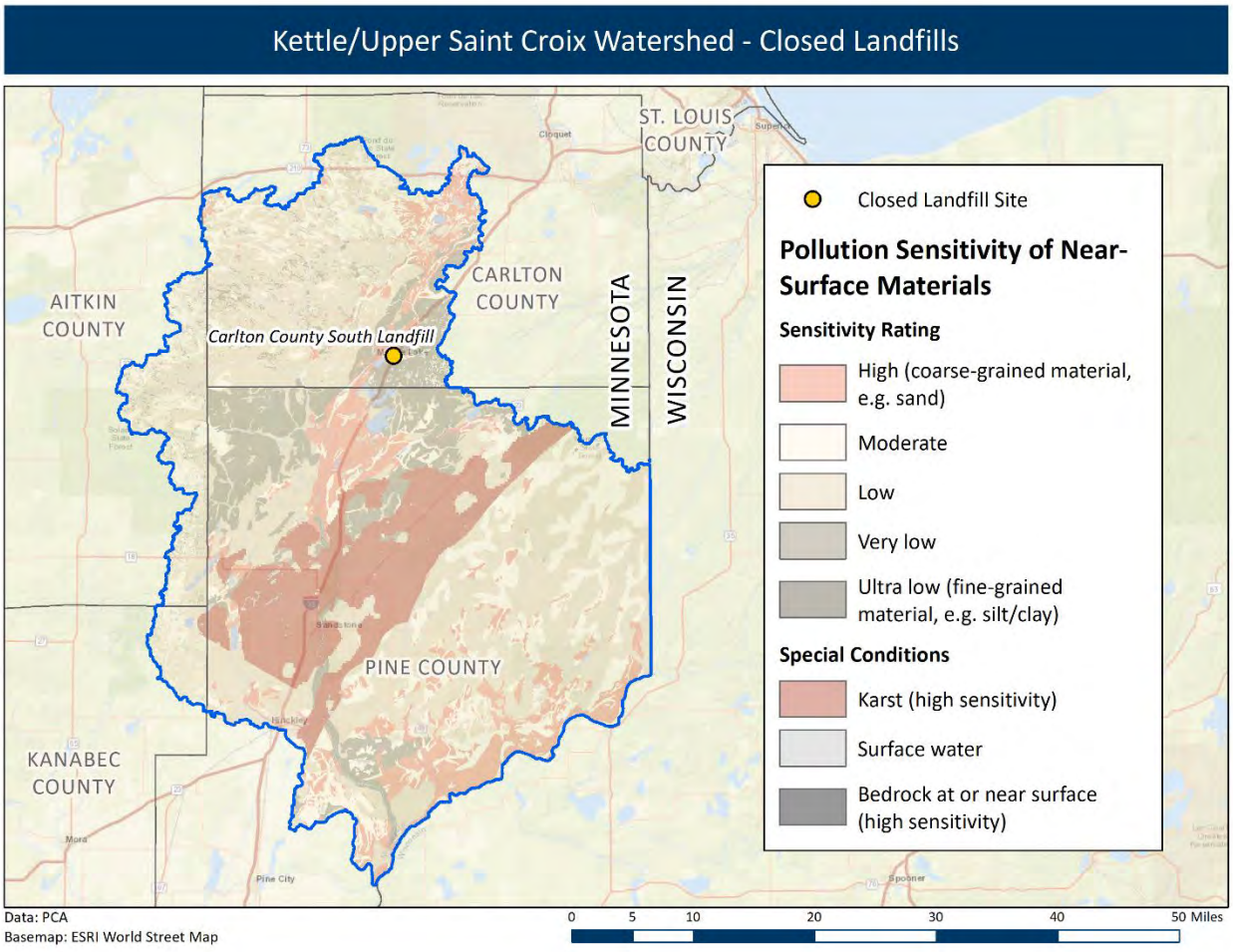

Figure 19: Kettle and Upper St. Croix River Watersheds - MPCA Closed Landfills and Superfund Site. The Superfund site is located at the Kettle River Company's former creosote plant in Sandstone.

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 8 provides a more comprehensive list of specific actions the KUSCRW 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. MS4s in Minnesota must satisfy the requirements of the MS4 general permit if they are located in an urbanized area and used by a population of 1,000 or more or owned by a municipality with a population of 10,000 or more, or a population of at least 5,000 and the system discharges to specially classified bodies of water. 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. Several 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 8 provides a more comprehensive list of additional actions the KUSCRW 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 8 provides a more comprehensive list of specific actions the KUSCRW 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 (https://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

Permitted groundwater use was generally between 375 and 531 million gallons per year from 1988 to 2021. Approximately 85.2 percent of groundwater use is for water supply and 7.5 percent is used for non-crop irrigation. The watershed has 18 DNR groundwater-level monitoring wells.

Groundwater Use

A water-use appropriation permit is required from the DNR for groundwater users 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 which aquifers are being used and for what purpose. Permits require annual water-use reporting. This information is recorded using Minnesota Permitting and Reporting System (MPARS), which helps the DNR track the volume, source aquifer, and type of water use. The DNR has records of reported water use from 1988 to the present.

Figure 20 - Figure 22 show graphs of reported water use by calendar year from 1988 to 2021. A summary of reported 2019 water use by use category versus source aquifer is shown in Table 6. Figure 23 and Figure 25 show the distribution of permitted wells with reported 2021 water use, categorized by use category and aquifer type, respectively.

Annual groundwater use in the KUSCRW had between 375 and 531 million gallons per year (Figure 20). Groundwater use peaked in 1996 at 531 million gallons per year.

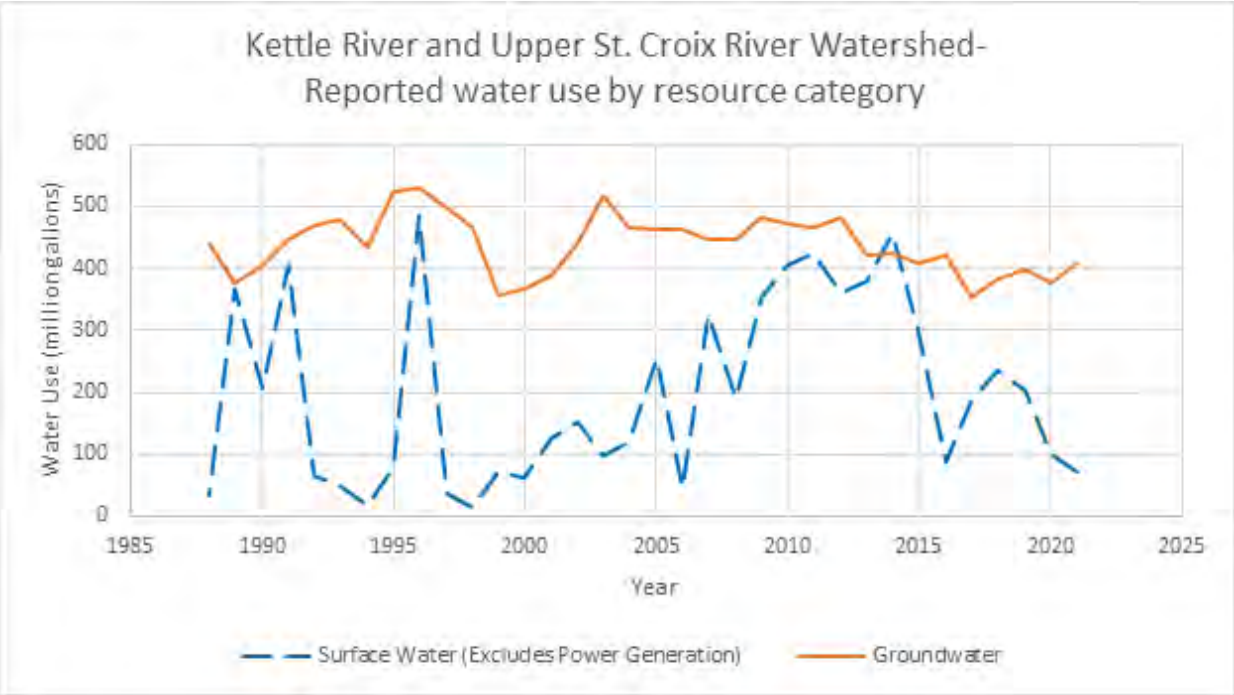

Figure 20: Reported water use from the DNR permit holders by resource category. Groundwater use decreased from about 531 million gallons per year in 1996 to about 353 million gallons per year in 2017.

Most permitted groundwater withdrawals are pumped from bedrock aquifers (Figure 21). Most permitted groundwater use is for water supply (Figure 23).

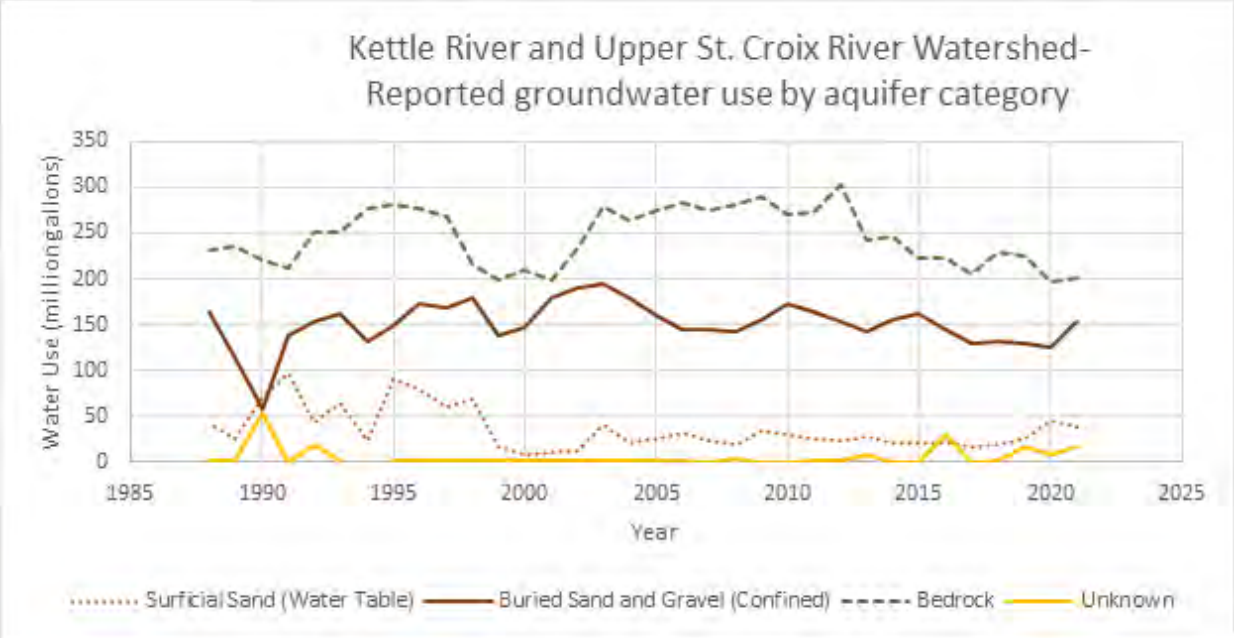

Figure 21: Reported groundwater use from DNR permit holders by aquifer category. Most permitted groundwater use is drawn from bedrock aquifers. Pumping from bedrock aquifers varied from about 196 million gallons per year in 2020 down from 302 million gallons per year in 2012.

In 2021, approximately 85.2 percent of permitted groundwater use was for water supply, 7.5 percent was used for non-crop irrigation, 2.7 percent for industrial processing, and the remainder spread among other use categories (Table 6). Approximately 34.9 percent of permitted groundwater was sourced from the buried sand and gravel aquifers, 9.3 percent from surficial sand aquifers, 48.9 percent from bedrock aquifers, and 4.4 percent from unknown aquifers.

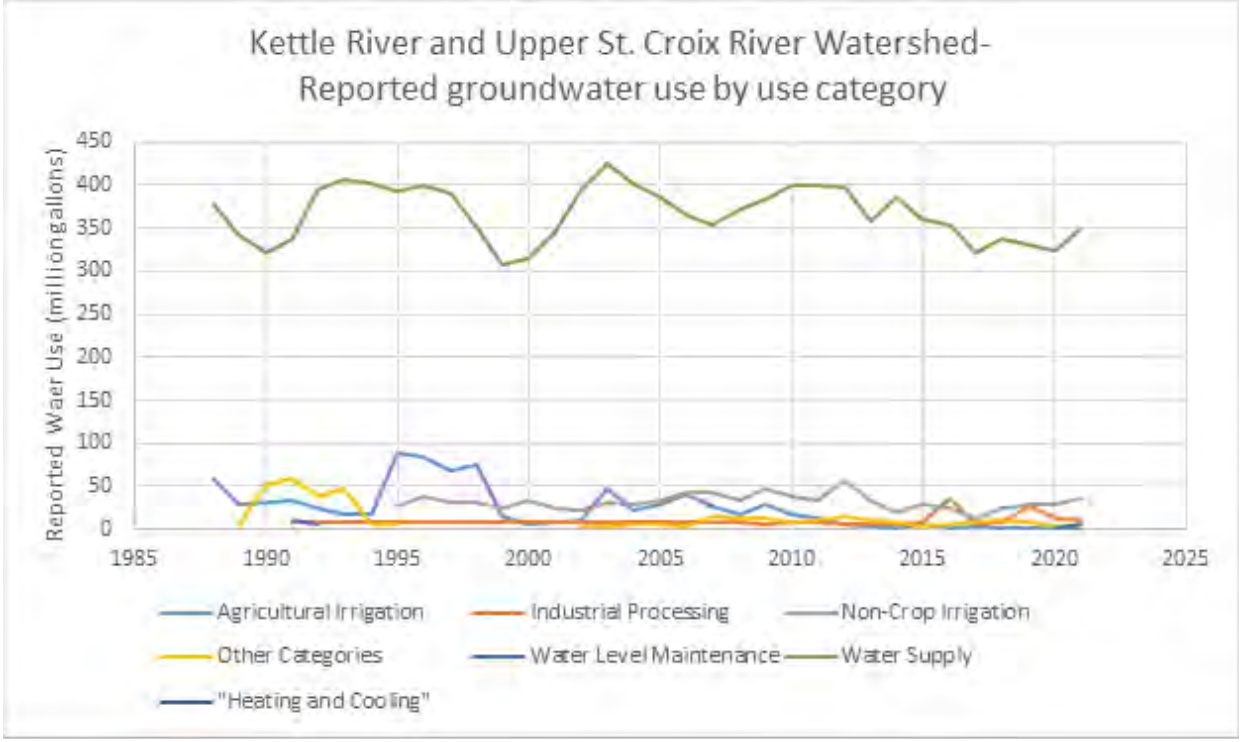

Figure 22: Reported groundwater use from DNR permit holders by use category. Most permitted groundwater withdrawals are used for water supply. Pumping for water supply was fairly constant over the period of record.

Table 6 [11]: Reported 2021 water use from DNR groundwater permit holders in million gallons per year.

Use Category	Surficial Sand Aquifer (Water Table)	Buried Sand and Gravel Aquifer (Confined)	Bedrock Aquifer	Unknown	Total (mgy)	Total (percent)
Agricultural Irrigation	1.6	—	—	—	1.6	0.4
Heating/Cooling	—	—	0.8	—	0.8	0.2
Industrial Processing	—	—	—	11.1	11.1	2.7
Non-Crop Irrigation	—	—	30.7	—	30.7	7.5
Other Categories	—	3.3	—	1.3	4.6	1.1
Power Generation	—	—	—	—	—	—
Water Level Maintenance	—	—	—	5.1	5.1	1.2
Water Supply	36.3	143	168.8	0.6	348.7	85.2
Total (mgy)	37.9	153	200.3	18.1	409.3	—
Total (percent)	9.3	34.9	48.9	4.4	—	98.4 *

[11] Data from MPARS; mgy, million gallons per year; dash marks (-) indicate no use in those categories; * percentages may not equal 100 due to rounding.

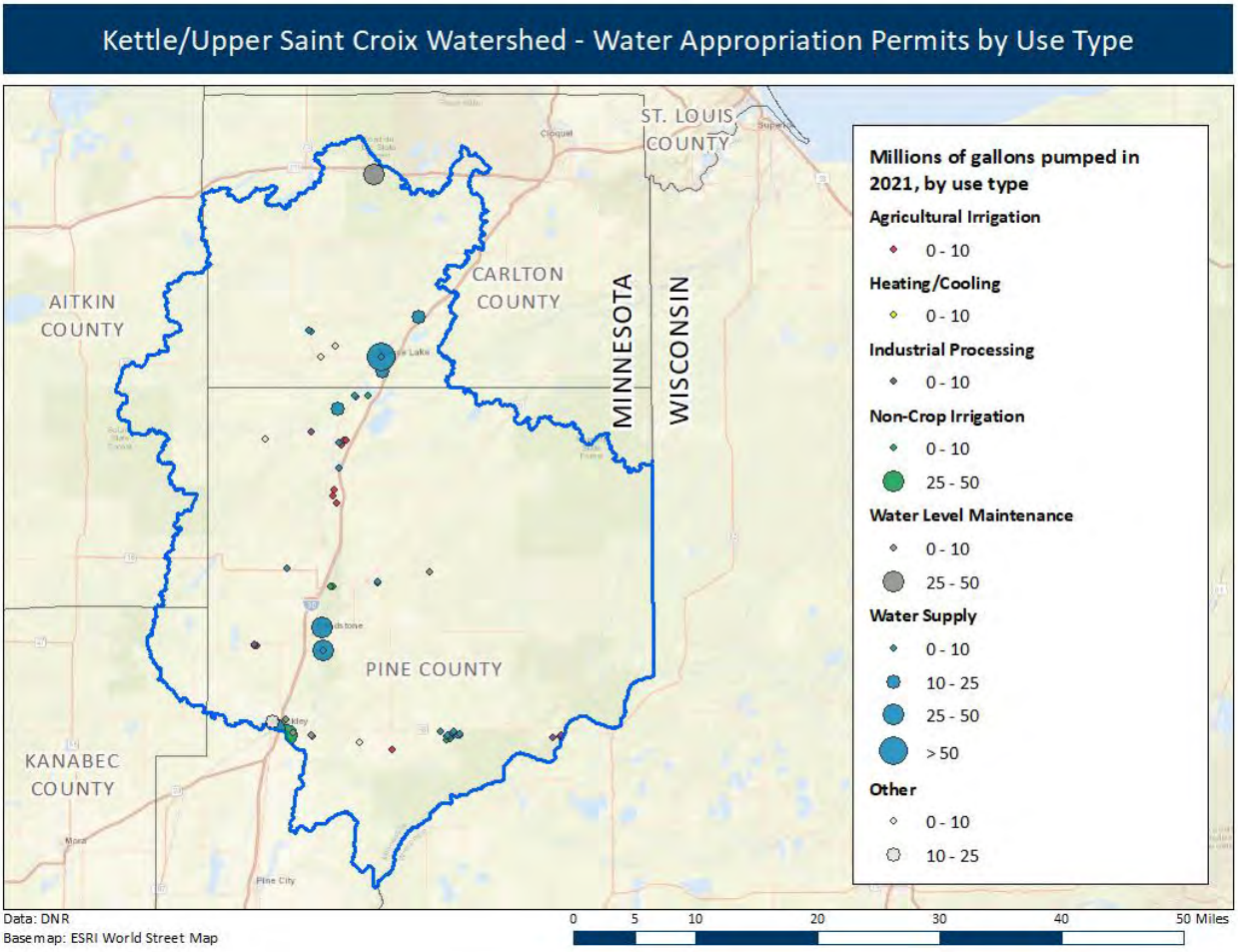

Figure 23: Kettle and Upper St. Croix River Watersheds - Distribution of groundwater appropriation permits for 2021 by volume reported and use category. Water supply is the largest water use in the watershed. The largest individual water users in the watershed are the cities of Moose Lake and Hinckley followed by the U.S. Department of Justice-Sandstone.

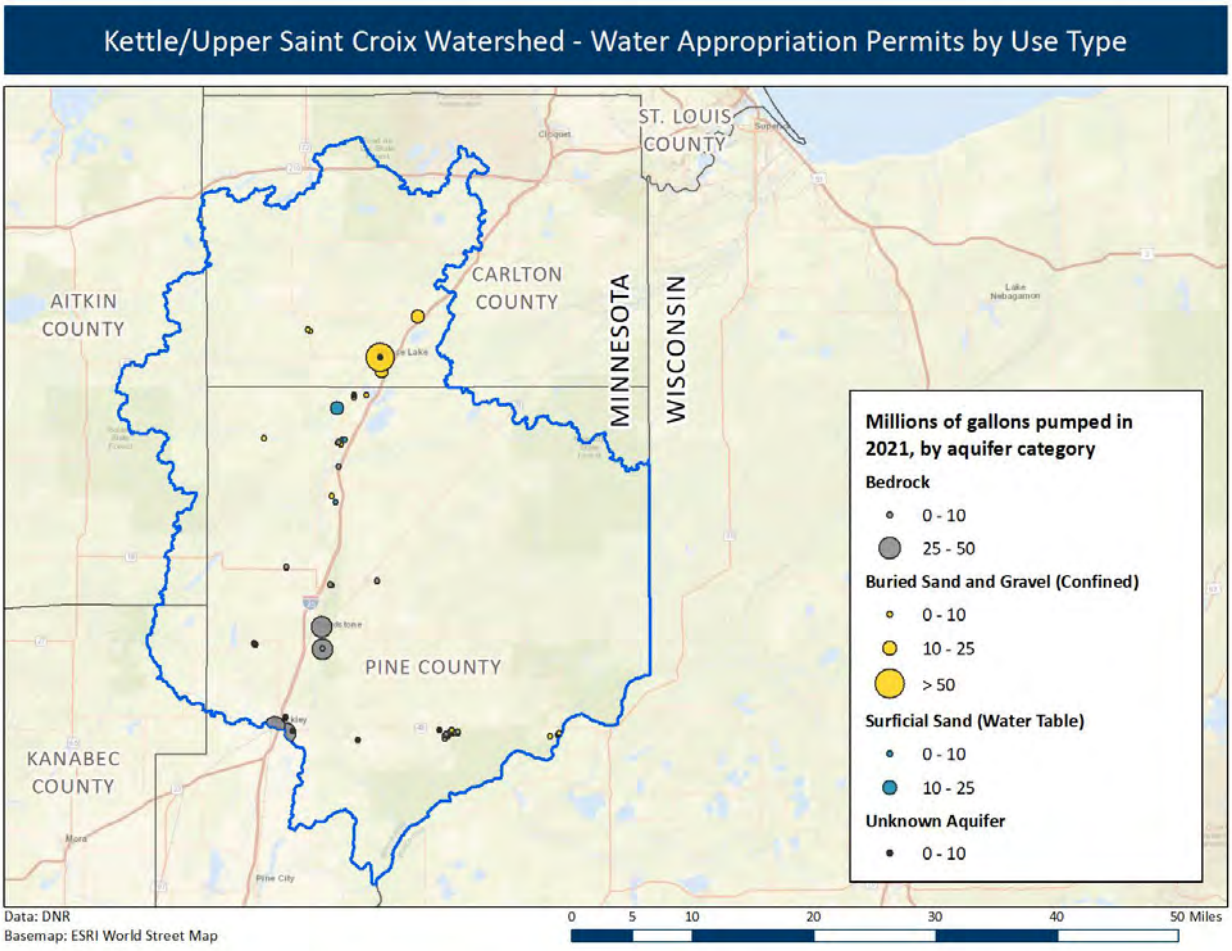

Figure 24: Kettle and Upper St. Croix River Watersheds – Distribution of groundwater appropriation permits for 2021 by volume reported and aquifer category. Bedrock aquifers supply 48.9 percent of the reported water use. Buried sand and gravel aquifers supply 34.9 percent of the reported water use. Surficial sand aquifers supply 9.3 percent of the reported water use. Most of the rest is drawn from wells where the aquifer is not known.

Groundwater Level Monitoring

The DNR maintains a statewide groundwater-level monitoring program for assessing groundwater resources, determining long-term trends, interpreting impacts of pumping and climate, planning for water conservation, evaluating water conflicts, and managing water resources.

There are 18 active groundwater-level monitoring wells in the planning area. Eight wells were installed in the 1960s and 1970s, two wells were installed in the 1980s, and eight wells were installed in the 2010s and 2020s (Figure 23). Nine wells had sufficient water-level data to calculate a long-term trend over the period 1990-2020: nine had no trend (Figure 26).

Wells with two numbers separated by an underscore indicate the water-level record from two wells has been joined together. The first number is the active well; the second number is the well that was sealed and replaced. Location of hydrographs are also shown.

Hydrographs for eight wells are shown in Figures 30 through Figure 38.

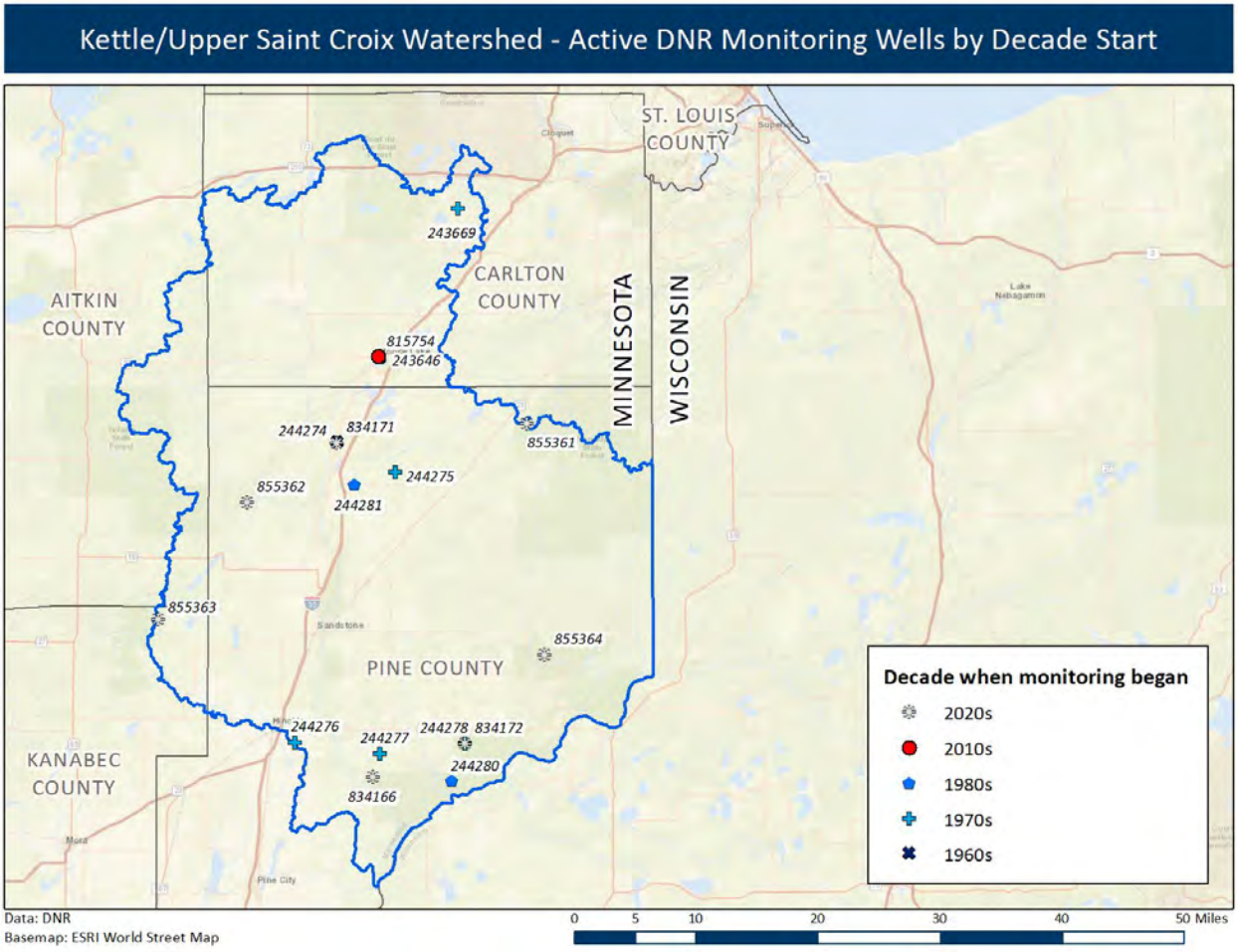

Figure 25: Kettle and Upper St. Croix River Watersheds – Location of active groundwater-level monitoring wells by decade monitoring started. Eighteen wells are measured for groundwater levels in the watershed.

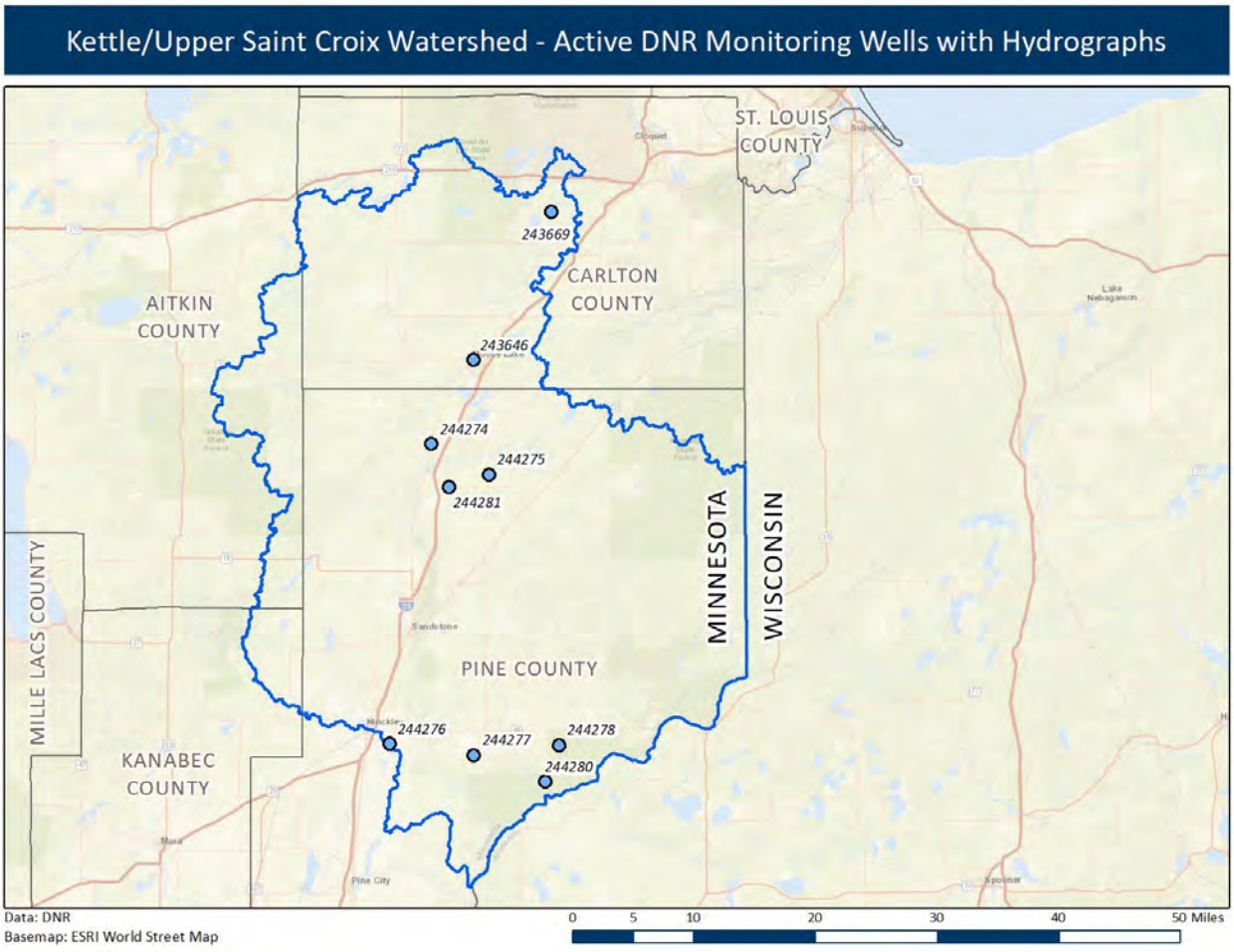

Figure 26: Kettle and Upper St. Croix River Watersheds – Location of active groundwater-level monitoring wells with enough data to calculate a statistical trend. Trends are calculated by the Mann-Kendall non-parametric statistical method. Location of wells with hydrographs are also shown. Nine wells had sufficient water-level data to calculate a long-term trend over the period 1990-2020. All nine wells had no trend.

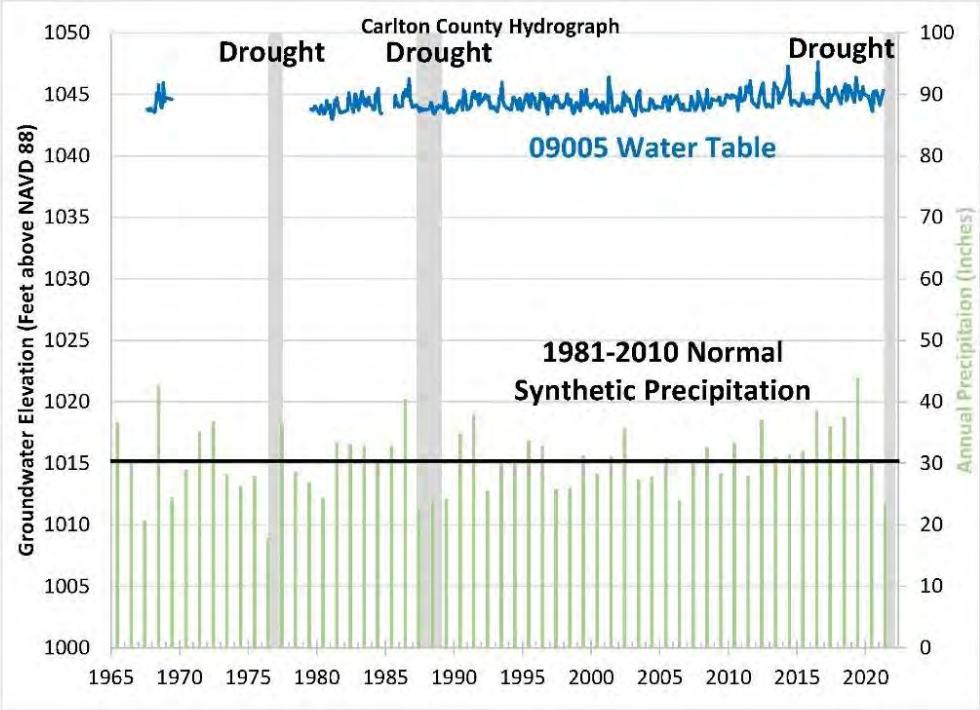

Figure 27: Hydrograph of water-table well 09005. The water level varies a few feet from year to year with a total variation of 5 feet over the period of record. The water-level record has an upward trend.

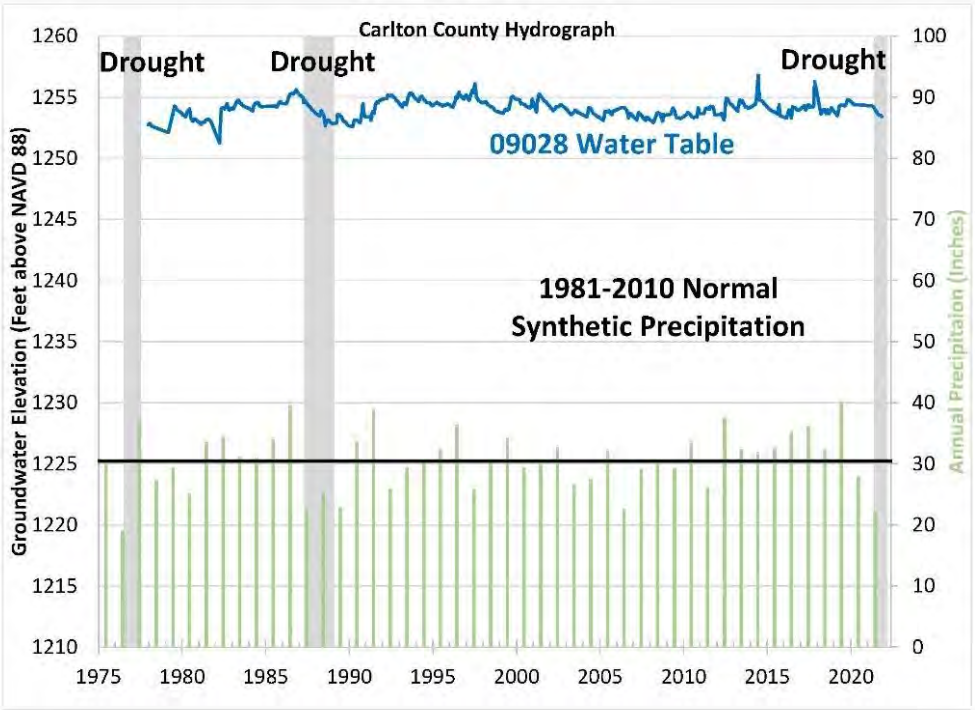

Figure 28: Hydrograph of water-table well 09028. The water level varies a few feet from year to year with a total variation of about 10 feet over the period of record. The water-level record has a no trend over the 1990 to 2020 period.

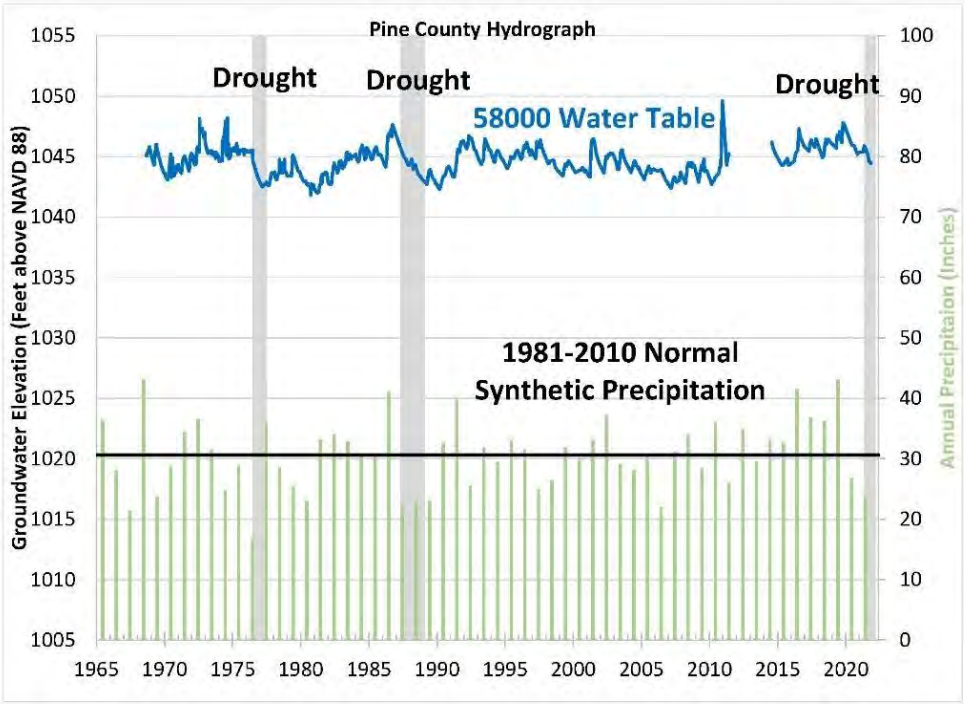

Figure 29: Hydrograph of water-table well 58000. The water level varies a few feet from year to year. The water-level record has no trend over the 1990 to 2020 period.

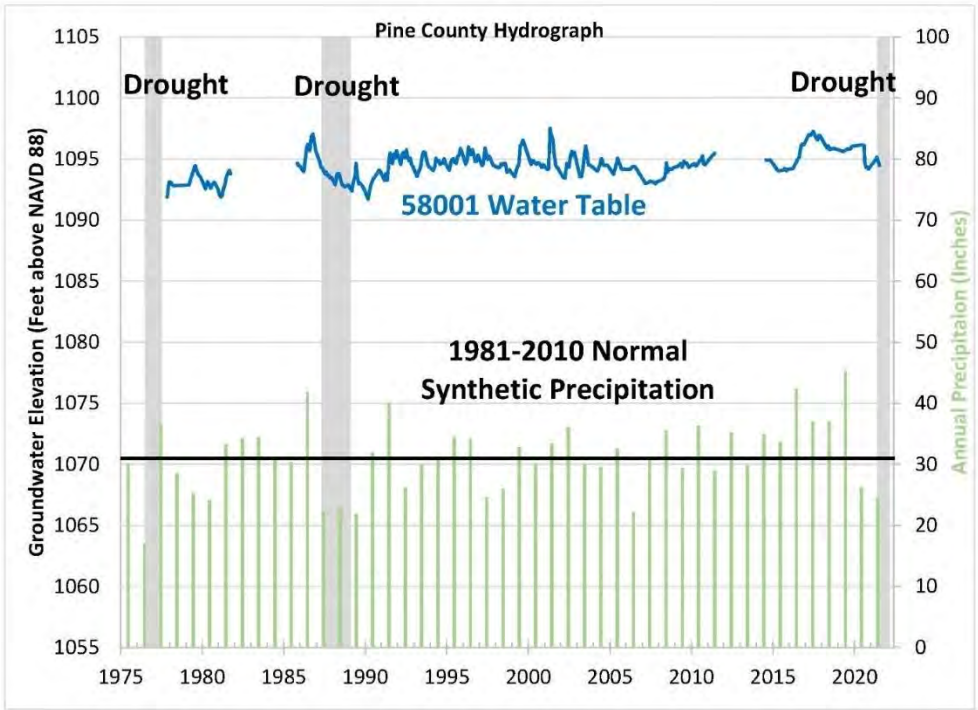

Figure 30: Hydrograph of water-table well 58001. The water level varies a few feet from year to year. The water-level record has no trend over the 1990 to 2020 period.

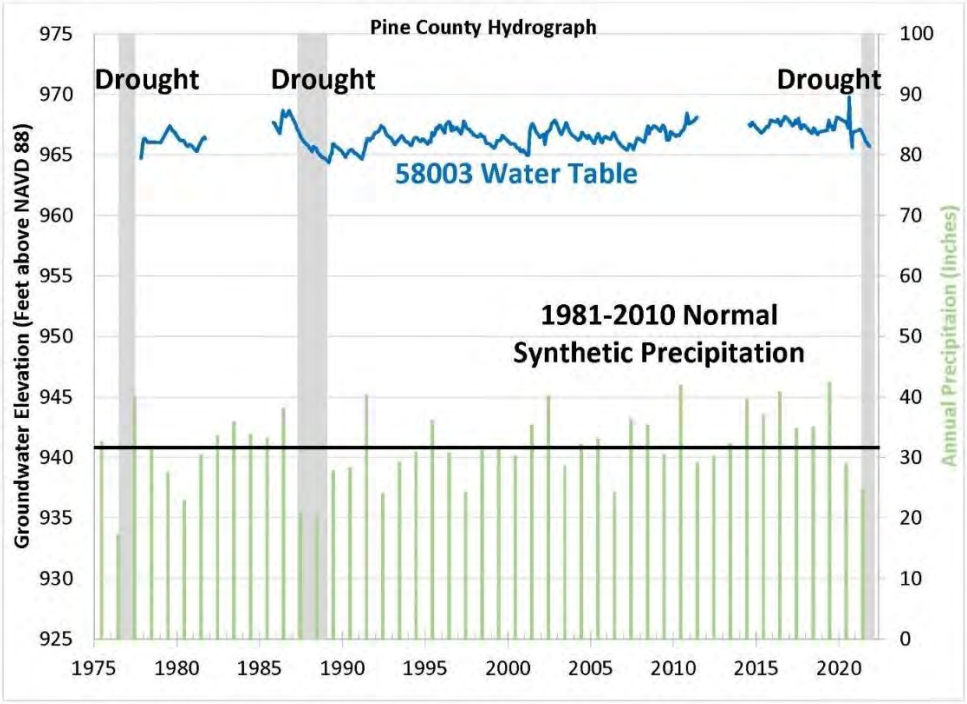

Figure 31: Hydrograph of water table well 58003. The water level varies a few feet from year to year. The water-level record has no trend over the 1990 to 2020 period.

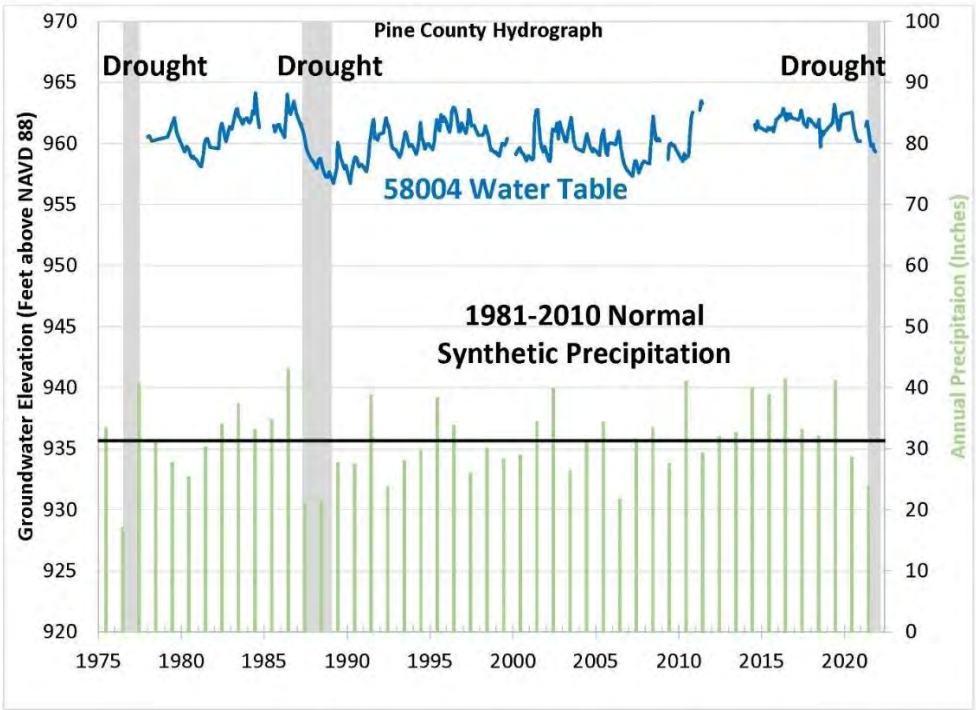

Figure 32: Hydrograph of water-table well 58004. The water level varies a few feet from year to year. No trend is observed for the 1990 to 2020 period.

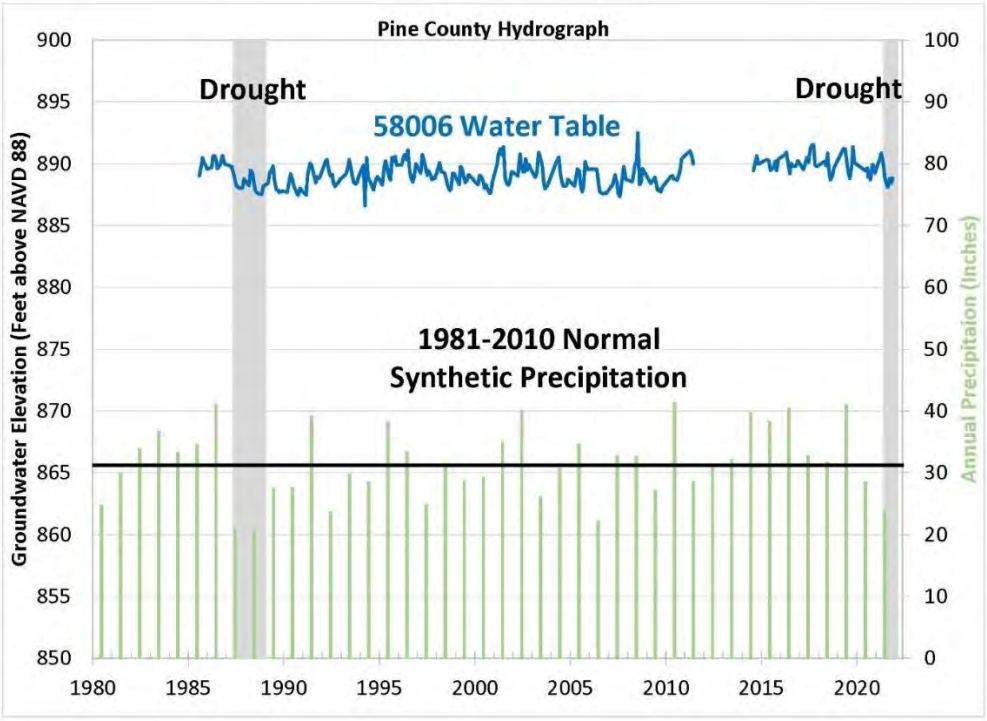

Figure 33: Hydrograph of water-table well 58006. The water level varies a few feet from year to year and is down during the two drought periods. No trend over the 1990 to 2020 period.

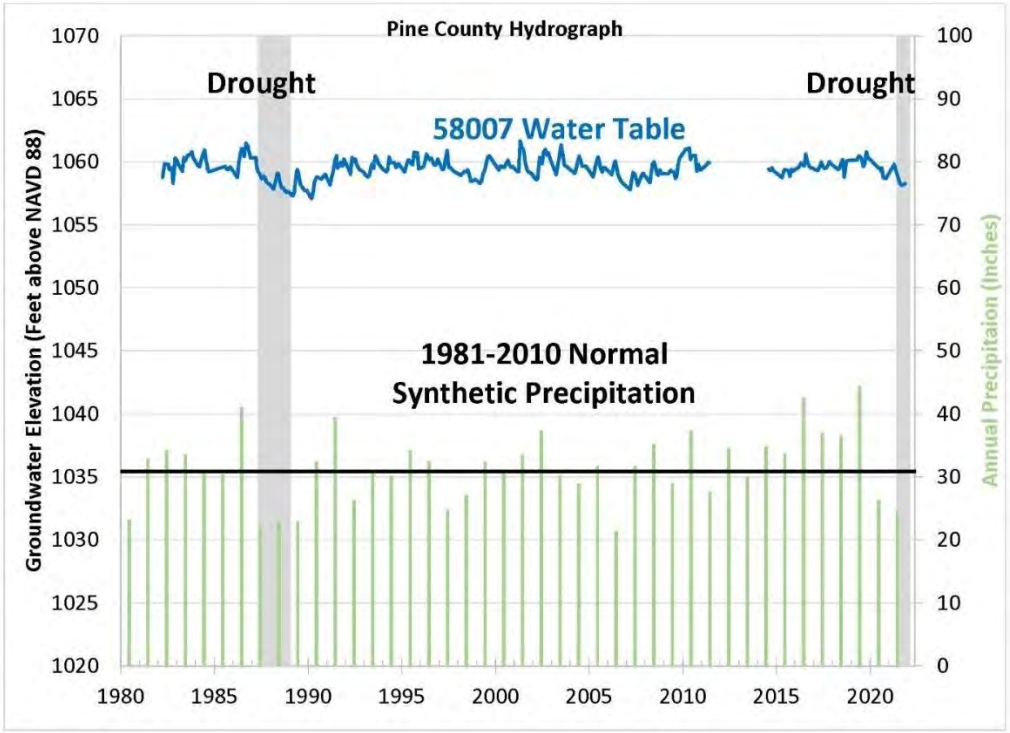

Figure 34: Hydrograph of water-table well 58007. The water level varies a few feet from year to year. The water-level record has no trend over the 1990 to 2021 period.

Groundwater Connected Natural Features at Risk

The KUSCRW boundary includes significant natural features, including surface waters that depend on groundwater to sustain them. 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.

Integrating native systems into our land and water use is extremely important for maintaining and achieving healthy, resilient watersheds that are able to provide for current and future generations.

Rare Natural Features Connected with Groundwater

Rare features can include species of unique plants and animals as well as native plant communities (www.dnr.state.mn.us/npc/index.html) (habitats) and geologic features. In Minnesota, rare species (www.dnr.state.mn.us/ets/index.html) are categorized as endangered, threatened, special concern, and species of greatest conservation need based on how uncommon the species is (its rarity), their distribution in the state, and their vulnerability to extinction. Rare natural features contribute to the health of our environment. Some even contribute directly to local economies in the form of recreation—including hunting/fishing, wildlife viewing, and camping. These resources are at risk if groundwater quantity or quality is disrupted.

There are seven kinds of native plant communities associated with groundwater in the KUSCRW and one native plant community complex. Native plant community complexes include a variety of native plant communities that are so intricately mixed or so small that mapping them individually would not be practical. The native plant communities range from fens and seepage wetlands to wet prairies, wet

meadows, marshes, and forested wetlands. Everything in nature is connected—often tied together with many complex pathways and connection points. Groundwater connections to wildlife species are no exception. 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.

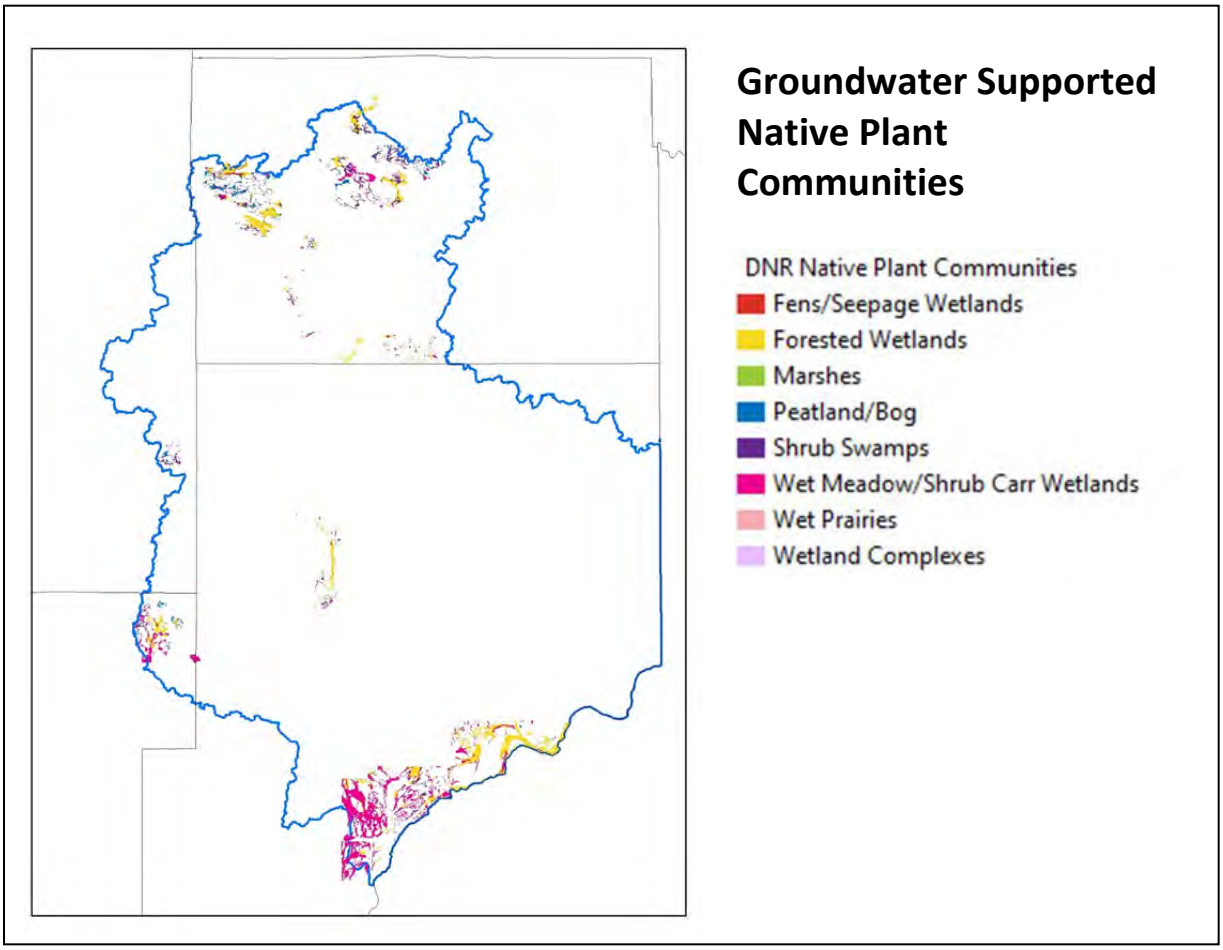

Figure 35: Kettle and Upper St. Croix River Watershed – Groundwater Supported Native Plant Communities. The two largest plant community types are wet meadow/Shrub Carr Wetlands and forested wetlands.

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) (Gergel and others, 1999). This lake type is often landlocked with no surface outlet. Although for the purposes of this GRAPS

report, the lake level 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 36). There are 56 groundwater-flow dominated lakes in the KUSCRW. Of these 56 lakes, 33 have a watershed to lake area ratios between 5 and 10, and 23 lakes have watershed to lake area ratios less than 5. Large-scale groundwater pumping near a lake will likely have more impact to groundwater-flow dominated lakes than to surface water-flow dominated lakes.

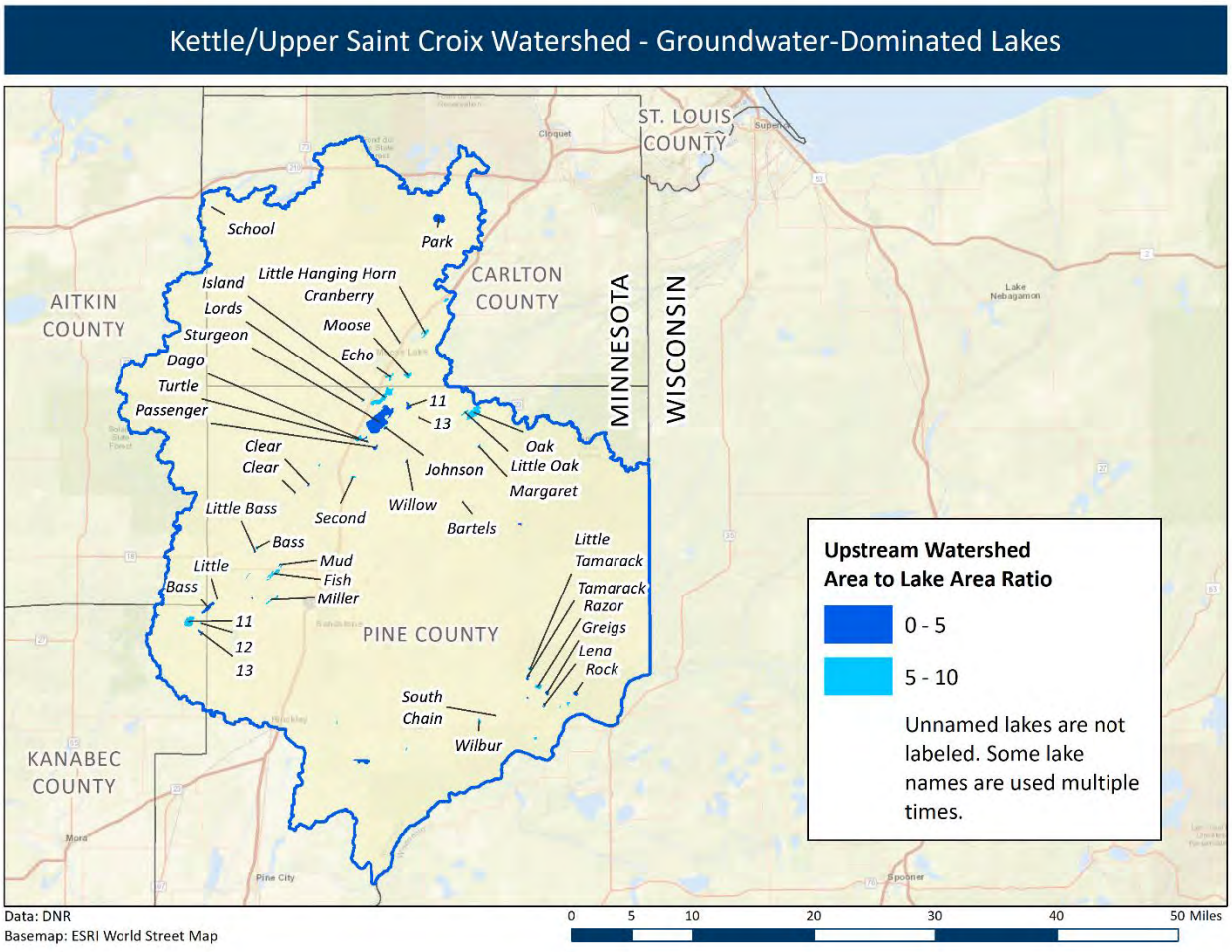

Figure 36: Groundwater-Dominated Lakes in the Kettle and Upper St. Croix River Watersheds planning area. There are 56 groundwater-flow dominated lakes in the planning area. Of these lakes, 33 have a watershed area to lake area ratio between 5 and 10, and 23 have a watershed to lake area ratio of less than 5. These lakes may be groundwater dominated. Lake specific data should be collected before making a final determination on the amount of influence groundwater has on a particular lake.

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 8 provides a more comprehensive list of specific actions the KUSCRW can take to conserve water and promote recharge.

Kettle and Upper St. Croix River Watersheds 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 8) 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 8) 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 5). 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 8) 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 KUSCRW 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 8) 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 measurable 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 Kettle and Upper St. Croix River Watersheds

This section provides a table of strategies and actions local partners in the KUSCRW 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 37 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.

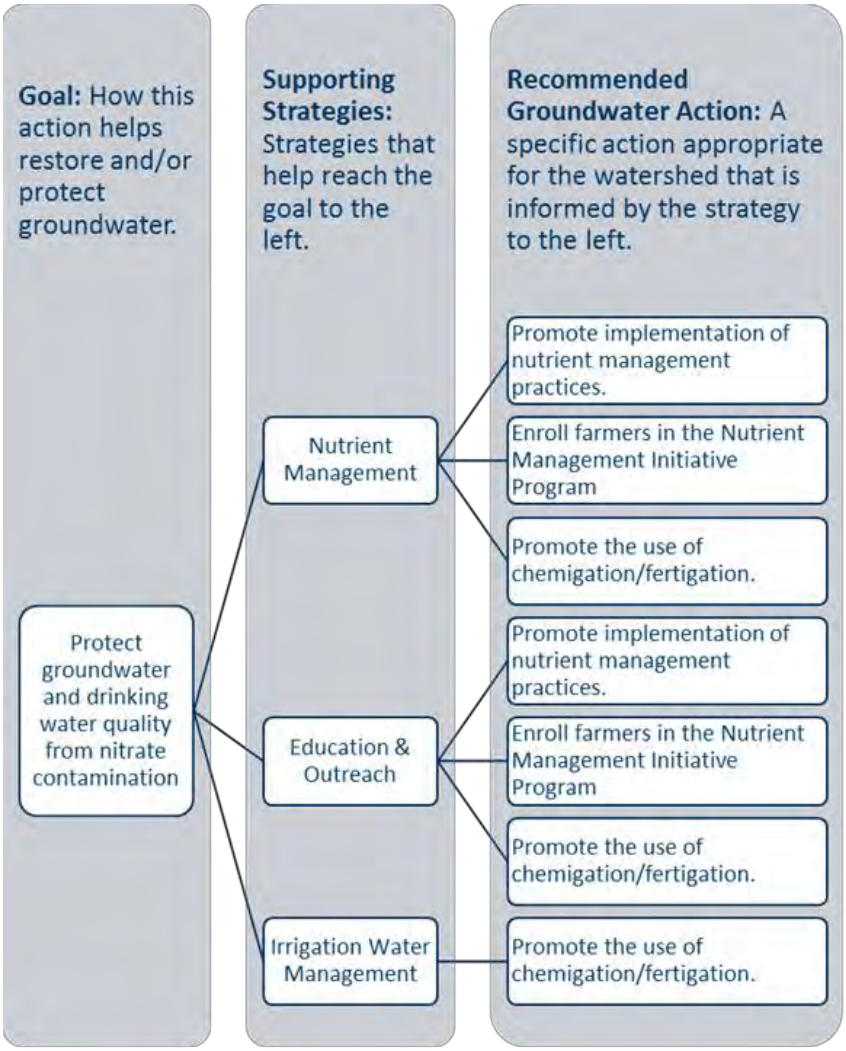

Figure 37: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 8) 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 8 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-10s Involved**: This column denotes which HUC-10 subwatershed(s) within the KUSCRW to consider using the action described in the corresponding row. There are nine HUC-10s within the watershed. Table 7 provides the name and the HUC-10 number assigned to each major watershed. Figure 2 is a map of the HUC-10s.

- **Agencies that can assist**[12]**:** 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:_____**[13]**:** 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 7: HUC 10 subwatersheds within the Kettle and Upper St. Croix River Watersheds

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Grindstone River	Grindstone	0703000305
Lower Kettle River	Lower Kettle	0703000306
Moose River	Moose	0703000302
Pine River	Pine	0703000304
Upper Kettle River	Upper Kettle	0703000301
Willow River	Willow	0703000303
Bear Creek	Bear	0703000111
Chases Brook-St. Croix River	Chases Brook	0703000112
Crooked Creek	Crooked	0703000107
Lower Tamarack River	Lower Tamarack	0703000106
Sand Creek	Sand	0703000110
Upper Tamarack River	Upper Tamarack	0703000103

Summary of Key Findings and Issues

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

Key Groundwater Quality Findings and Issues

- **Nitrate** – less than 1 percent of the 1,803 tested drinking water wells had nitrate levels at or above the SDWA standard of 10 mg/L.

[12] 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*)

[13] 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*).

- MDA fall nitrogen fertilizer application restrictions apply to the karst region in Pine County and extends up into the eastern portion of the watershed in Carlton County following the band of high pollution sensitivity.
  - The Moose Lake DWSMA in Carlton County has been identified by MDA as a community PWS with elevated nitrates. More data needs to be collected to determine if it will be regulated by the Groundwater Protection Rule.
- There are no MDA ambient monitoring wells in the watershed.
- There are no MDA townships sampled under the Township Testing Program.
- There are 12 MPCA ambient groundwater monitoring wells that were sampled between 2008 and 2020. Of all the chemicals sampled for, nitrate and chloride are of particular concern. No samples from any ambient wells in these watersheds exceeded the nitrate standard of 10 mg/L. Chloride is categorized as a secondary contaminant with a maximum contaminant level of 250 mg/L for drinking water being it can produce an unpleasant taste. Chloride levels at most of these sites were well below these levels. Two sites occasionally exceeded 250 mg/L but did not sustain those levels year-to-year.
- **Arsenic** – just over three percent of the 215 tested drinking water wells had levels 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. MDH started collecting arsenic samples from newly constructed wells in 2008 and may not be a true reflection of risk.
- **Pesticides –** There are no MDA monitoring wells in the watersheds.
- About 92 percent of the wells in the watershed rely on buried glacial aquifers. These aquifers are generally protected by clay and silt that imped water infiltration and potential contaminants from the lands surface.
- **DWSMAs** cover over 3,985 acres in the watershed. All 13 community PWS are engaged in the wellhead protection planning process or are implementing their plans.
  - The city of Moose Lake has a conjunctive WHPA delineation with a surface water contribution area in their DWSMA.
- Approximately 42 percent of the people living in the watershed get their drinking water from a community public water supply system.
- **Private wells** – there are approximately 2,925 private drinking water wells with known locations ranging from 13 ft. to 610 ft. deep, with an average depth of 113 ft. Approximately 23 percent (668 wells) of private wells are in a highly vulnerable setting.
- **Flood events** can threaten the safety and availability of drinking water by washing pathogens and chemical contamination into source aquifers. There is limited flood data for Aitkin, Carlton, and Kanabec counties to evaluate flood risk.
- **Animal feedlots – t**here are 429 active feedlots in the watershed. None of the counties have a delegated feedlot program and rely on the MPCA to administer the feedlot rule.
- **Row crop agriculture** – approximately 2 percent of the land cover is in row-crop agriculture in the watersheds. In areas with high pollution sensitivity, agricultural inputs can contaminate the underlying aquifer.
- **SSTS** are found throughout the watersheds. Carlton County is the only county in the KUSCRW that doesn't require a point-of-sale inspection through a property sale.
- **Contaminated sites –** the MPCA identified 201 active tanks at 75 unique sites that could leak chemicals into the environment and 10 leak sites that may cause localized groundwater pollution if not properly managed. The risk to groundwater is greatest in areas of high pollution sensitivity.

- One closed landfill and one Superfund site with known groundwater contamination plumes are found within the watershed. The identified sites are the Carlton County South Landfill and the Superfund site located at the Kettle River Company's former creosote plant in Sandstone.

Key Groundwater Quantity Findings and Issues

- Annual groundwater use in the KUSCRW had between 375 and 531 million gallons per year over the period 1988-2021. Groundwater use peaked in 1996 at 531 million gallons per year.
- In 2021, approximately 85.2 percent of permitted water use was for water supply and 7.5 percent was used for non-crop irrigation.
- Approximately 34.9 percent of permitted groundwater was sourced from the buried sand and gravel aquifers, 9.3 percent from surficial sand aquifers, 48.9 percent from bedrock aquifers, and 4.4 percent from unknown aquifers.
- The watershed has 18 DNR groundwater-level monitoring wells. Eight wells were installed in a the 1960s and 1970s, two wells were installed in the 1980s, and eight wells were installed in the 2010s and 2020. Nine wells had sufficient water-level data to calculate a long-term trend over the period 1990-2020: all nine wells had no trend.
- There are 56 groundwater-flow dominated lakes in the KUSCRW. Of these lakes, 33 have a watershed to lake area ratios between 5 and 10, and 23 lakes have watershed to lake area ratios less than 5. These lakes may be groundwater dominated.
- There are seven kinds of native plant communities associated with groundwater in the KUSCRW and one native plant community complex.

Table of Actions and Strategies to Restore and Protect Groundwater

Table 8: Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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	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 15)* *Drinking Water Wells Map (Figure 12)*						
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	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 5)* *Pollution Sensitivity Wells (Figure 7)* *Arsenic Map (Figure 15)* *Drinking Water Wells Map (Figure 12)* *Nitrate Map (Figure 14)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: Manage Wells **Protect Groundwater and Drinking Water Quality:** Manage Wells	Education and Outreach	Promote proper management of wells through MDH tools, such as the 'Well Owners Handbook' in landowner outreach efforts.	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells. *Drinking Water Wells Map (Figure 15)*						
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	All	MDH Well MGMT	Prioritize areas with a high density of private wells and DWSMAs. *Drinking Water Wells Map (Figure 12)* *DWSMA Map (Figure 10)*						
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	All	MDH Well MGMT	*N/A*						
Protect Groundwater and Drinking Water Quality: Closed Landfills	Contaminant Planning and Management	▪ Identify MPCA closed landfill/superfund locations and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying the location will help		X			Moose	MPCA CLP Land Manager	*Closed Landfill Map (Figure 19)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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*
	Land Use Planning and Management	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 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	Contaminant Planning and Management	▪ Identify leaky and active tank sites in your area in comprehensive land use plans, zoning maps and ordinances. Identifying these		X		X	Bear Charles Brook	MPCA Tanks Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs.						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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 Quality: Leaky Tanks	Land Use Planning and Management	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.					Crooked Grindstone Lower Kettle Moose Pine Sand Willow		*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Tank & Leak Site Map (Figure 18)*						
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	Bear Crooked Grindstone Lower Kettle Pine Moose Sand Upper Kettle	MPCA Feedlot Program	*Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs.* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Active Feedlot Map (Figure 17)*						X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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*
							Willow								
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	Bear Crooked Grindstone Lower Kettle Pine Moose Sand Upper Kettle Willow	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Active Feedlot Map (Figure 17)*			X	X		X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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 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 ▪ 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		X	X	X	Bear Crooked Grindstone Lower Kettle Pine Moose Sand Upper Kettle Willow	MPCA Feedlot Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Active Feedlot Map (Figure 17)*			X	X		X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote implementation of nutrient management practices to improve farm profitability and reduce nitrogen loss. Practices include: ▪ Improve nitrogen efficiency by practicing the 4 R's of nitrogen stewardship (right source, right rate, right timing, and right place)				X	Bear Crooked Grindstone Lower Kettle Pine Sand	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)*						X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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*
		▪ 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					Willow		*DWSMA Map (Figure 10)*						
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	Bear Crooked Grindstone Lower Kettle Pine Sand Willow	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						X
Protect Groundwater and Drinking	Nutrient Management	Identify programs and opportunities for growers to test and implement new nitrogen practices, innovative technology or cropping systems that protect groundwater quality				X	Bear Crooked	MDA Pesticide &	Focus on areas with high pollution sensitivity, and highly vulnerable DWMSAs.	X		X		X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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 Quality: Nitrate	Education and Outreach Cropland Management	that prevent or reduce nitrogen loss. (E.g. Cover Crops, Alternative Crops, Precision Ag / New Technologies, Nutrient Management Initiative, etc.)					Grindstone Lower Kettle Pine Sand Willow	Fertilizer Division	*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
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	Bear Crooked Grindstone Lower Kettle Pine Sand Willow	NRCS Field Office	Focus on areas with high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Nitrate in Wells Maps (Figure 14)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:**	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	Bear Crooked Grindstone Lower Kettle Pine Sand	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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							Willow		*Nitrate in Wells Maps (Figure 14)*						
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	Bear Crooked Grindstone Lower Kettle Pine Sand Willow	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Nitrate in Wells Maps (Figure 14)*		X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides **Groundwater Sustainability:**	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	Bear Grindstone Lower Kettle Moose Pine Upper Kettle Willow	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 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *DNR Water Appropriation Permits by Use Type (Figure 23)*			X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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															
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	Bear Crooked Grindstone Lower Kettle Pine Sand Willow	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						X
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach	Promote to farmers and area businesses the Agricultural and Non-Agricultural Waste Pesticide Collection Program to dispose of unwanted and unusable pesticides.	X	X	X	X	All	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, and highly vulnerable DWMSAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
Protect Groundwater and Drinking	SSTS Management	▪ Enforce state and locally adopted SSTS ordinances for the protection of groundwater and drinking water sources.		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						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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 Quality: SSTS		▪ 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.							Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 15)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Educate citizens about SSTS including: ▪ The basic principles of how a septic system works ▪ How to operate the system efficiently and effectively ▪ Risks to human health and the environment ▪ Financial options to repair or replace failing or non-compliant system		X	X	X	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 15)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: 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	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 15)* *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
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	Bear Grindstone Lower Kettle Moose Pine Sand Upper Kettle	MDH SWP Unit	*Wellhead Protection Plan Development Status (Figure 9)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: Wellhead Protection	Land Use Planning and Management	Integrate WHP plan strategies into local plans, such as the 1W1P and land use plans.		X		X	Bear Grindstone Lower Kettle Moose Pine Sand Upper Kettle	MDH SWP Unit	*DWSMA Map (Figure 10)*						
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	All	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: 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	All	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
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	All	MDH CEC Program	Focus on areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*						
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	All	DNR Ecological & Water Resources	Focus in areas with high pollution sensitivity. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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	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	All	MDH Well MGMT & SWP Unit	N/A						
Protect Groundwater and Drinking Water Quality **Water Sustainability:** Recharge	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	All	MN Assoc. of Counties	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs and groundwater connected natural features *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)*		X				

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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:** Recharge	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	All	MDH SWP Unit	*Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *Primary Aquifers by Section (Figure 4)* *DWSMA Map (Figure 10)* *Tank & Leak Site Map (*Figure 18*)*						
Protect Groundwater and Drinking Water Quality	Land Use Planning and Management	Conduct a survey of property owners within the flood plain to identify unused/unsealed wells. Seal those wells identified to prevent contamination of the aquifer.	X			X	All	MDH Well MGMT	Prioritize areas of greatest risk to flooding						
Protect Groundwater and Drinking Water Quality	Land Use Planning and Management	Request flooded well test kits from MDH Well Management to distribute to private well owners after a flood event.	X			X	All	MDH Well MGMT	*Prioritize areas impacted by recent flooding that may be at risk to contamination*						

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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:** Recharge	Conservation Easements	Enroll private lands in land acquisition programs or conservation easements. Programs may include: Continuous CRP, and RIM Reserve for wellhead protection.	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 natural features. Examine areas where you can expand on existing easements and protected lands to increase protections. *Pollution Sensitivity Map (Figure 5)* *Pollution Sensitivity Wells (Figure 7)* *DWSMA Map (Figure 10)* *Monitoring Wells/Pumping (Figure 26)* *RIM Easements Map (Figure 38)*	X	X	X	X	X	X
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	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 38)* *Pollution Sensitivity Map (Figure 5)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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 10) *Groundwater Dominated Lakes (Figure 36)*						
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	X	All	MPCA MS4 Program	Prioritize MS4 communities, target highly sensitive areas and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X		X		X
Groundwater Sustainability: Water Conservation	Education and Outreach	Provide education on water conservation practices that can be adopted in people's homes and businesses. Use the Met Council's Water Conservation Toolbox as an example.	X	X	X	X	All	DNR Ecological & Water Resources	N/A		X				
Groundwater Sustainability: Water Conservation	Land Use Planning and Management	Assist communities serving over 1,000 people with water conservation measures outlined in their DNR municipal water supply plans.		X		X	Grindstone Lower Kettle Moose	DNR Ecological & Water Resources	N/A		X				
Water Sustainability: Recharge	Land Use Planning and Management	Promote and increase the adoption of recharge BMPs including wetland construction/restoration, perennial	X	X	X	X	All	DNR Ecological &	Target areas near sensitive features and groundwater fed lakes.	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: Rare or Declining Habitats		establishment, riparian buffers, and conservation easements.						Water Resources	Groundwater Dominated Lakes Map *(Figure 36)*						
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Promote forest land long-term easements, and forest management on private lands, utilizing local, state, and federal technical and financial assistance options.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Promote forestland cover in vulnerable DWSMAs in local comprehensive plans and ordinances, and in comprehensive watershed management plans such as the County Local Water Plan, or 1W1P for drinking water protection.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Inform landowners who own 20 acres or more of forested land cover that they are eligible to have private forest management plans prepared for their forested property.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ **Recommended Groundwater Actions**	Target Aitkin Co.	Target Carlton Co.	Target Kanabec Co.	Target Pine 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: Forestry	Land Use Planning and Management	Assist private forest landowners to implement a DNR certified and registered private forest management plan.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Land Use Planning and Management	Explore grant opportunities for protecting or establishing forested lands.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Education and Outreach	Promote education and awareness of the benefits of forests on groundwater and drinking water.		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Forestry	Education and Outreach	Provide technical assistance for public and private landowners on tree and forest health and invasive species. ▪ Monitor forest health for invasive pests to minimize the spread		X	X	X	All	DNR Ecological & Water Resources	Prioritize private lands with high sensitivity, as well as vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 5)* *DWSMA Map (Figure 10)*	X	X	X	X	X	X

Descriptions of Supporting Strategies

Conservation Easements

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

Existing Programs and Resources

- BWSR **Conservation Reserve Program** (https://bwsr.state.mn.us/conservation-reserve-program): A voluntary program designed to help farmers restore and protect environmentally sensitive land.
- BWSR **Conservation Reserve Enhancement Program - CREP** (https://bwsr.state.mn.us/mn-crep-landowners): 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. Figure 38 shows where RIM easements are in the watershed.

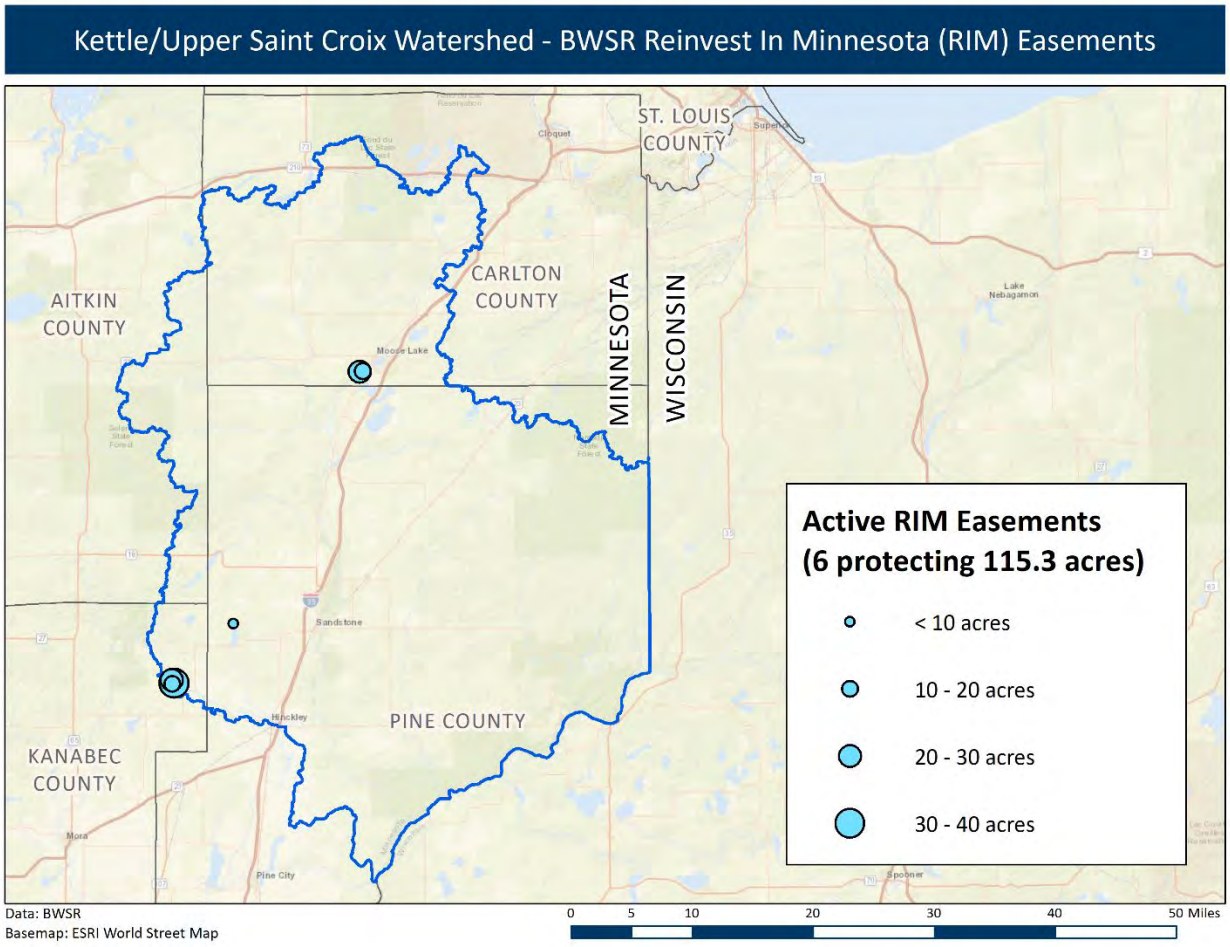

Figure 38: Kettle and Upper St. Croix River Watersheds – BWSR RIM easements

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** (https://extension.umn.edu/animals-and-livestock#manure-management): Information about manure characteristics, application, and economics.
- 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** (https://www.mda.state.mn.us/protecting/cleanwaterfund/research/handbookupdate): 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 lan

- 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** ()https://www.mda.state.mn.us/environment-sustainability/minnesota-agricultural-water-quality-certification-program 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** (www.mda.state.mn.us/pesticide-fertilizer/pesticide-best-management-practices): A program that develops and implements statewide strategies for the increased use of IPM on private and state managed lands.
- MDA **Groundwater and Surface Water Protection from Agricultural Chemicals** (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** (https://www.mda.state.mn.us/irrigation-outreach-farm-nitrogen-management-central-minnesota): 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 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 **Fertilizer** (https://www.mda.state.mn.us/pesticide-fertilizer/fertilizers). 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** (www.mda.state.mn.us/protecting/cleanwaterfund/onfarmprojects/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/township-testing-program): 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/pesticide-fertilizer/nitrogen-fertilizer-best-management-practices-agricultural-lands)): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (www.mda.state.mn.us/pesticide-fertilizer/minnesota-nitrogen-fertilizer-management-plan): The state's blueprint for preventing or minimizing impacts of nitrogen fertilizer on groundwater.
- MDA Monitoring & Assessment for Agricultural Chemicals in the Environment (www.mda.state.mn.us/node/2696): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (https://extension.umn.edu/crop-production#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 **Nitrogen Application with Irrigation Water: Chemigation** (https://extension.umn.edu/irrigation/applying-nitrogen-irrigation-water-chemigation): Information about risks, benefits, and methods.
- MDA **The Agricultural BMP Handbook for Minnesota** (https://www.mda.state.mn.us/protecting/cleanwaterfund/research/handbookupdate): 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** (https://extension.umn.edu/animals-and-livestock#manure-management): Information about manure characteristics, application, and economics.

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** (https://septic.umn.edu/septic-system-owners): 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 39 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.

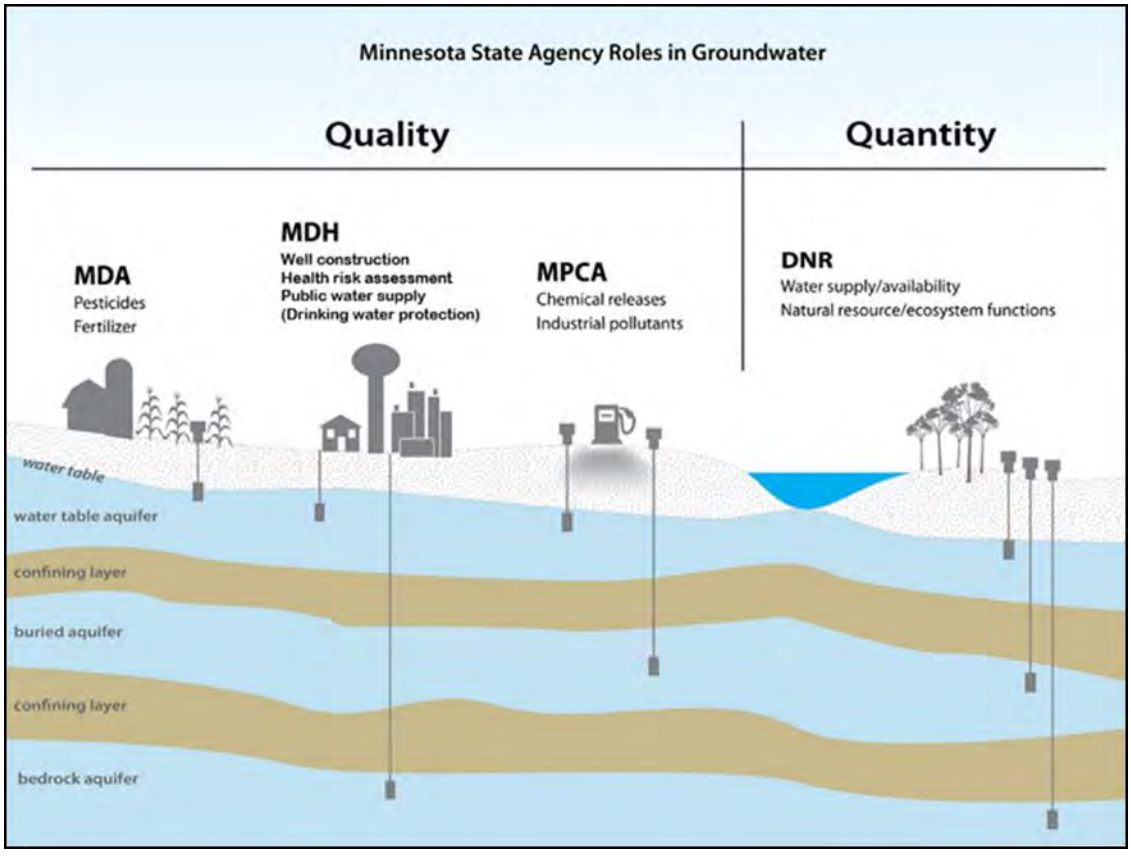

Figure 39: Minnesota State Agency Roles in Groundwater

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 40 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 difficult 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.

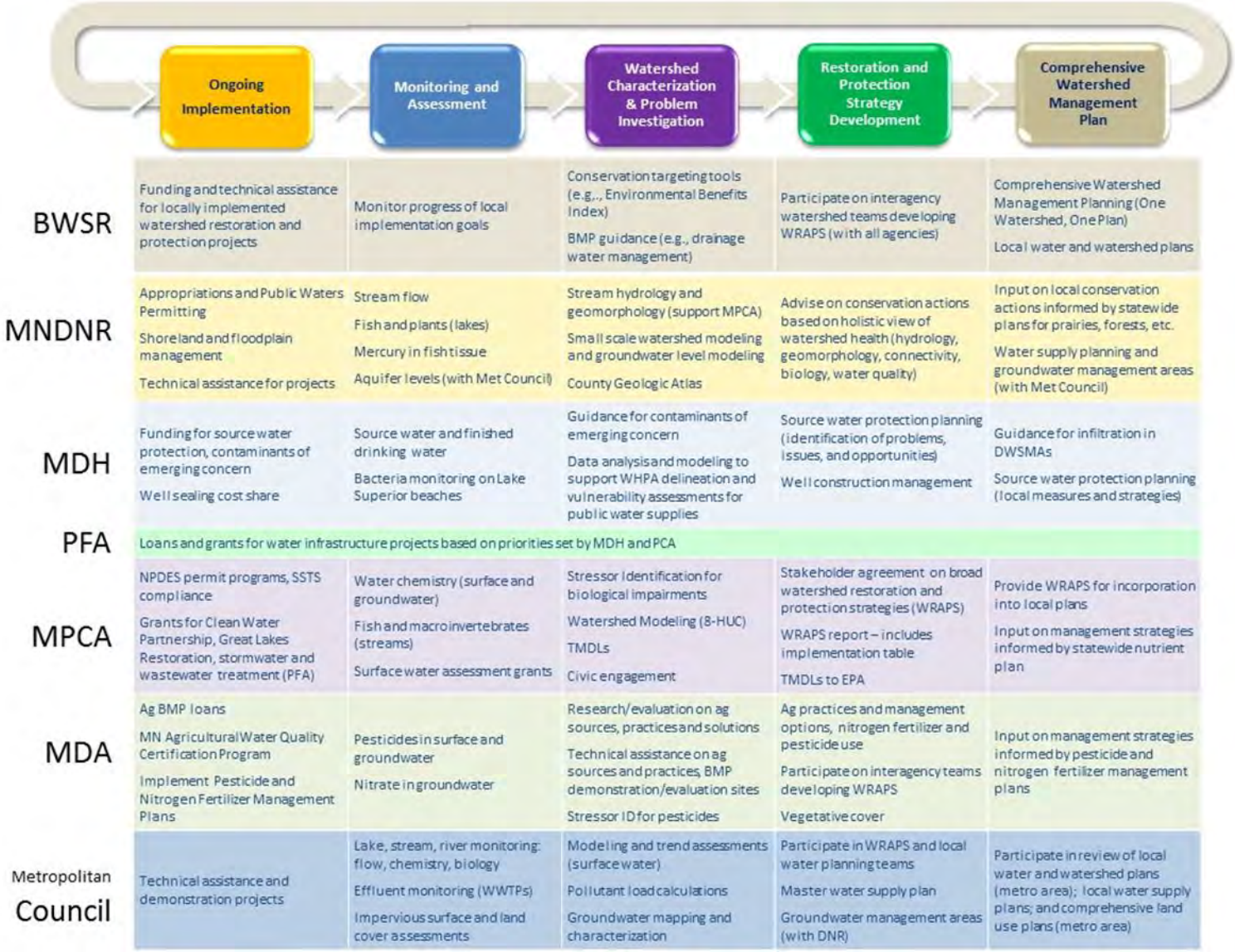

Figure 40: Role's agencies play within the Minnesota Water Management Framework

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. ▪ Protecting Drinking Water Sources (www.health.state.mn.us/communities/environment/water/swp/about.htm) ▪ 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 (www.pca.state.mn.us/water/state-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/communities/environment/water/dwar.html)
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/communities/environment/water/swp/swa.html) ▪ Maps and Geospatial Data (www.health.state.mn.us/communities/environment/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 and update the

Type of Information	Where you can get more information
	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. ▪ MWI (www.health.state.mn.us/communities/environment/water/mwi/index.html)
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. ▪ Protecting Drinking Water Sources (www.health.state.mn.us/communities/environment/water/swp/about.htm) ▪ 651-201-4700

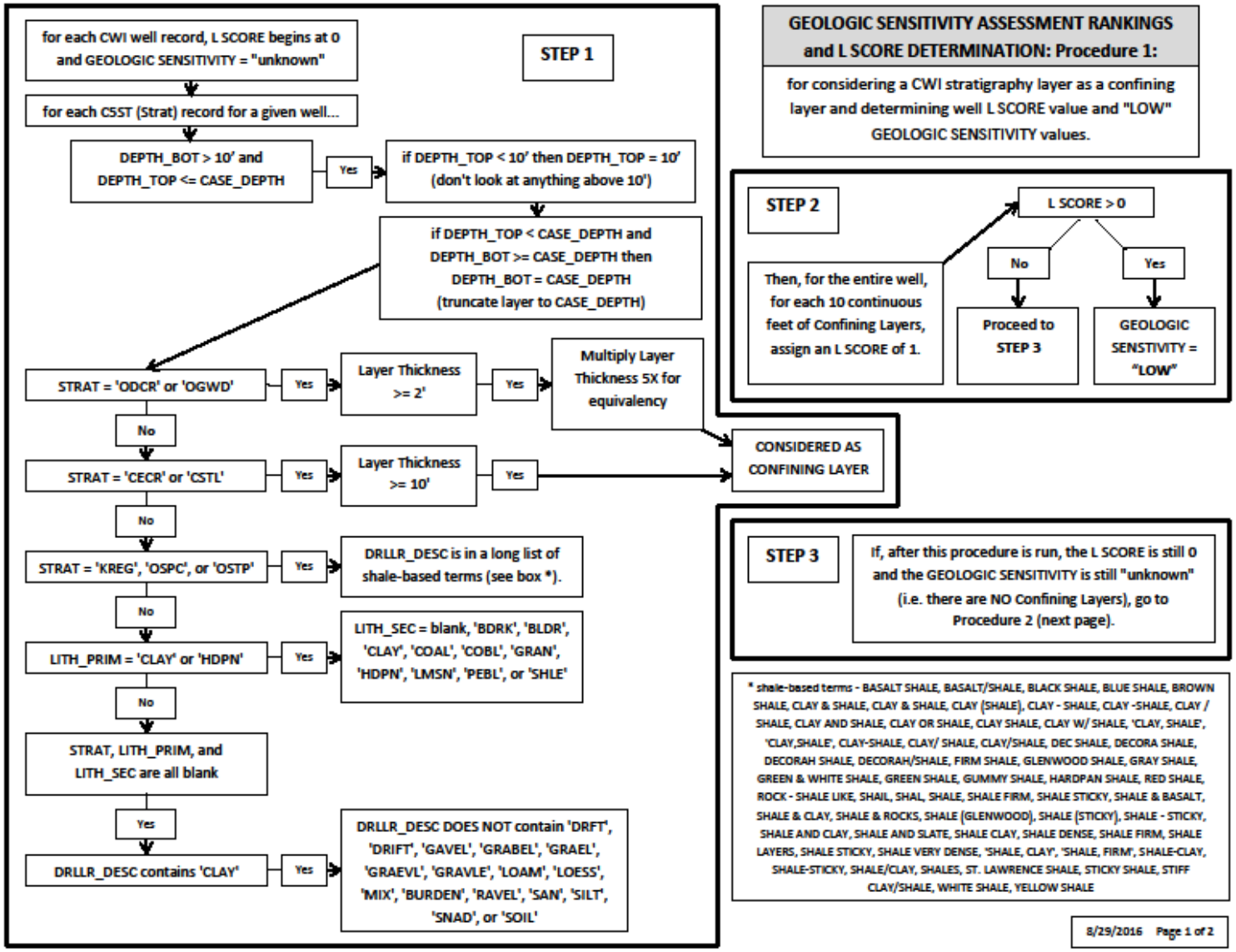

Figure 41: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9)

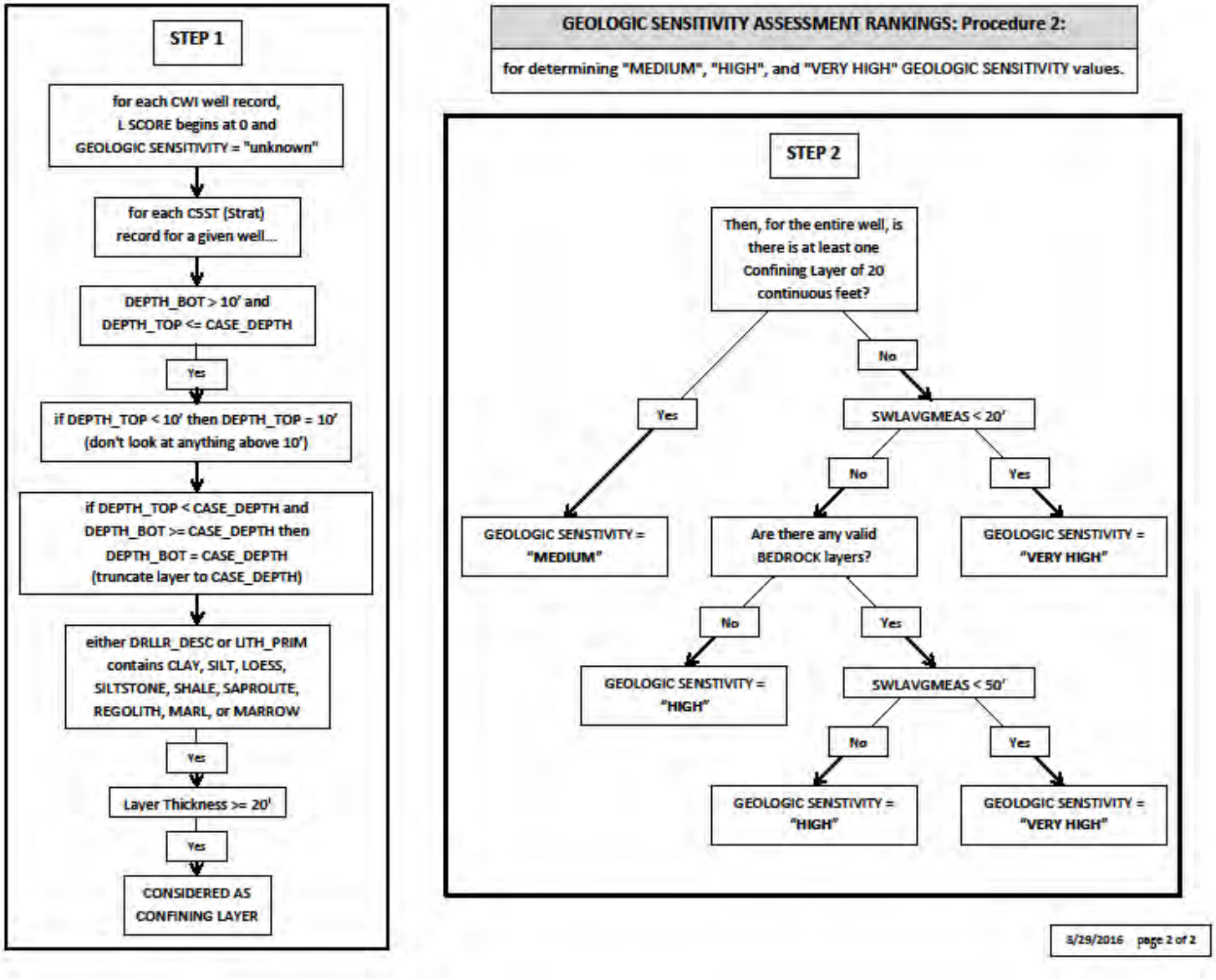

Figure 42: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9) continue

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