Buffalo Red River Watershed (BRRW)

Groundwater Restoration and Protection Strategies Report

May 2019
GRAPS Report #8

MINNESOTA

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Contributors

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

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

Photo Credit: The photo on the front page is in the Buffalo Red River Watershed and is courtesy of the Minnesota Pollution Control Agency.

Summary

Groundwater is an important resource in the Buffalo Red River Watershed (BRRW) One Watershed One Plan (1W1P) planning effort[1]. Groundwater accounts for 50 percent of reported water use in most years. More than 58 percent of groundwater withdrawn is for public water supply use, with nearly 39 percent used for agricultural irrigation. In addition, groundwater accounts for 100 percent of the region's drinking water, except for the City of Moorhead that uses the Red River as its primary water source reducing its dependence on groundwater. It is important to ensure adequate supplies of high quality groundwater remain available for the region's residents, businesses, and natural resources.
The BRRW depends on the sand and gravel aquifers, both surficial (water table) and buried (confined) for drinking water. The western portion of the watershed is covered by a thick section of low-permeability clay deposited in glacial Lake Agassiz. Buried sand and gravel aquifers beneath the lake clay are isolated from the land surface and are usually limited use. The Buffalo aquifer is an exception. It is a long linear sand body. In some areas, the Buffalo aquifer is buried beneath low permeability sediment and in other areas, the aquifer is at the land surface making it more sensitive to contamination. The eastern portion of the BRRW has sediment with greater sand and gravel than the western portion resulting in more and higher yielding aquifers that are better connected to recharge from the land surface.
Groundwater has a greater risk to contamination in areas of high pollution sensitivity[2]. A band of 'high' pollution sensitivity extends through the middle part of the watershed, typically along the beach ridge of Lake Agassiz and shoreland areas along rivers and lakes in the eastern portion of the watershed. Understanding pollution sensitivity is a key consideration to prevent groundwater pollution. Many land-use activities (including row crop agriculture, stormwater, septic systems, and tanks/landfills) within the watershed could contaminate groundwater if pollutants are not carefully managed, especially in areas of high pollution sensitivity.

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

- **Arsenic** – approximately 30 percent of the tested wells had levels exceeding the Safe Drinking Water Act (SDWA) of 10 µg/L. The EPA has set a goal of 0 µg/L for arsenic in drinking water because there is no safe level of arsenic in drinking water.
- **Nitrate** – less than one percent of tested drinking water wells had levels at or above the SDWA standard of 10 mg/L.
  - MDA ambient monitoring well in Wilkin County recorded the highest nitrate result at 11.8 mg/L in the surficial aquifer. The sample exceeded the SDWA standard.
  - MDA Township Testing Program (TTP) sampled 622 drinking water wells for nitrate in 10 townships in the BRRW. Nitrate exceedances were detected in Elkton and Riverton townships in Clay County where row crop production combined with vulnerable geology has resulted in samples exceeding the SDWA standard.
  - MPCA ambient monitoring wells had no nitrate exceedances.
- **Pesticides** – seven pesticides were detected in the MDA monitoring well, but not at concentrations above human-health based drinking water standards or reference values.

[1] For this report, the boundary of the BRRW was expanded to include the Buffalo River, Red River of the North, and the southwestern portion of the Otter Tail River to match the 1W1P planning boundaries.

[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.

- **Contaminated sites –** there are 227 active tank sites that could leak chemicals into the environment and 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 plume is found within the watershed.

These contaminants can affect both private wells and public water systems when levels exceed drinking water standards. Some of the public water systems have water quality issues in their untreated source water that requires either blending or treating the water to meet SDWA standards. Nearly 80 percent of the people living in the watershed get their drinking water from a community public water supply system. Wellhead Protection Plans have been developed for 14 of the 17 community public water suppliers in the BRRW and identify land use protections strategies for the approximately 9,100 acres in Drinking Water Supply Management Areas (DWSMAs).

Groundwater is sourced from sand and gravel aquifers, both surficial (water table) and buried (confined). The bedrock aquifer in this area is not used as a water source due to low yield. All calculated trends from observation wells in the BRRW reported seven of the wells had an upward trend, 12 had no trend, and three had a downward trend, indicating water use has remained consistent or experienced reduced demand in most wells over the period of record. All of the wells in the northern portion of the Buffalo aquifer had an upward trend. This is due to the City of Moorhead's decision to transition much of their water use from the Buffalo aquifer, a groundwater source, to surface water from the Red River around 1995.

Activities on the land surface can affect groundwater levels by reducing infiltration (groundwater recharge) especially in the eastern portion of the watershed; these activities include tiling, changes in vegetation, increased areas of impervious surface, and changing surface water or stormwater flow.
The BRRW includes significant natural features, including surface waters that depend on groundwater to sustain them. If groundwater quantity or quality is degraded, these resources are at risk. The following features occur within the watershed:

- Fifteen designated calcareous fens and one designated trout stream and associated unnamed creeks.
- One-hundred-thirty-three of the 586 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes, susceptible to changing aquifer levels.
- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Thirty-one kinds of native plant communities and 13 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater that are at risk to changing aquifer levels and degraded groundwater quality.

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

1. **Education and Outreach:** Educate landowners, private well users, and others about how their actions affect groundwater and how they can conserve, restore, and protect groundwater.
2. **SSTS Management:** Monitor, maintain, and/or upgrade SSTS to ensure proper operation and treatment.

3. **Irrigation Water Management:** Control the volume, frequency, and application rate of irrigation water to sustain groundwater.
4. **Land Use Planning and Management:** Use city or county government planning and regulations along with land management goals that implement best management practices (BMPs), conserve water, and educate stakeholders to protect groundwater levels, quality, and contributions to groundwater dependent features.
5. **Contaminant Planning and Management:** Use land use planning, ordinances, and collaboration with state regulatory agencies to protect groundwater and drinking water supplies from contaminant releases.
6. **Conservation Easements:** Maintain and expand the amount of land protected from being converted to high intensity uses, such as row crop agriculture.
7. **Cropland Management:** Encourage the implementation of voluntary practices to manage resource concerns while minimizing environmental loss.
8. **Nutrient Management:** Assure that application of crop fertilizer or manure follows guidelines for the right source, right rate, right time, and right place.
9. **Integrated Pest Management:** Implement a pest management approach that incorporates the many aspects of plant health care/crop protection in ways that mitigate harmful environmental impacts and protect human health.

This GRAPS report was designed to help prioritize and target local efforts to restore and protect groundwater resources in the watershed. Representatives from BWSR, MDA, MDH, DNR, and MPCA compiled existing state and regional data, and developed maps to establish a baseline understanding of groundwater conditions and associated resource management concerns for the 1W1P planning boundary. The team highlighted strategies and supporting actions that can be applied at a county or watershed-level to help restore and protect groundwater. To target local implementation, actions listed in this report are paired with those counties and subwatersheds (HUC-10) where risks have been identified. This report should be used in conjunction with the WRAPS report, which focuses on surface water issues and needs, to ensure that both groundwater and surface water are effectively addressed during the 1W1P planning process.[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 (www.bwsr.state.mn.us/planning/1W1P/Setting_Measurable_Goals.pdf) to meet the 1W1P measurability requirement.

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Introduction

What Is the GRAPS Report?

The State of Minnesota adopted a watershed approach to address the state's 81 major watersheds[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).

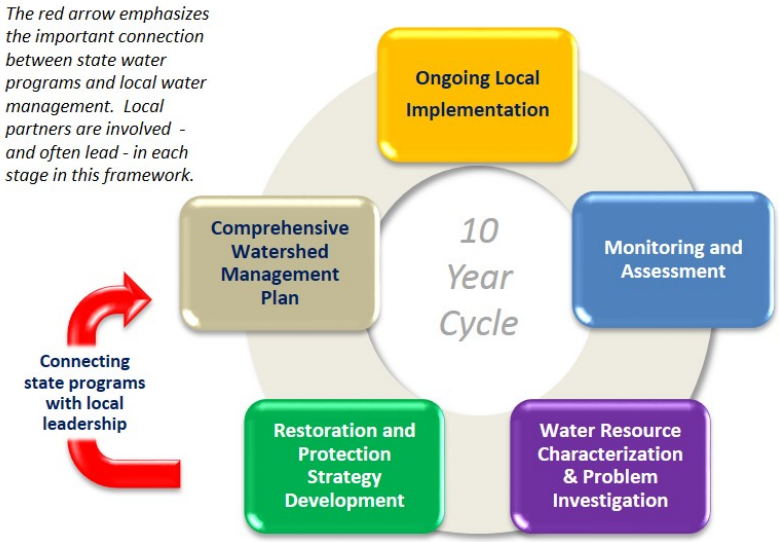


Figure 1: Watershed Approach Framework

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.

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

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

determine the rate of BMP adoption needed to restore groundwater, therefore quantification is not part of GRAPS.

How to Use this Report

This report is a resource and tool for developing local water management plans. The report is divided into six parts to accommodate the different needs and information partners and agencies may seek. This report is not necessarily designed to be read cover to cover. Rather, you can flip to the parts that are most relevant to the issues facing your community. If you are accessing this document electronically, you can click on hyperlinks throughout the report to jump to related information and/or access webpages (all hyperlinks are in blue type).

The report is divided into the following parts:

1. Watershed Overview: This section provides a brief overview of the watershed.
2. Watershed Groundwater Issues and Concerns: This section highlights the main groundwater quality and quantity concerns, where each concern is most prevalent within the watershed, and general ways to address the concern.
3. Watershed Strategies and Actions to Protect and Restore Groundwater: This section provides tips for prioritizing and targeting restoration and protection strategies, makes suggestions about what strategies and actions would be most appropriate in which counties and subwatersheds, describes the suggested strategies, and provides information about existing programs and resources for each strategy.
4. Making Sense of the Regulatory Environment: This section provides an overview of the roles state agencies play in managing groundwater and drinking water.
5. Appendices

Buffalo Red River Watershed Overview

This report provides a brief overview of land use, geology, hydrogeology, pollution sensitivity, wellhead protection planning and drinking water, and water use and groundwater withdrawals affecting the Buffalo Red River Watershed (BRRW) 1W1P planning boundary groundwater quality and quantity. You can find more detailed information about the BRRW and groundwater through the following resources:
Restoration and Protection Plans

- MPCA Buffalo River Assessments (https://www.pca.state.mn.us/water/watersheds/buffalo-river)
- MPCA Upper Red River of the North Assessments (https://www.pca.state.mn.us/water/watersheds/upper-red-river-north)
- MPCA Otter Tail River Assessments (https://www.pca.state.mn.us/water/watersheds/otter-tail-river)

The Buffalo Red River Watershed 1W1P planning boundary encompasses the Buffalo River, Red River of the North, and the southwestern portion (lower reach) of the Otter Tail River in western Minnesota within the Red River Basin. The watersheds includes portions of Clay, Becker, Wilkin, and Otter Tail counties (Figure 2). There are several municipalities in the watershed of which the city of Moorhead is the largest. The Buffalo and Red River of the North watersheds have seen a population increase of roughly twelve percent between 2000 and 2010.
Of the roughly 67,858 people living in the watershed, approximately 53,696 (79 percent) utilize community public water and the remaining 21 percent obtain their drinking water from private wells.

Buffalo Red River Watersheds

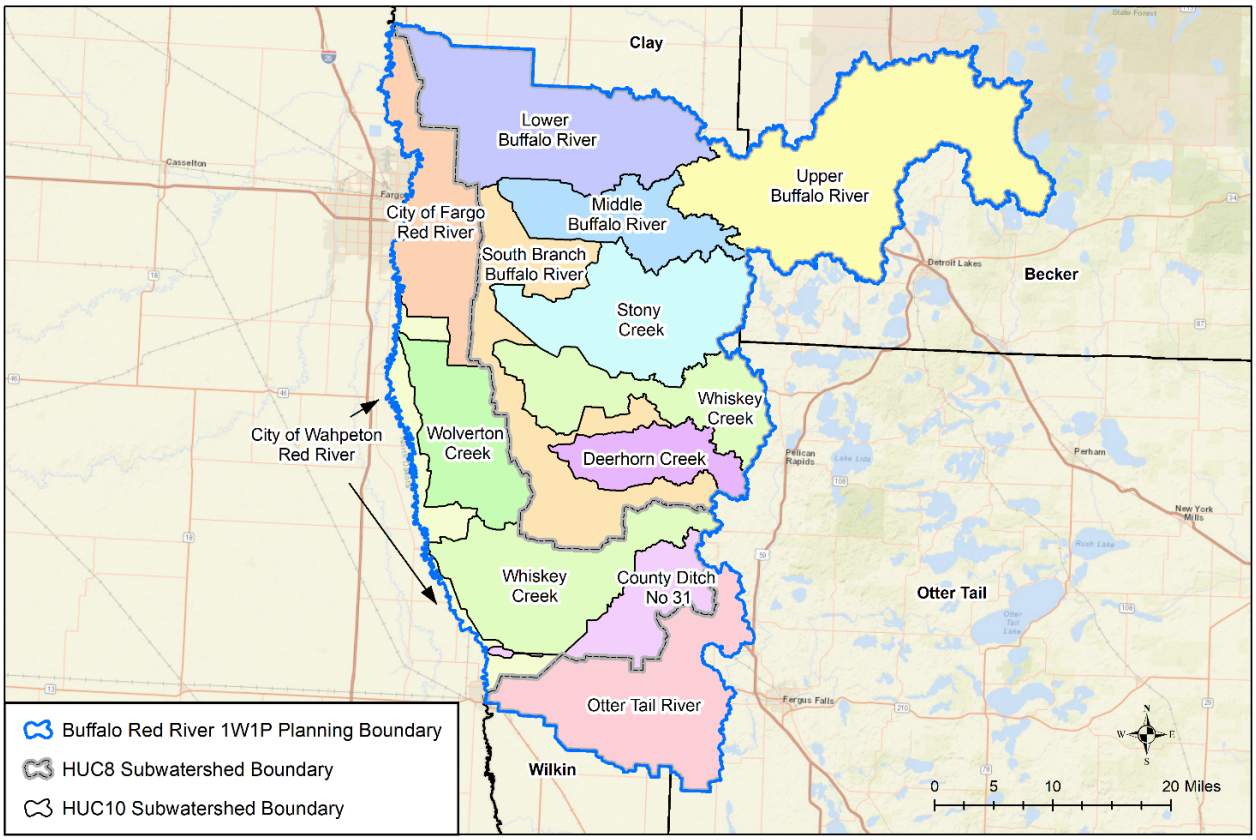


Figure 2: Buffalo Red River Watershed – is comprised of thirteen subwatersheds (HUC-10)

Land Use

The BRRW is largely agricultural (row crops and pasture) with forested land and lakes on the eastern edge. Flooding impacts the watershed from a poorly defined flood plain and relatively flat gradient, combined with excessive drainage and the widespread conversion of tallgrass prairie to farmland (Figure 3). Development pressure is moderate to considerable in some areas of the watershed.

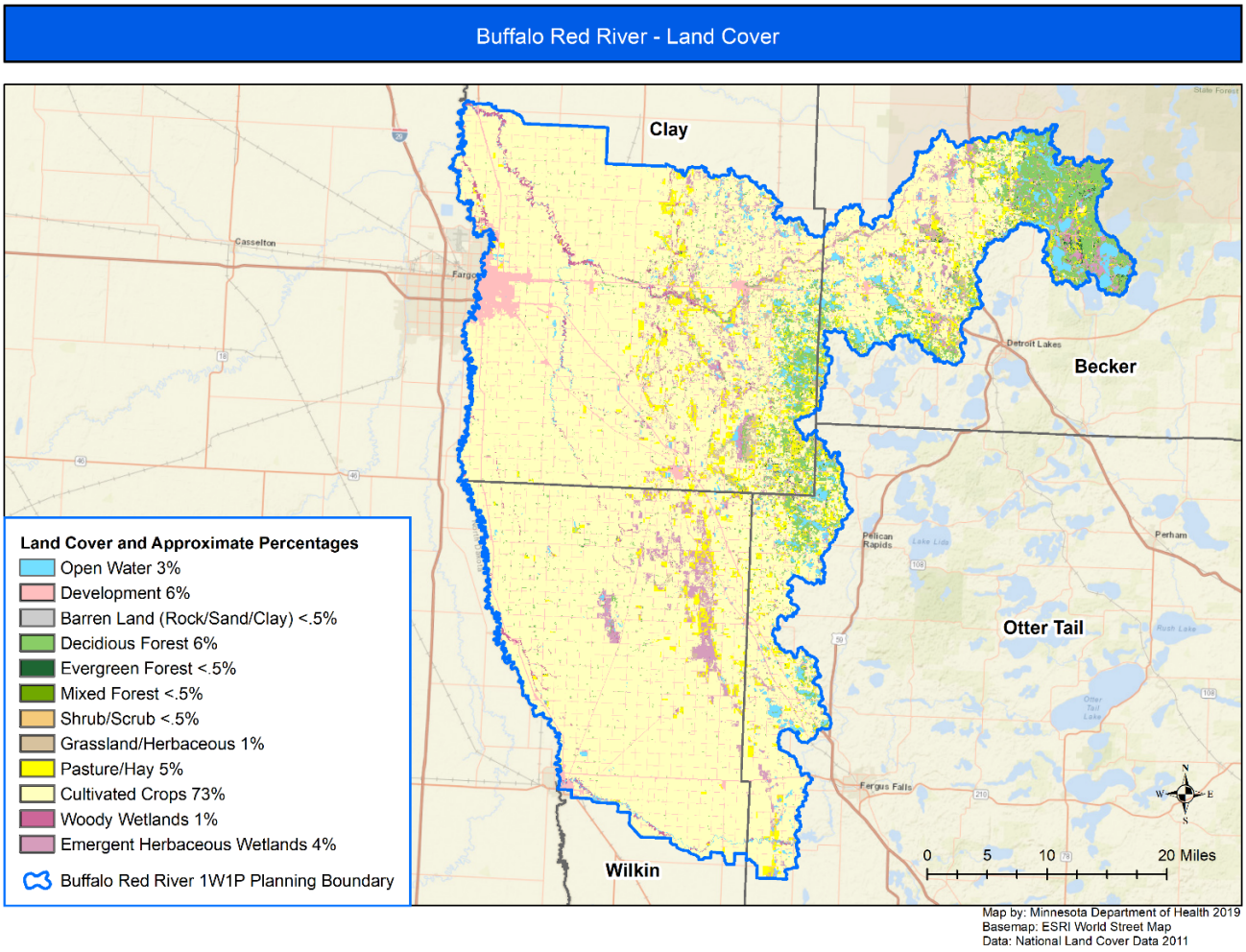


Figure 3: Buffalo Red River Watershed - Land Cover

Geology and Hydrogeology

Groundwater sources within the BRRW vary according to the underlying geology. The geology in the BRRW is the result of complex processes, which occurred from igneous, metamorphic, sedimentary and glacial action that took place in the region over several geologic time periods. Figure 4 depicts a generalized map of aquifers in the watershed.

There are three main types of aquifers in the watershed (Figure 4):

- Surficial (unconfined) sand and gravel aquifers derived from glacial outwash material. These units are depicted in yellow in Figure 4.

- Buried (confined) sand aquifers enclosed in glacial till. These units serve as the major aquifers in the watershed and are depicted in gray in Figure 4.
- Cretaceous and pre-Cambrian bedrock aquifers are also utilized for water supply within the BRRW and consist mainly of sandstone, siltstone and shale. These aquifers are of limited extent are not considered major aquifers in the region.

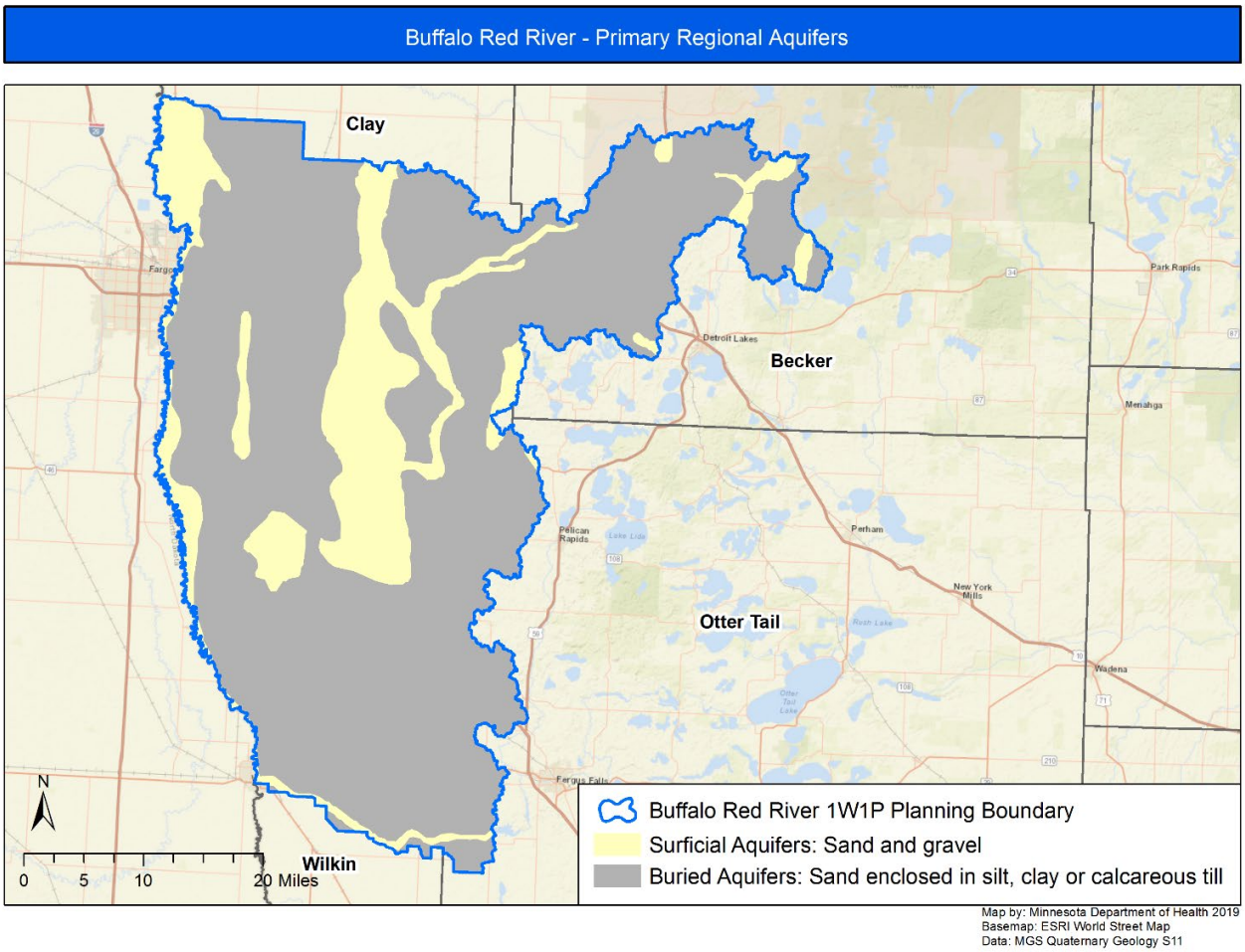


Figure 4: Buffalo Red River Watershed – Primary Regional Aquifers: Surficial sand and gravel aquifers; buried sand enclosed in silt, clay or calcareous till aquifers.

Pollution Sensitivity

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

It is important to understand the target aquifer when assessing pollution sensitivity. Certain aquifers may be deeper and more geologically protected than water table aquifers, or surficial sand aquifers, in a given area. Figure 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. This figure shows that the watershed has a mix of pollution sensitivity ratings based on surficial materials. Most of the western half of the watershed has a pollution sensitivity of 'ultra low', but the eastern half of the watershed ranges from 'very low' to 'high' pollution sensitivity. The areas of 'high' sensitivity tend to correspond to regions where glacial outwash is the predominant type of

geomorphology. These areas also coincide with the surficial aquifers in the watershed. More information on this dataset can be found on the DNR website Minnesota Hydrogeology Atlas (MHA) (http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-ns.html).
The pollution sensitivity of deeper aquifer materials depicted in Figure 7 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. Figure 7 shows that the watershed primarily has a 'low' pollution sensitivity rating, but patches of 'moderate' and 'high' pollution sensitivity exist throughout the watershed. Similar to Figure 5, the ratings of 'moderate' and 'high' tend to be associated with the glacial outwash units in the BRRW. More information on the geologic sensitivity calculations used to make this figure is included in the references section of this report as Figure 37 and Figure 38.
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.

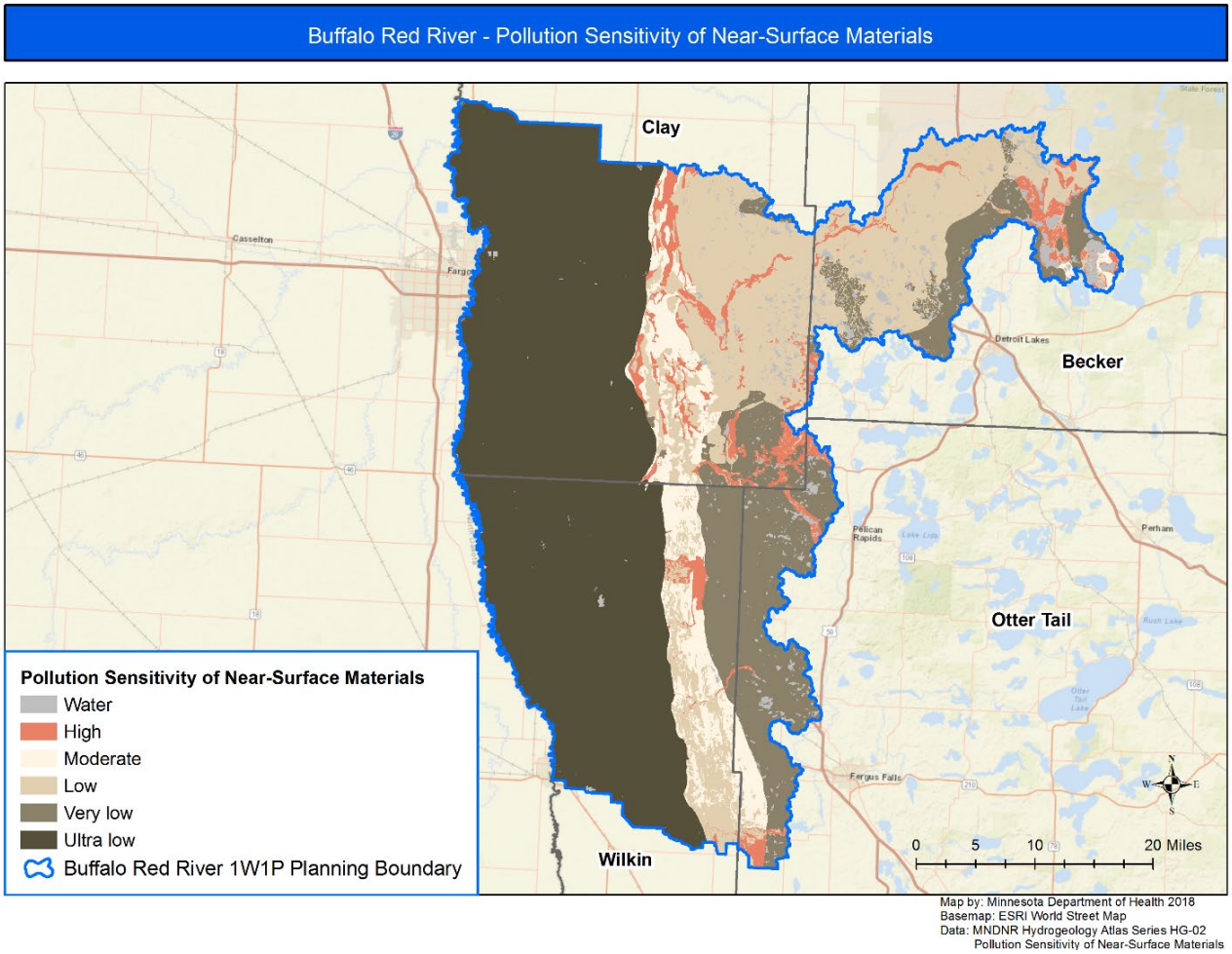


Figure 5: Buffalo Red River Watershed - Pollution Sensitivity of Near Surface Materials

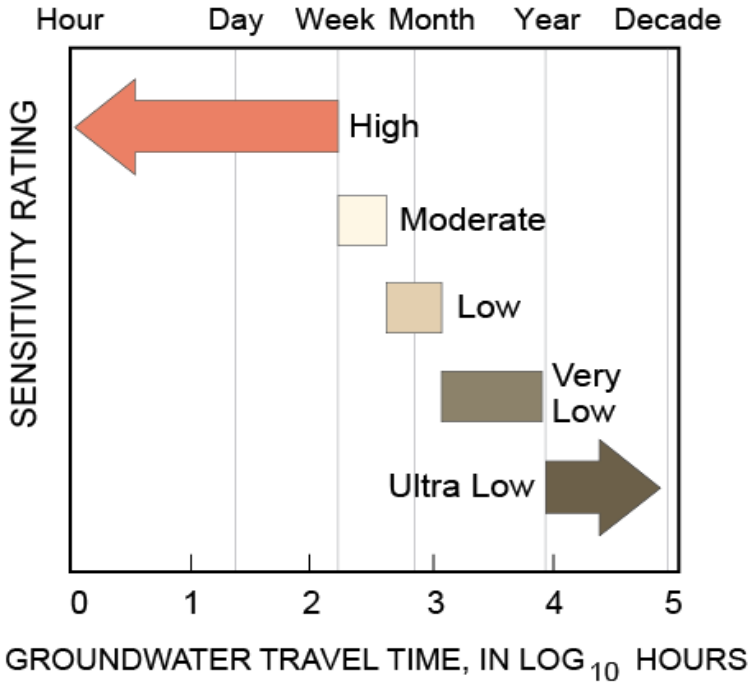


Figure 6: Recharge Travel Time for Near-Surface Materials

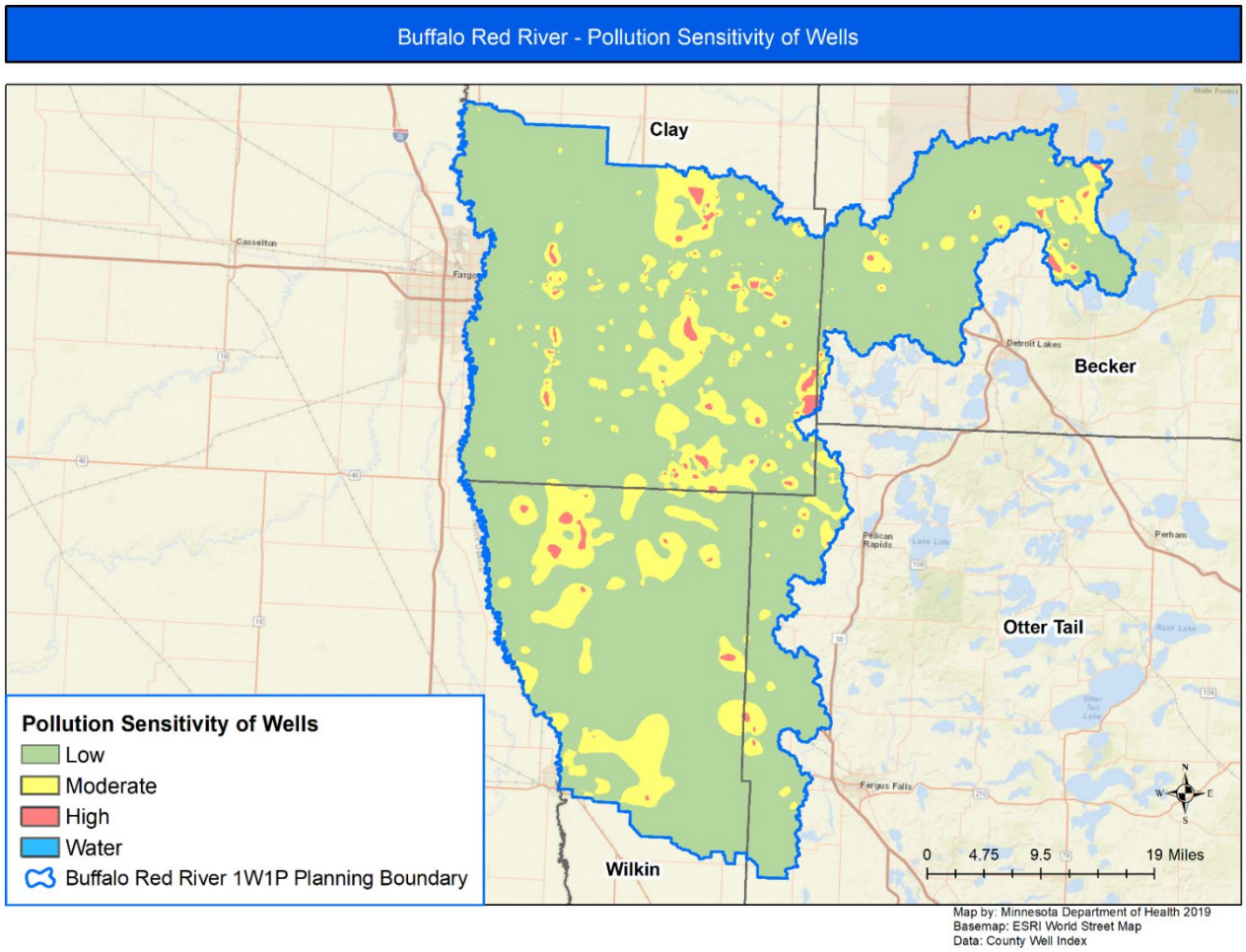


Figure 7: Buffalo Red River Watershed - Pollution Sensitivity of Wells

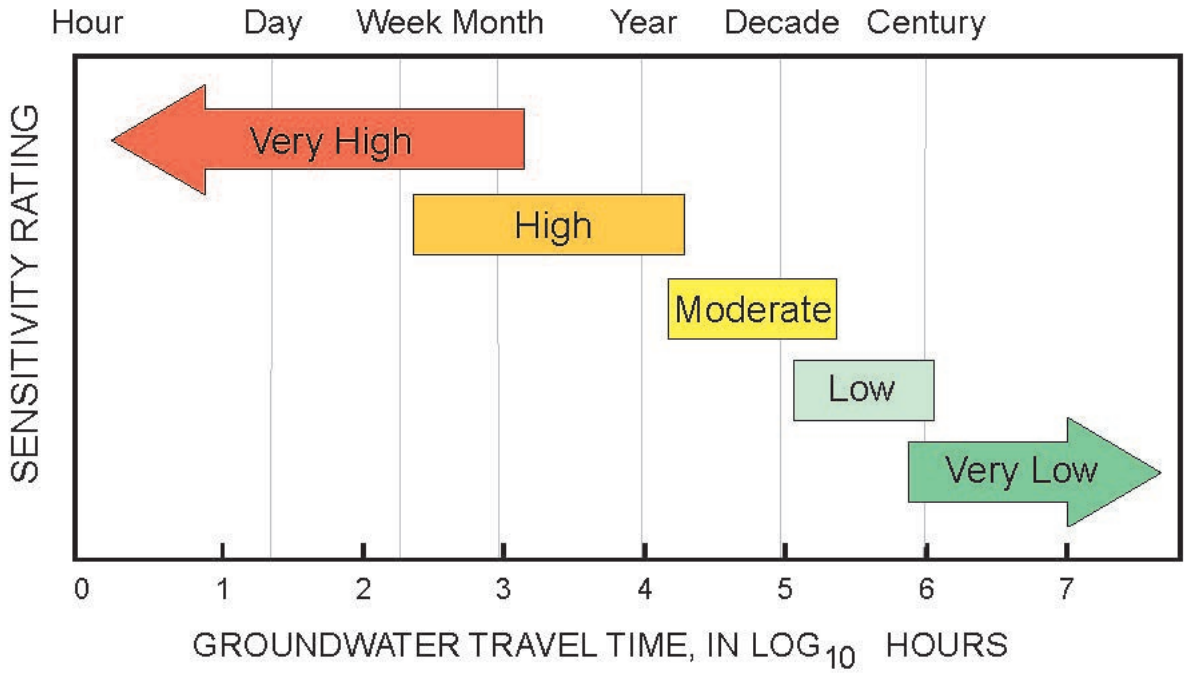


Figure 8: Recharge Travel Time for Buried Aquifers

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 in order 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 can be easily contaminated by activities at the ground surface. Others are deeper or more protected by geologic materials; these tend to exhibit a low vulnerability to overlying land uses. The types of management activities required within WHPAs will vary based largely on the vulnerability assessments. Highly vulnerable WHPAs require a greater level of management to prevent potential contaminants at the ground surface from entering the aquifer. Whereas for WHPAs with low vulnerability the primary focus is on sealing unused/unsealed wells, since this is the primary pathway for contaminants to reach the aquifer.

Fourteen of the 17 community public water systems, within the BRRW are engaged in the wellhead protection planning process or are implementing their plans. Of the 14 systems with approved plans, the vulnerability varies across the watershed from low to high. One of the approved wellhead protection plans exhibit a high vulnerability in all or part of their DWSMA and is considered vulnerable to contamination from the land surface, with all others exhibiting moderate or low 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 in the BRRW, covering approximately 9,100 acres. It is important to note that WHP areas do not follow watershed boundaries and can be located in different watersheds.

[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.

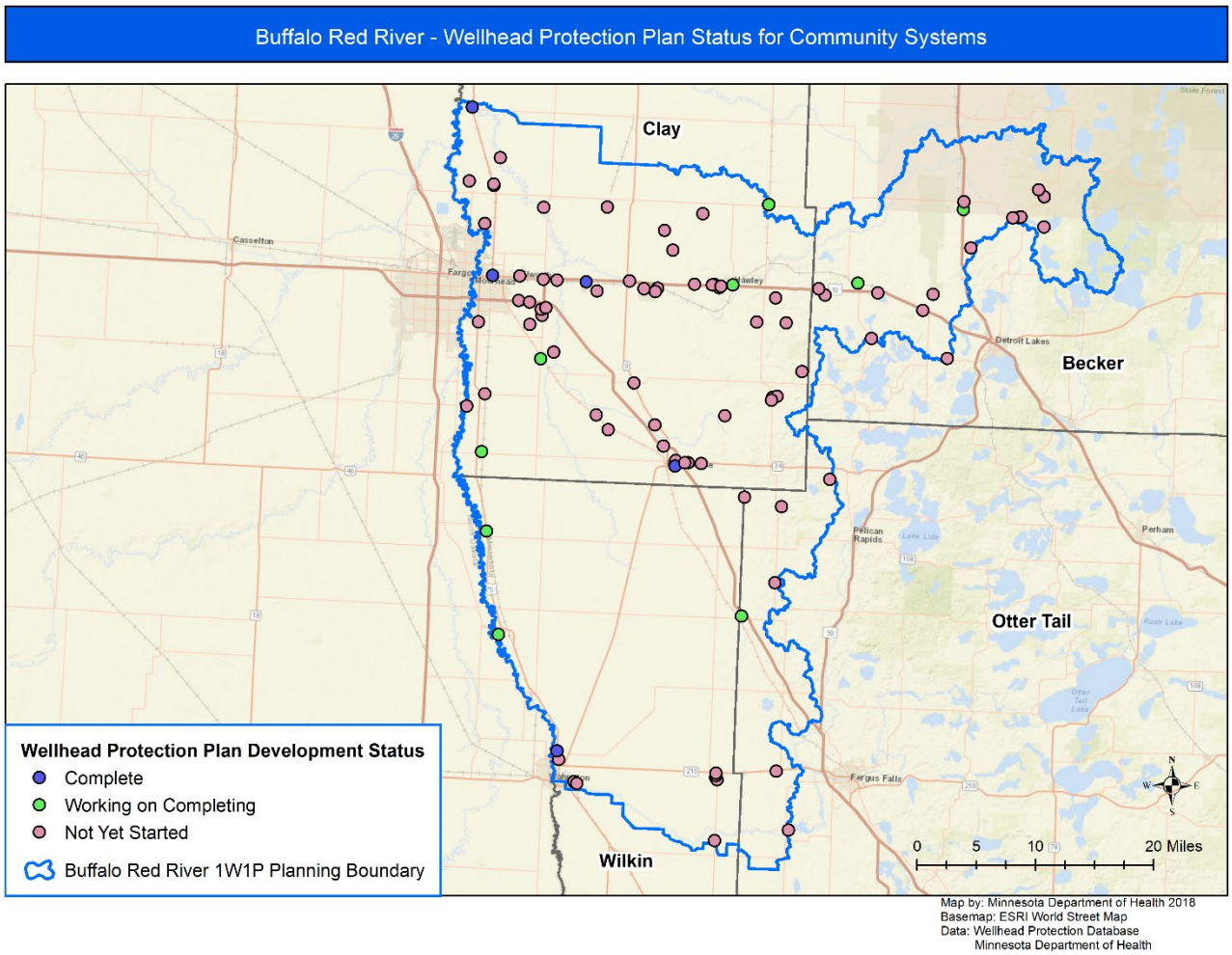


Figure 9: Buffalo Red River Watershed - Wellhead Protection Plan Development Status for Community Public Water Systems. Fourteen *of the 17 community public water supply systems are engaged in the wellhead protection planning process or are implementing their plans.*

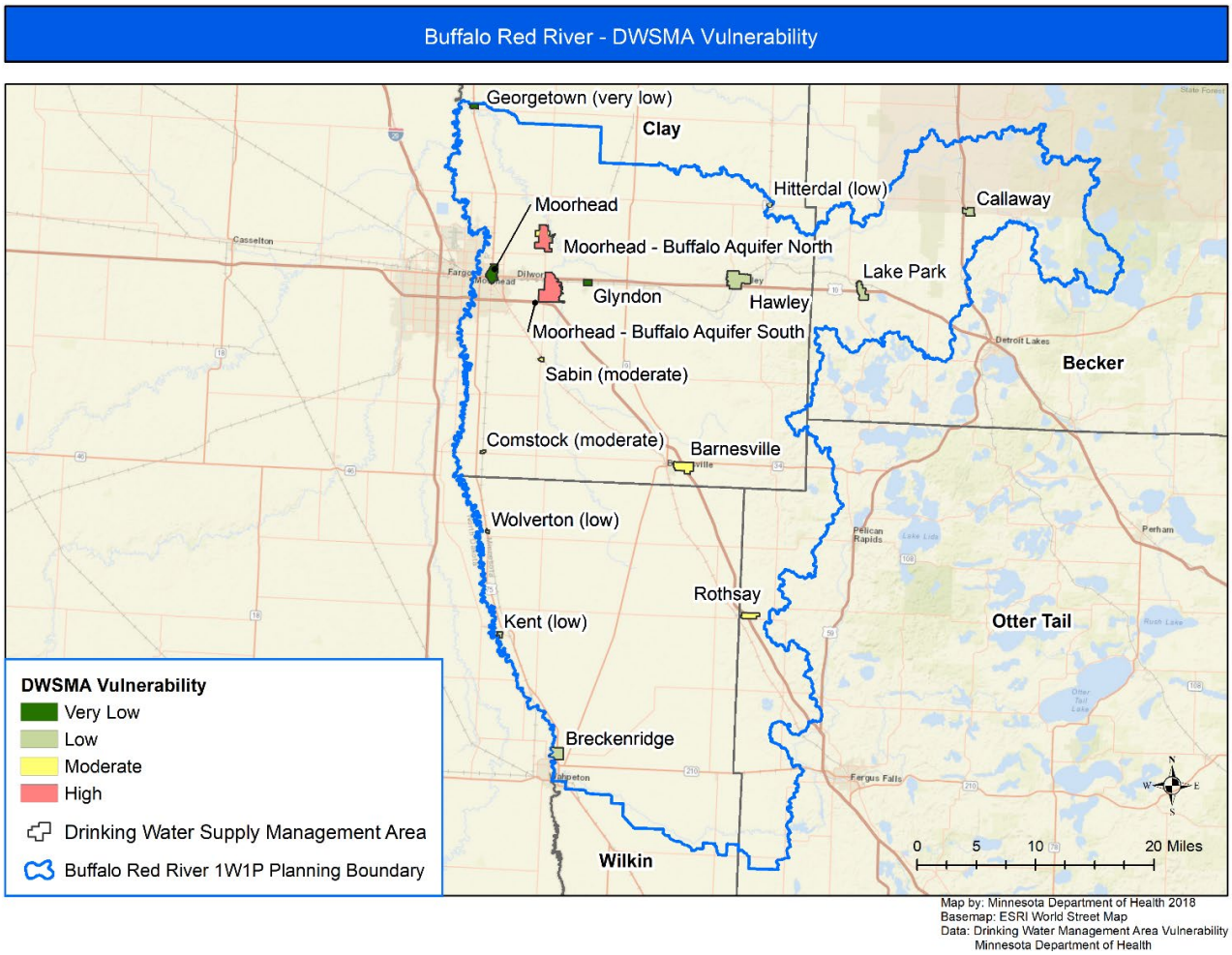


Figure 10: Buffalo Red River Watershed - Drinking Water Supply Management Areas. There are 14 approved Drinking Water Supply Areas (DWSMA) for community public water supply systems in the watershed.

The Moorhead Buffalo Aquifer North and South WHPAs in the BRRW are conjunctive delineations. A conjunctive WHPA delineation occurs when a strong connection exists between the groundwater capture zone for a well and either a surface water body or the land surface area intersected by that capture zone. In these instances, the WHPA consists of a composite area created by merging the well capture zone and the watershed area for the surface water body or land surface area which it intersects. The management of conjunctive WHPAs can present challenges because of their large size relative to more traditional WHPAs that are based solely on groundwater capture areas. In addition, management practices of potential contaminant sources can differ between the GWCA and SWCA. Within the GWCA, the focus will be on contaminants likely to soak into the ground; whereas, in the SWCA, the focus will be on those contaminants most likely to runoff during rainfall or snowmelt events. It should be noted that conjunctive WHPAs do provide a means of achieving multiple benefits within a watershed. Improvements in land use management in these areas stand to benefit both the aquifer used by the public water supplier and associated surface water bodies.

Private Wells

The BRRW has 2,935 private wells with known locations ranging from 20 feet to 468 feet deep that provide drinking water to residents. 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.

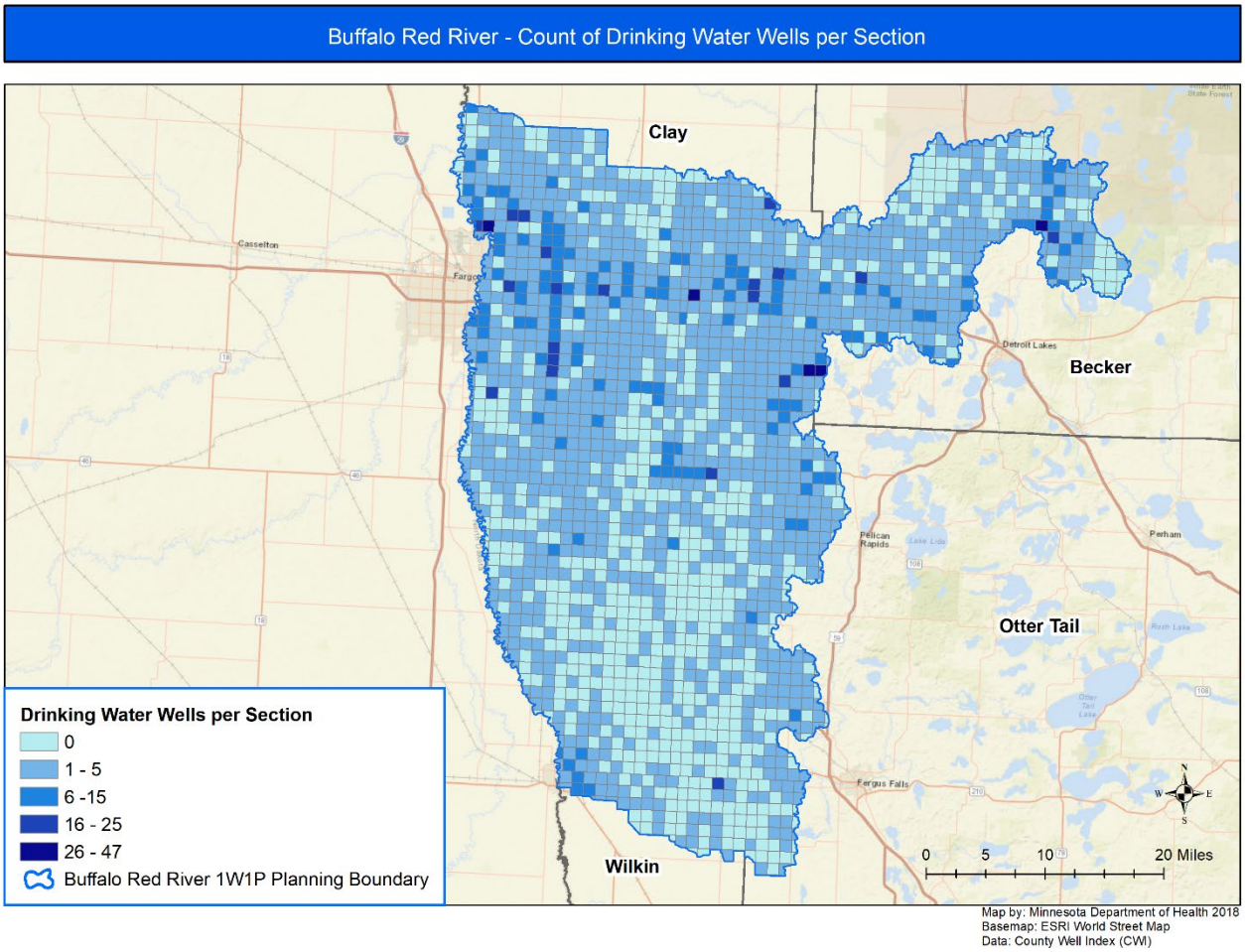


Figure 11: Buffalo Red River Watershed - Density of drinking water wells per section. There are 2,935 private wells identified.

Figure 11 illustrates well density and water use data in the BRRW. 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. Figure 12 displays drinking water wells and flood zone risk to contamination in the BRRW.

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).

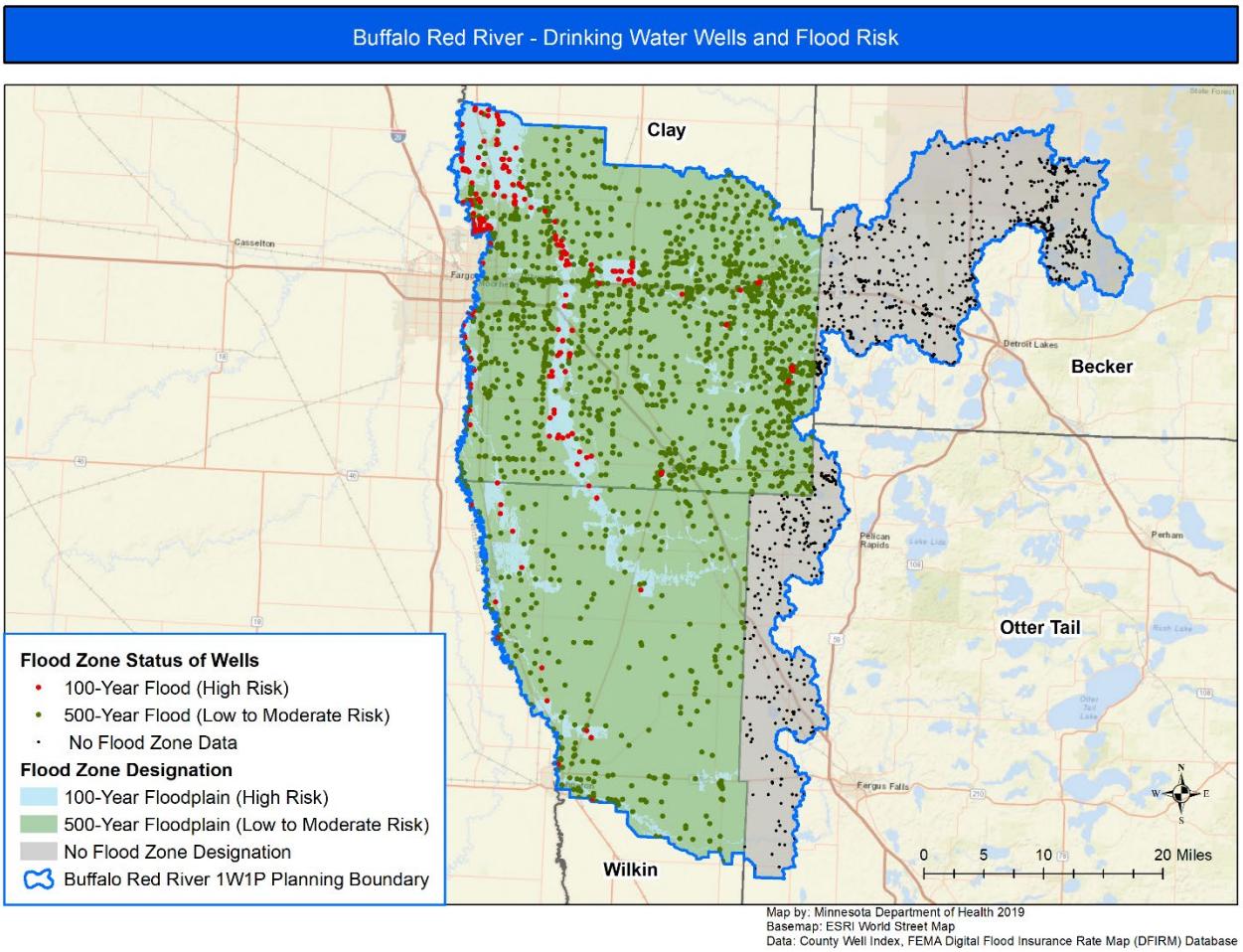


Figure 12: Buffalo Red River Watershed – Drinking water wells and flood zone risk to contamination.

Buffalo Red River Watershed Groundwater Issues and Concerns

This section of the report describes the key groundwater quality and quantity issues for the BRRW. 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 BRRW 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 BRRW groundwater quality. Multiple state agencies monitor different types of groundwater wells and public water systems for contaminants. Nitrate, pesticides, and arsenic have been detected in wells sampled in the BRRW. 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 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 3 shows nitrate test results for samples taken from these wells.

Table 2: Summary of nitrate results in drinking water wells of the Buffalo Red River Watershed.

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	36	0	4.95	0.45	8.3	0
50 - 99	534	0	33.98	0.5	1.2	0.3
100 - 149	549	0	26.5	0.29	1.25	0.4
150 - 199	343	0	9.0	0.48	0.95	0
>= 200	311	0	4.16	0.42	1.17	0
Total	1773	0	33.98	0.43	2.57	0.35

Where Is Nitrate in Buffalo Red River Watershed?

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

- Figure 12 compares nitrate levels in wells in the BRRW with the pollution sensitivity of the area. The absence of elevated nitrate concentrations throughout most of the watershed may be a function of low-impact land use near the wells or the presence of favorable geochemical conditions in the aquifers. Nitrate requires relatively oxidizing conditions to persist in groundwater, and the presence of locally reducing conditions can remove nitrate. The dataset used to create this figure is the same as that used in Table 3. These nitrate samples were taken

[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).

from newly constructed wells, private wells, and other drinking water supply wells sampled by the Minnesota Department of Health (MDH).

- Figure 13 shows the Township Testing Program (TTP) schedule. Ten townships were tested for nitrate in the BRRW. Sampling results for Clay County are going through the final review. Otter Tail County sampling is complete. MDA identified townships where groundwater is vulnerable and row crop agriculture is present as the focus of the testing program.

  Clay County – 444 wells were sampled through the initial round of the TTP in 2017. When measurable nitrate was detected during the first sample, a second test was offered. The final report is expected in 2019.

Township	All Sampled Wells	Percentage of wells ≥ 10 mg/L nitrate – Round One
Barnesville	26	0%
Cromwell	71	0%
Elkton	49	2%
Hawley	78	0%
Humboldt	43	0%
Keene*	19	0
Riverton	78	2.6%
Skree	35	0%
Spring Prairie	45	0%

* Part of the township is outside of the project watershed

Table 3- Summary of MDA Township Testing Program results for Clay County.

Ottertail County – 178 wells were sampled in Scambler Township in 2015 with follow-up sampling completed in 2017. The percentage of wells the exceeding the SDWA standard for nitrate is zero. Only the southwestern part of the township is included in the BRRW planning boundary.

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

- Figure 14 shows the nitrate concentrations recorded at each MDA ambient monitoring well location in the BRRW in 2016. The sampling data collected from northern Wilkin County, recorded the highest nitrate result at 11.8 mg/L.

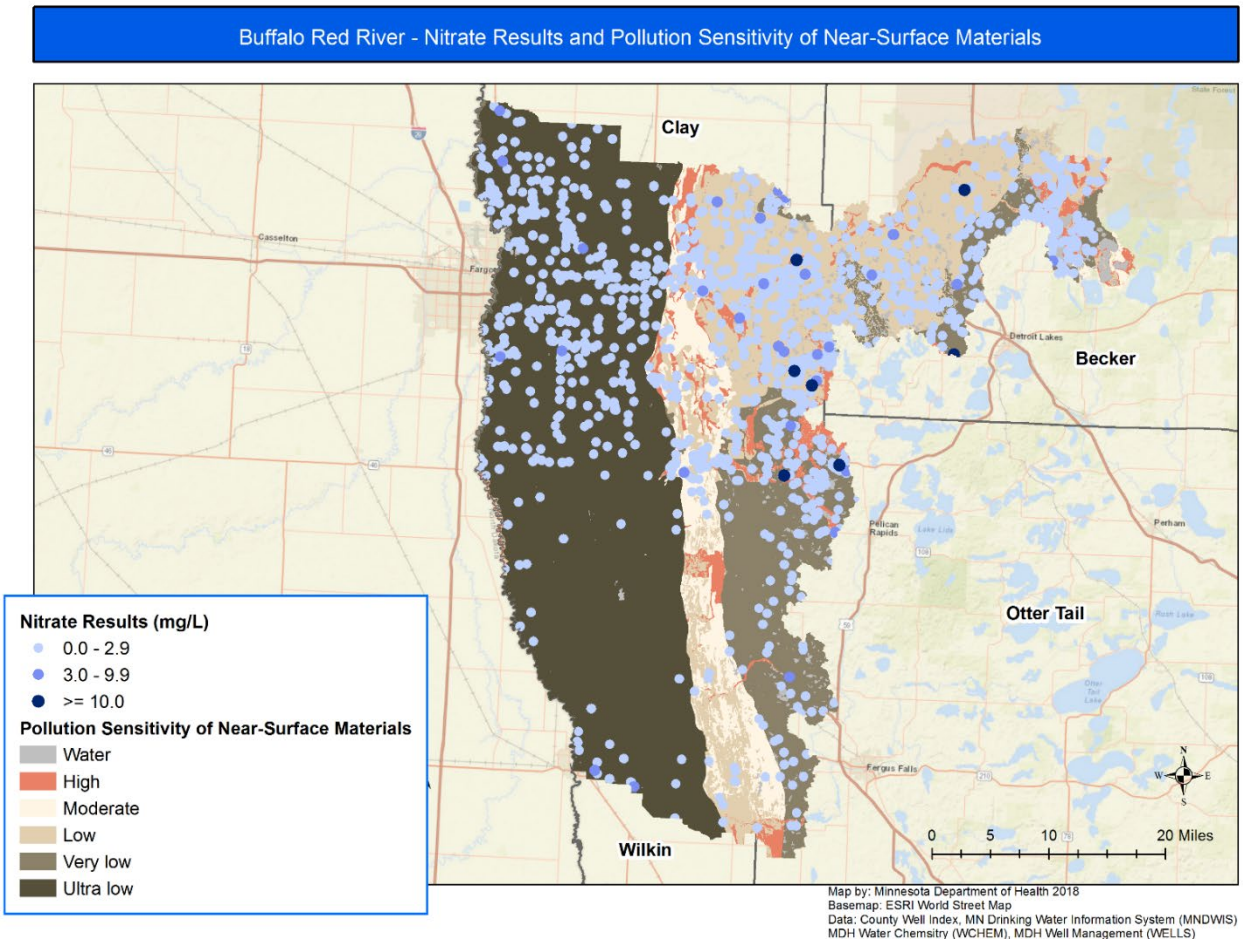


Figure 13: Buffalo Red River Watershed - Nitrate Results and Pollution Sensitivity of Near Surface Materials

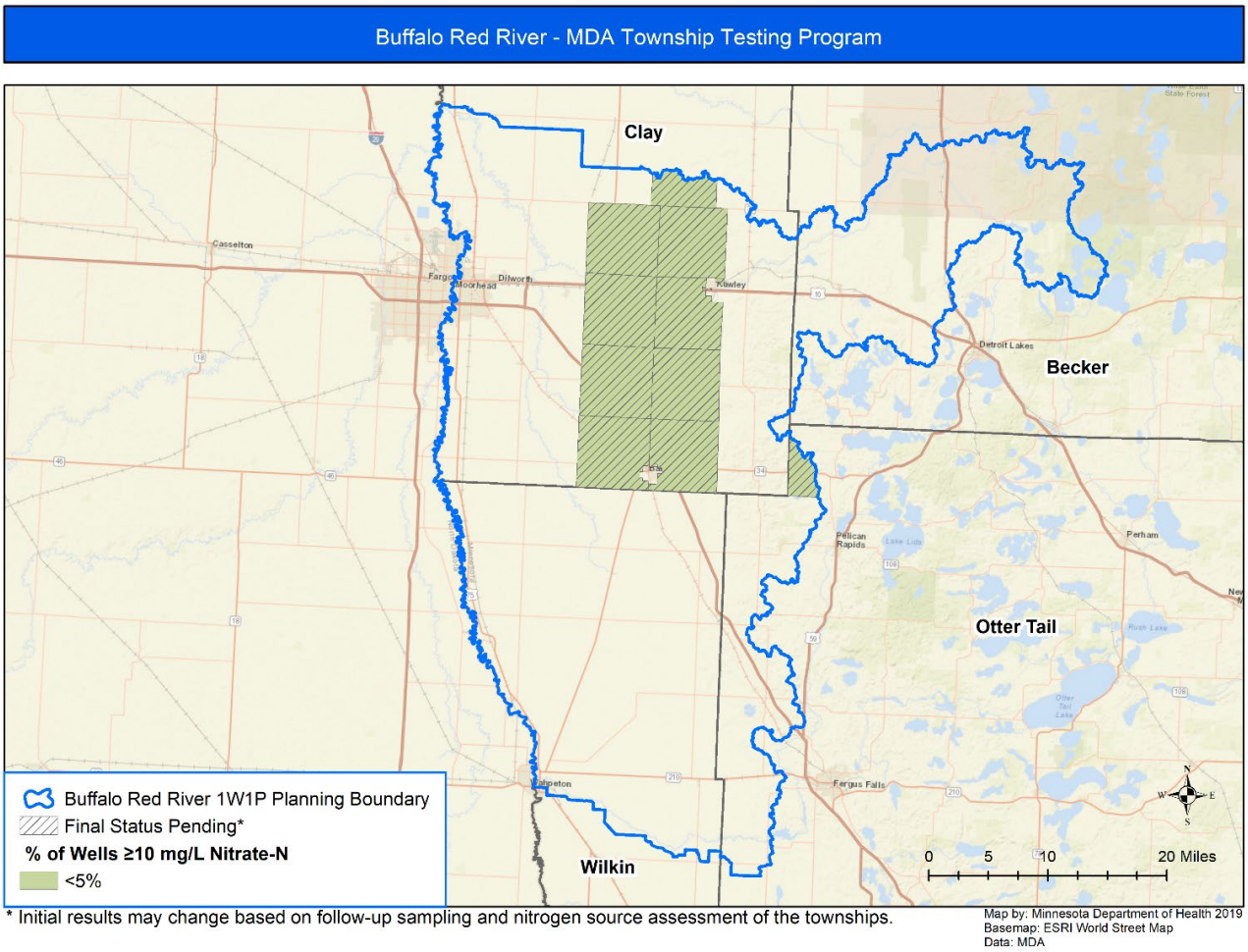


Figure 14: Buffalo Red River Watershed - MDA Township Testing Program. Ten townships in two counties tested 622 wells for nitrate.

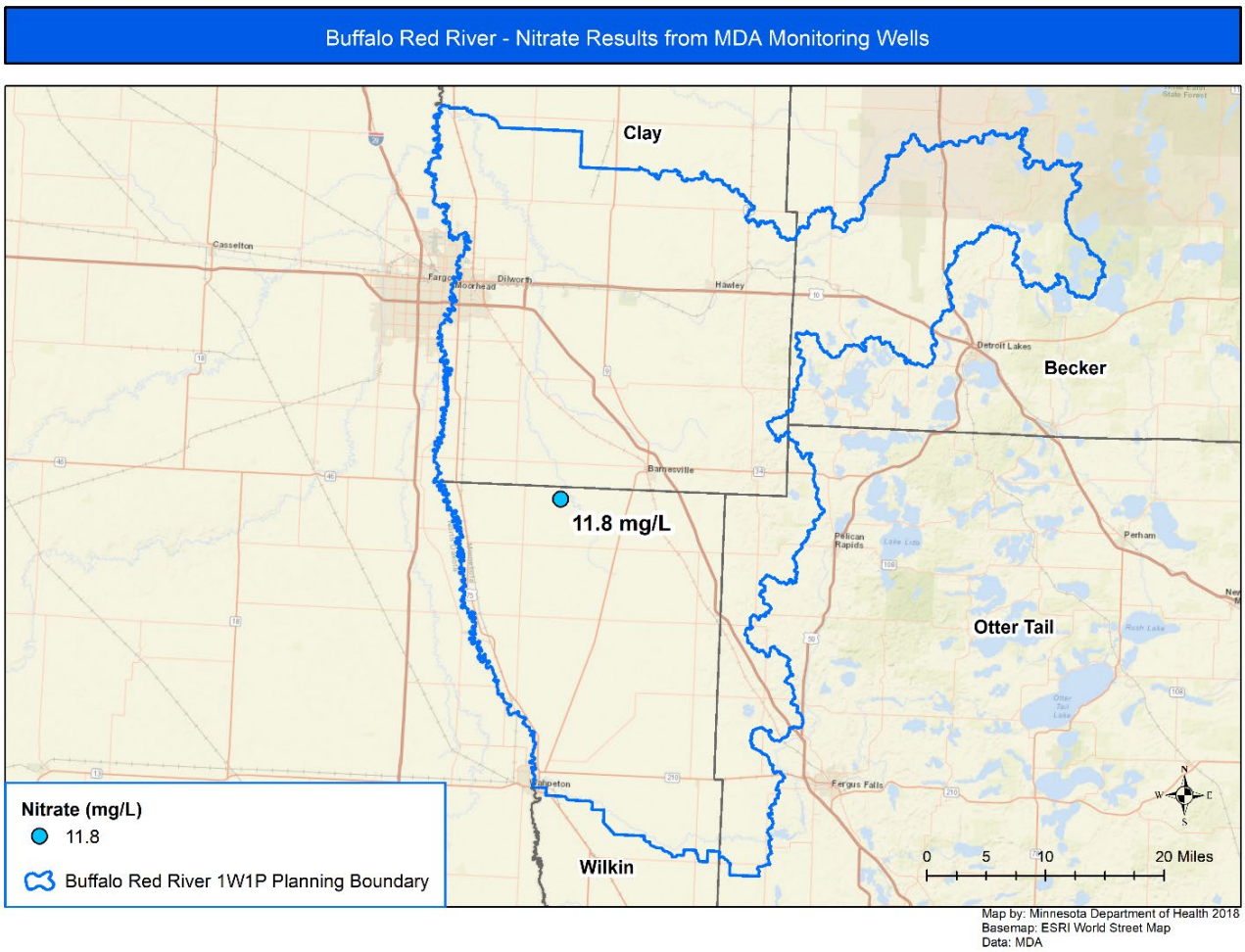


Figure 15: Buffalo Red River Watershed - MDA Monitoring Wells and Nitrate Results.

How to Address Nitrate in Groundwater

The Minnesota Groundwater Protection Act established a prevention goal that groundwater be maintained in its natural condition, free from any degradation caused by human activity. When degradation exists, it is important to understand the reflected level of management required based on the nitrate concentration. Table 4 provides a protection framework that identifies management priorities reflective of nitrate concentrations.

Table 4: 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;

Nitrate Protection Framework	Nitrate Concentration	Implementation Emphasis
		▪ 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 12 provides a more comprehensive list of specific actions counties and subwatersheds in the BRRW can take to restore and protect groundwater quality related to nitrate.

Pesticides

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

Where Are Pesticides in Buffalo Red River Watershed?

MDA uses one monitoring wells in the BRRW to monitor for common detection pesticides. The monitoring well is in this region due to the sensitive geology and row crop agriculture, which increases the potential for pesticides or pesticide degradants to get into groundwater. Figure 15 shows the number of common detection pesticides recorded at each monitoring location in the BRRW in 2016. Seven common detection pesticides were identified in the samples from the monitoring well. No detections exceeded any human health-based drinking water standards or reference values. MDA's monitoring wells only provide information about pesticides at their specific locations. Pesticide sampling of private wells is included as part of the TTP, which is currently underway and will provide more information on the presence of pesticides in other locations in the watersheds.

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

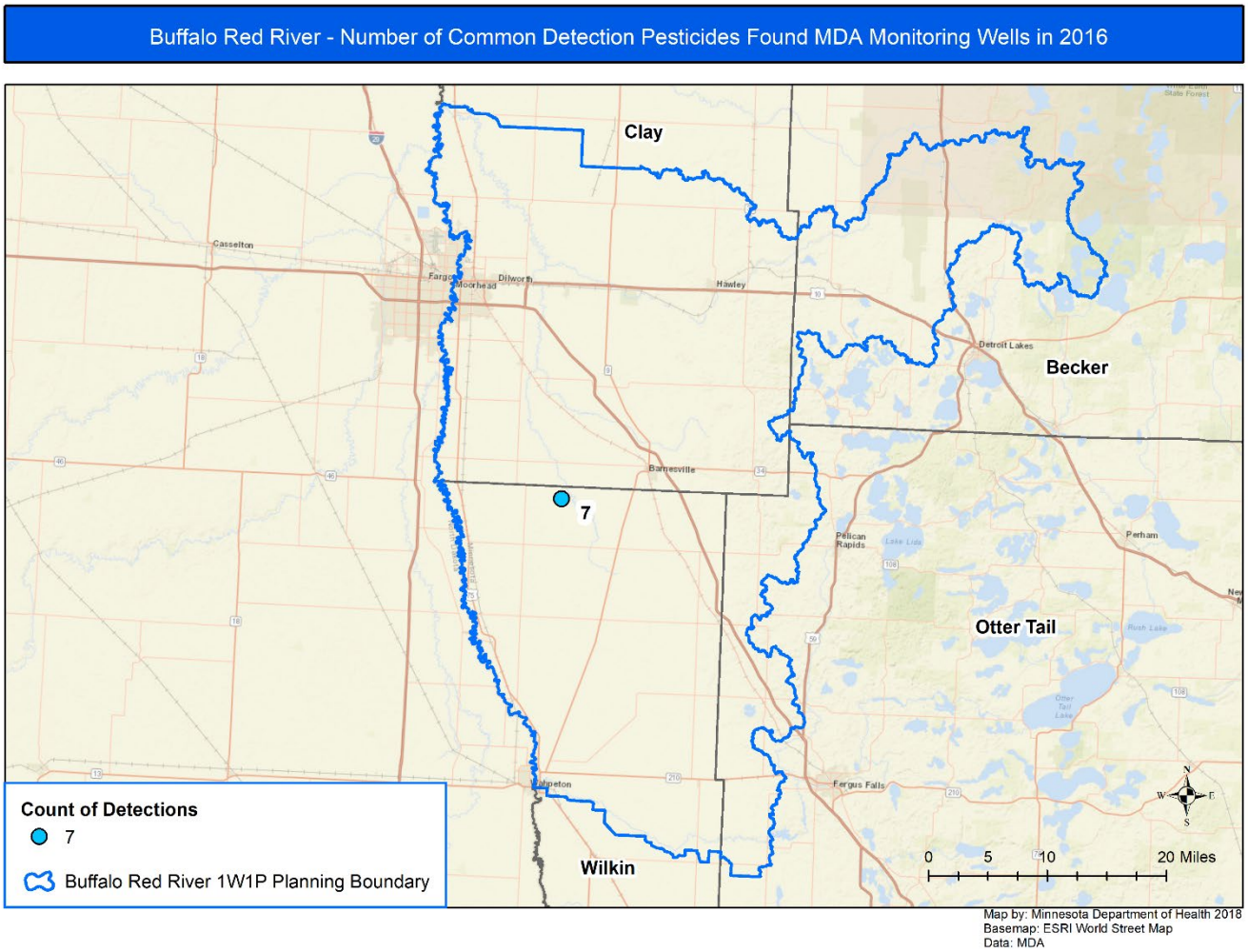


Figure 16: Buffalo Red River Watershed - Common Detection Pesticides Found in MDA Monitoring Wells

How to Address Pesticides in Groundwater

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

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

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

Arsenic

Approximately 30 percent of the 454 arsenic samples taken from wells in the BRRW 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

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

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

Table 5: Summary of arsenic (As) concentrations in wells of the Buffalo Red River Watershed.

Depth Completed Range (feet)	Total samples (n)	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)	Samples at or above 5 µg/L (%)	Samples at or above 10 µg/L (%)
< 50	12	0	37	1.56	41.7	25
50 - 99	129	0	47	2.63	59.2	54.43
100 - 149	156	0	62	1.48	28.85	23.5
150 - 199	65	0	92	5.2	38.35	32.9
>= 200	92	0	63.3	0.52	23	14.5
Total	454	0	92	2.28	38.22	30.1

Where Is Arsenic in the Buffalo Red River Watershed?

Figure 17 shows that arsenic is found throughout the watershed. The dataset used to create Figure 17 is the same information displayed in Table 5. These samples were taken from newly constructed wells, domestic wells, and other drinking water supply wells.

Arsenic is most prevalent in Quaternary Buried Artesian Aquifers (lenses of sand and gravel enclosed within clay-rich sediments). Elevated levels are likely related to local geochemical conditions that allow for mobilization of the metal. These geochemical conditions tend to be moderately reducing and are often associated with the contact between sand and gravel aquifers and adjacent clay-rich sediments (Erickson and Barnes, 2004 and 2005).

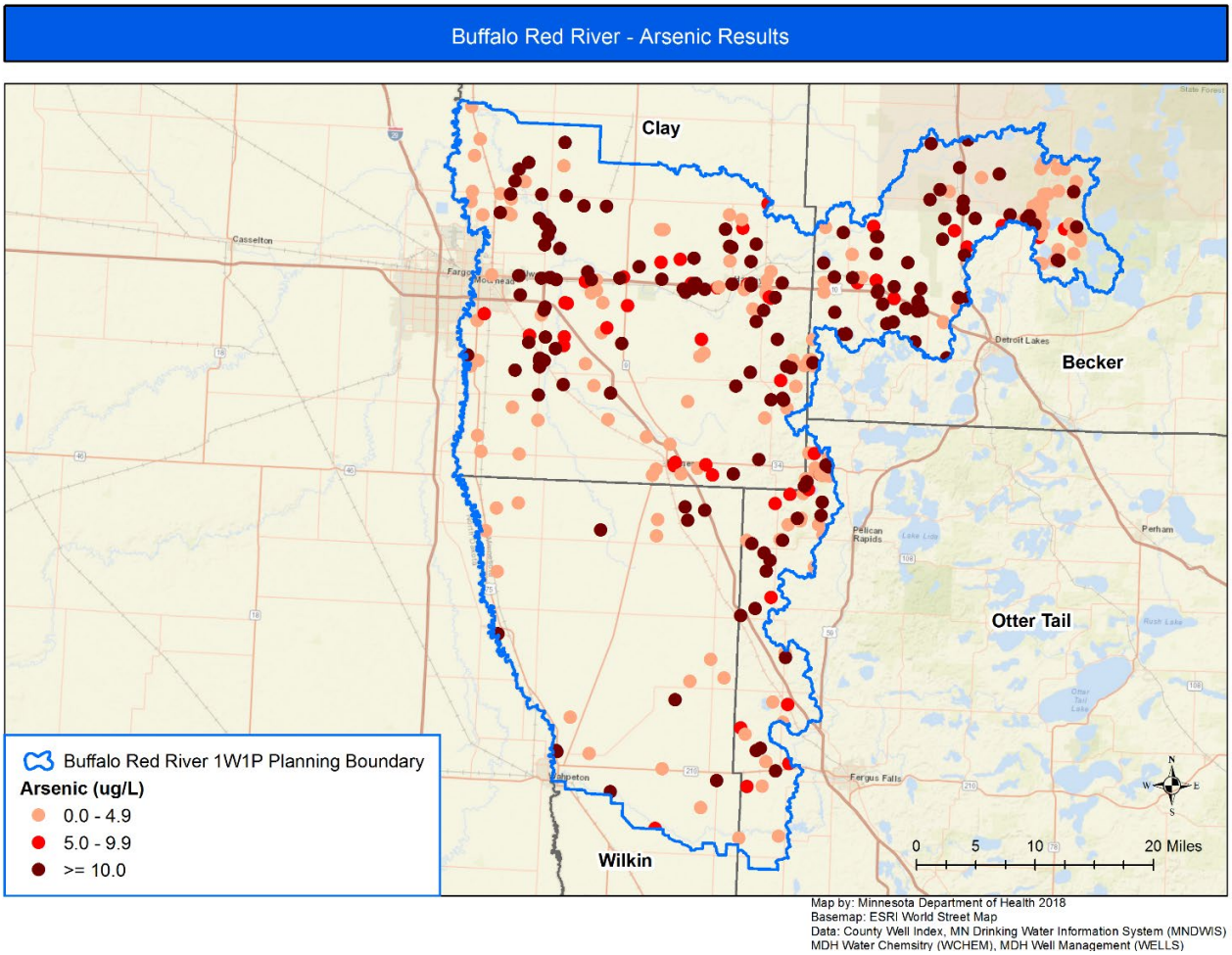


Figure 17: Buffalo Red River Watershed - Arsenic Results

How to Address Arsenic in Groundwater

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

Radionuclides

Concentrations of naturally occurring radioactive radium has not been detected in groundwater samples in the BRRW. The exact source of these compounds is not well understood. They may originate in the clay-rich glacial sediments or may be part of the original mineral composition of the Mt. Simon or fractured Sioux Quartzite geologic units. What is known is that their presence in the groundwater is related to reducing geochemical conditions and the very slow rate of groundwater flow in theses bedrock layers.

Where are Radionuclides in the Buffalo Red River Watershed?

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

How to Address Radionuclides in Groundwater

Human activity is unlikely to be the cause of radionuclides in the BRRW 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 BRRW groundwater are not well understood at this point. If private well users are concerned about radionuclides in their well, they can pay to have their water tested through an accredited laboratory. Learn more at Radionuclides (Radium) in Drinking Water (www.health.state.mn.us/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 (VOCs). The Ambient Groundwater Network currently consists of approximately 270 sites that represent a mix of deep domestic wells and shallow monitoring wells in non-agricultural regions across the state. The primary focus areas are shallow aquifers that underlie urban areas, due to the higher tendency of vulnerability to pollution. The wells are sampled annually. In addition to the annual ambient groundwater samples, MPCA staff collect approximately 40 contaminants of emerging concern (CEC) samples that are analyzed for over 267 analytes, such as pharmaceuticals, personal care products and fire retardants.

Two ambient monitoring wells within the BRRW have been sampled annually since 2006. Both are private wells in an agricultural area. Results from these wells indicate that the majority of detections were within the human health guidelines. There were some exceedances to these limits for groundwater quality issues, including arsenic, chloride, iron, manganese and sulfate.

- **Arsenic** was detected in both wells. Exceedances to the SDWA standard of 10 µg/L occurred in 100 percent of the samples. The human health risks associated with arsenic is referenced in the Arsenic section of the report.
- **Manganese** was detected in all of the samples. It has a Health Based Value (HBV) of 100 ug/L for infants and 300 ug/L for children and adults. Exceedances to the health based values were identified in both monitoring wells. For more information on Manganese (www.health.state.mn.us/communities/environment/water/contaminants/manganese.html)
- **Chloride** occurs naturally in groundwater, commonly detected, and was identified in one well 47.8 percent of the sampling. The concentration exceeded the EPA Secondary Maximum Contaminant Level of 250 mg/L in drinking water. Chloride has become an increasing concern due to salt being used as a deicing agent on roads. Elevated chloride concentrations can affect the taste of drinking water (Kroening & Ferrey, 2013).

In addition to the annual ambient groundwater samples, MPCA staff also collected samples for CECs. These samples were collected in one well twice, in 2013 and again in 2015. There were three detections: DEET, meprobamate, and metformin. There were no exceedances to applicable water quality guidelines.

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).

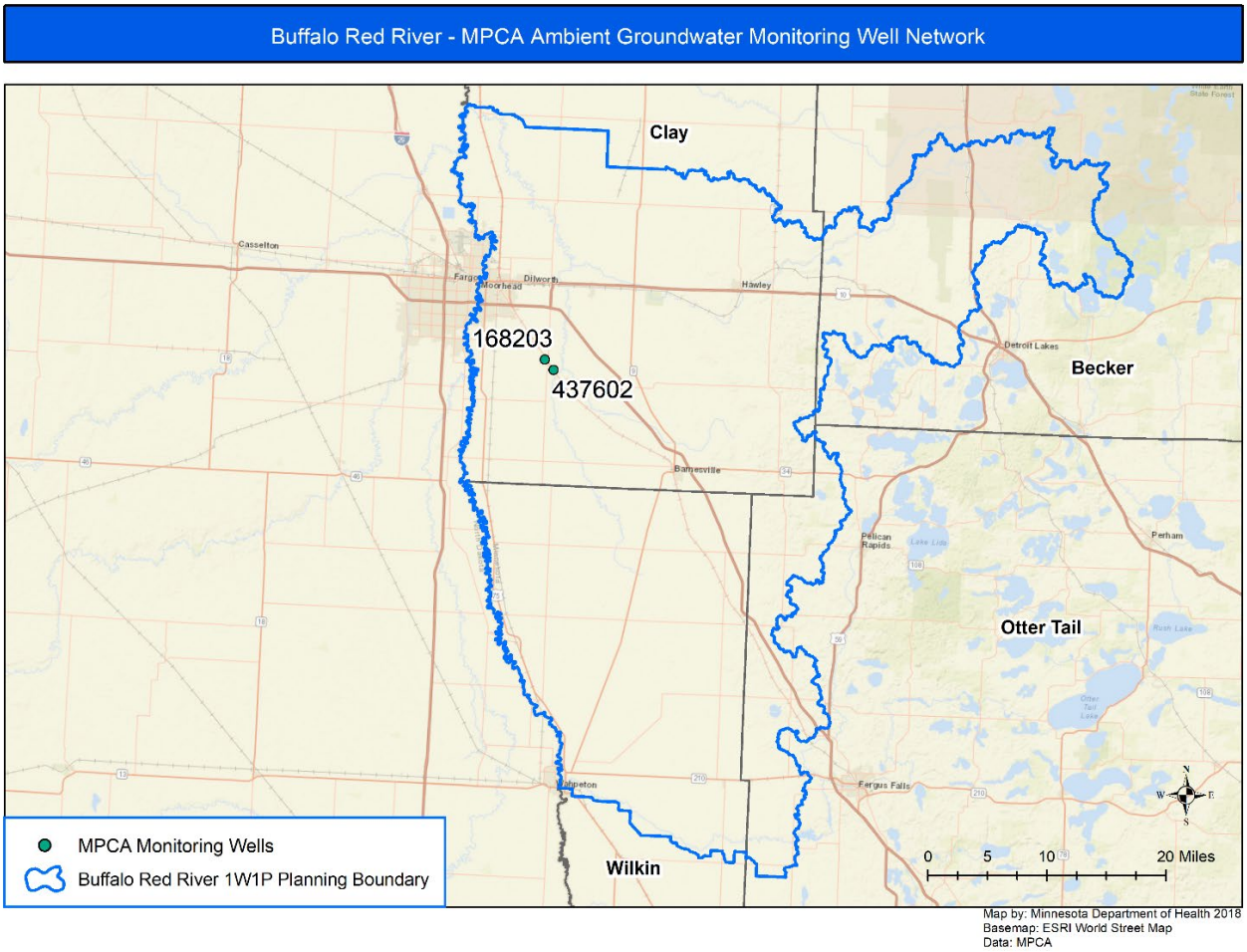


Figure 18: Buffalo Red River Watershed - MPCA Ambient Groundwater Monitoring Well Network

Potential Contaminant Sources

Some land use practices make it easier for contaminants to get into groundwater. Key land uses that are potential contaminant sources in the BRRW 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 Buffalo Red River Watershed?

The BRRW has 232 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. Clay County is the only delegated entity within the BRRW. The counties of Becker, Ottertail, and Wilkin rely on the MPCA to administer the feedlot program locally.

Table 6 outlines the number of registered feedlots in the BRRW for each county. Figure 18 contains a grid that depicts the number of active feedlots in each six by six-mile section of the watershed. Darker colors correspond to a higher concentration of active feedlots.

Table 6: Number of registered feedlots and the delegated counties

Counties	Number of Registered Feedlots per County	Delegated County
Becker	37	No
Clay	127	Yes
Ottertail	32	No
Wilkin	36	No

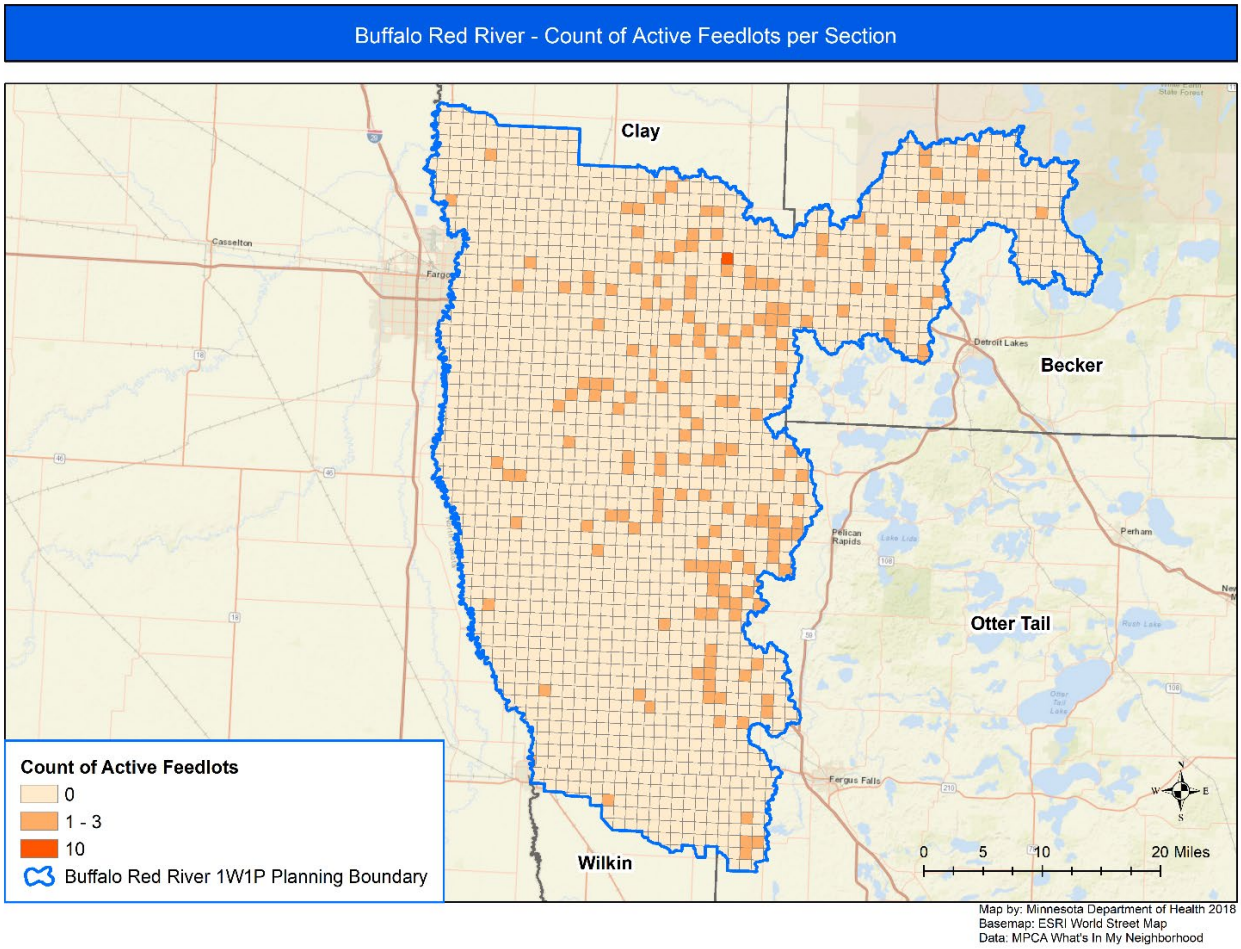


Figure 19: Buffalo Red River Watershed – 232 Active Feedlots

How to Protect Groundwater from Contamination

Manure management plans, feedlot inspections, permitting, technical assistance and record keeping are all used to manage nitrogen impacts to water quality. It is important to prioritize activities in the areas most sensitive to groundwater first. Table 13 provides a more comprehensive list of specific actions partners in can take to protect groundwater from nitrate and pathogen contamination.

Row Crop Agriculture

Row crop agriculture or cultivated crops (Figure 3) the largest land cover within the BRRW covers 73 percent of the watershed. Impacts from row crop production to water resources include nitrogen loss in the form of nitrate to groundwater, which can move downward to aquifers or be laterally dispersed to lakes and rivers. Tile drainage is another pathway for nitrogen to reach surface water systems, however this is not a focus of the GRAPS report being the TMDL and WRAPS reports assess impacts. Agricultural chemicals, including pesticides, are another risk for groundwater contamination from row crop agriculture. Both nitrate and pesticides are addressed in the **Groundwater Quality Issues and Concerns** section of this report.

Subsurface Sewage Treatment Systems (SSTS)

Of the approximately 450,000 SSTS (commonly called septic systems) across the state, slightly over 100,000 of them are estimated to be failing. As more time passes, additional systems are likely to fail. Failing SSTS can pollute both surface and groundwater. A failing system is one that does not provide adequate separation between the bottom of the drain field and seasonally saturated soil. The

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

Where Are SSTS in the Buffalo Red River Watershed?

SSTS are found in all four counties in the BRRW. Information reported by counties indicate a relatively small to high number of failing SSTS in the watershed (Table 7). State regulations require each county to adopt a local SSTS ordinance and that eminent health threats or failing systems be replaced and brought up to current standards. Even with a required ordinance, some counties still have identified gaps in their SSTS program, ranging from lack of records on treatment system age, type or function, known unsewered communities, and lack of a point of sale requirement triggering an inspection through a property sale.

Table 7: Reported number of failing SSTS in each county within the Buffalo Red River Watershed

County	Estimated number of failing SSTS per 1,000 acres
Becker	no data
Clay	0 -1
Ottertail	3 - 4
Wilkin	1 – 2

How to Protect Groundwater from SSTS Contamination

SSTS must be properly sited, designed, constructed and maintained to minimize the potential for disease transmission and groundwater contamination. Each county carries out permitting, inspections and operation of the SSTS program locally. Table 13 provides a more comprehensive list of specific actions the SRW can take to assure SSTS do not contaminate groundwater. You can find more information about building and maintaining SSTS at Subsurface Sewage Treatment Systems (https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems).

Contaminated Sites

The MPCA identified 227 active tank sites and one closed landfills in the BRRW. 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 Buffalo Red River Watershed?

Figure 19, maps active tank and leak sites compared to pollution sensitivity of near-surface materials in the BRRW. Figure 20 provides a map of the closed landfill in the BRRW. The following sites also provide maps to help identify contaminated sites.

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

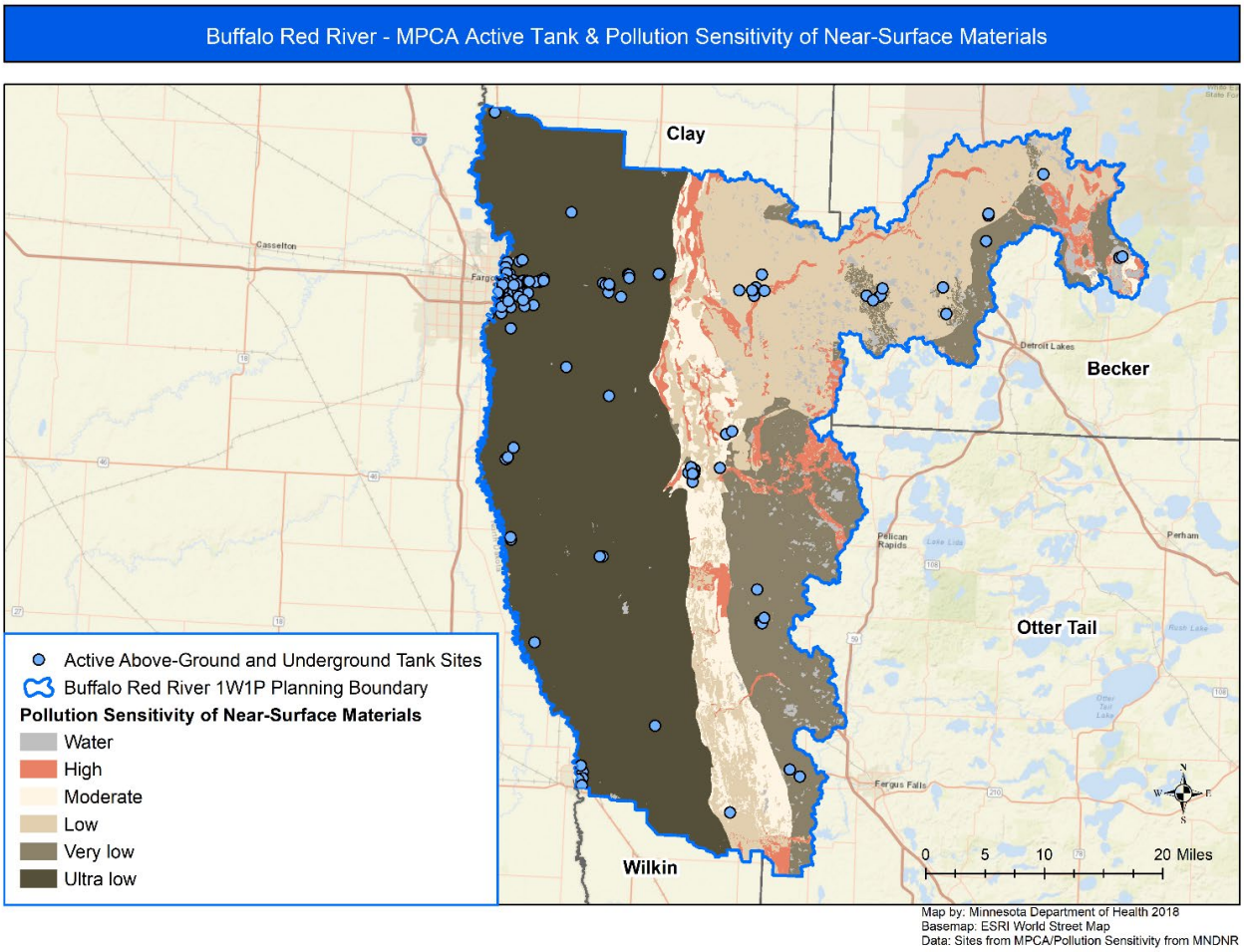


Figure 20: Buffalo Red River Watershed - MPCA Active Tank Sites and Pollution Sensitivity of Near-Surface Materials

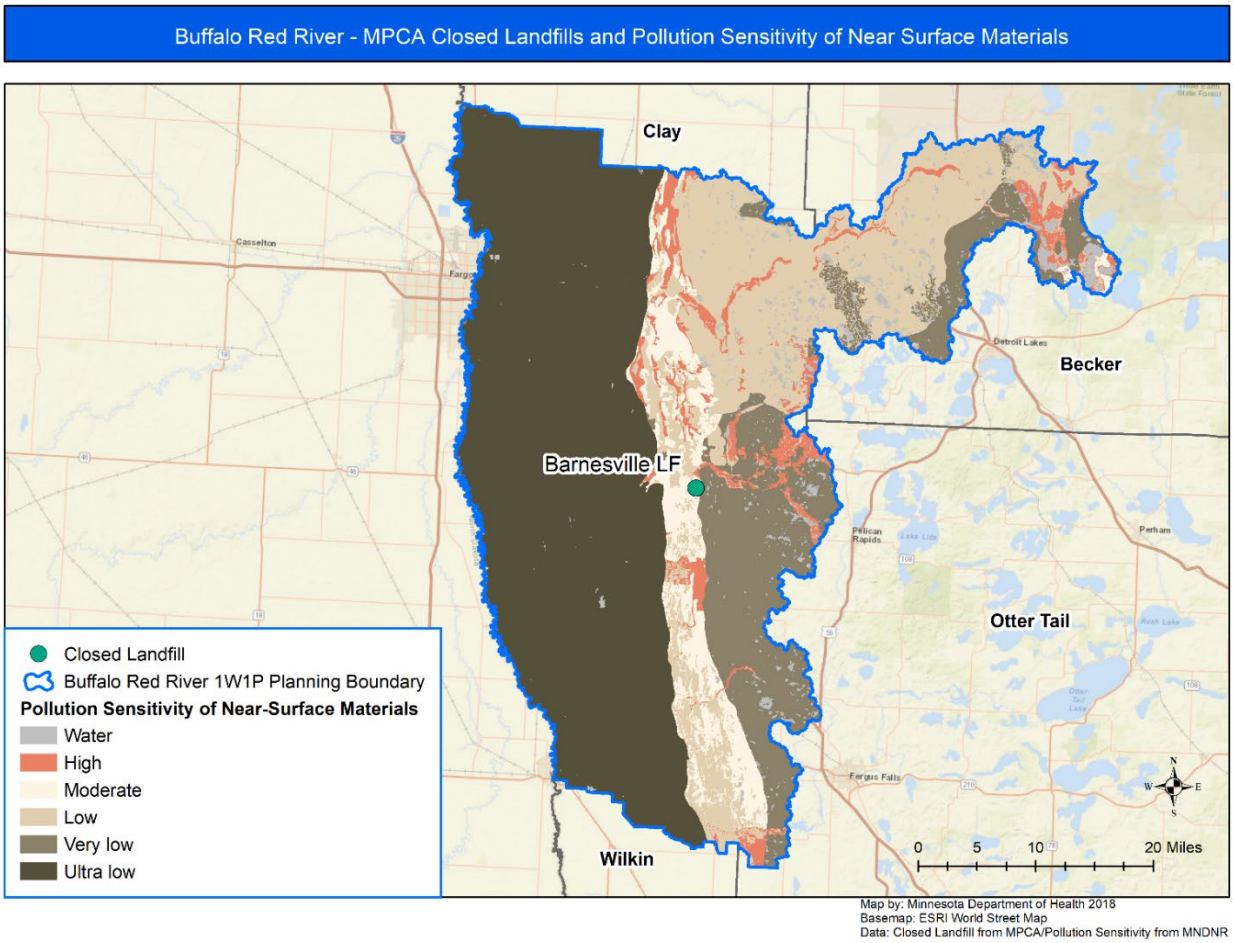


Figure 21: Buffalo Red River Watershed - MPCA Closed Landfill

How to Protect Groundwater from Contaminated Sites

Contaminated sites should be identified before making or changing any land use plans, zoning maps, and/or ordinances. Table 13 provides a more comprehensive list of specific actions the BRRW can do to assure contamination sites do not further contaminate groundwater.

Stormwater

The MPCA Stormwater Program (https://www.pca.state.mn.us/water/stormwater) regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems (MS4s), construction activities and industrial facilities, mainly through the administration of the National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Program. All MS4 permitted systems are located on the western edge of the BRRW, including Clay County, cities of Dilworth and Moorhead, MN State University-Moorhead, MN Community and Technical College-Moorhead, Buffalo Red River Watershed District, and MNDOT. Entities with an MS4 permit require the treatment and management of stormwater runoff.

The management of stormwater runoff is increasingly reliant on the infiltration of stormwater into the soil to control the volume of runoff. A number of stormwater practices concentrate runoff and force infiltration into the soil where it can recharge groundwater aquifers. The impacts of these practices on groundwater quality have not been thoroughly evaluated.

How to Manage Potential Stormwater Infiltration Risk

Caution should be observed when infiltrating stormwater, especially in areas with vulnerable drinking water sources. Use the MDH Stormwater Guidance for Sites in Drinking Water Supply Management Areas (https://stormwater.pca.state.mn.us/images/d/d3/Flow_Chart_-

_MDH_Stormwater_Guidance_for_Sites_in_Drinking_Water_Supply_Management_Areas.pdf) to better understand when infiltration is appropriate in wellhead protection areas. Table 13 provides a more comprehensive list of additional actions the SRW can take to prevent stormwater infiltration from contaminating groundwater.

Household Hazardous Waste

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

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

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

How to Protect Groundwater from Household Hazardous Waste Contamination

Promote HHW and the pesticide collection program availability to residents, and evaluate opportunities to expand services to increase participation. Table 13 provides a more comprehensive list of specific actions the BRRW can take to assure consumer products do not contaminate groundwater.

Pharmaceuticals

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

How to Protect Groundwater from Pharmaceutical Contamination

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

Groundwater Quantity Issues and Concerns

The western portion of the Buffalo-Red Watershed is covered by thick section of low-permeability clay deposited in Lake Agassiz. Buried sand and gravel aquifers beneath the lake clay are isolated from the land surface and are usually limited. The Buffalo aquifer is an exception. It is a long linear sand body. In some areas the Buffalo aquifer is buried beneath low permeability sediment and in other areas the aquifer is at the land surface. The main concern with the Buffalo aquifer is that it has historically been overused to provide water for the City of Moorhead because it was one of the only large aquifers available in western Clay County. Water levels in the Buffalo aquifer have recovered since 1995 when Moorhead transitioned its water source to the Red River.

The eastern portion of the Buffalo-Red Watershed has higher land elevations, is hummocky with an extremely irregular surface, and has more lakes. This sediment has more sand and gravel than in the western portion of the watershed and thus there are more and better aquifers in the eastern portion of the watershed and the aquifers are better connected to the recharge from the land surface.

Groundwater Use

A water-use appropriation permit from the DNR is required for all water appropriators (surface or groundwater) withdrawing more than 10,000 gallons of water per day or 1 million gallons per year. This provides the DNR with the ability to assess and regulate which aquifers are being used and for what purpose. One condition of the appropriation permit is to report actual water use; the DNR has records of reported water use from 1988 to the present.

Currently, groundwater accounts for about 50 percent of total water use (Figure 21). From 1988 to 1994, groundwater accounted for from 58 to 65 percent of total water use. Starting in 1995, the City of Moorhead moved a lot of their water production from the Buffalo aquifer to the Red River and surface water use either equaled or exceeded groundwater use from 1995 to the present day. Groundwater use was between 1000 and 1500 MG/year over that period.

Groundwater is sourced from three aquifer types (Figure 22): historically buried sand and gravel (confined) aquifers are the largest source of permitted groundwater withdrawal accounting for 50 to 70 percent of the total, and surficial sand aquifers (water table) are the next largest source accounting for 20 to 45 percent of the total. Bedrock aquifers account for less than 0.2 percent of the permitted water use.

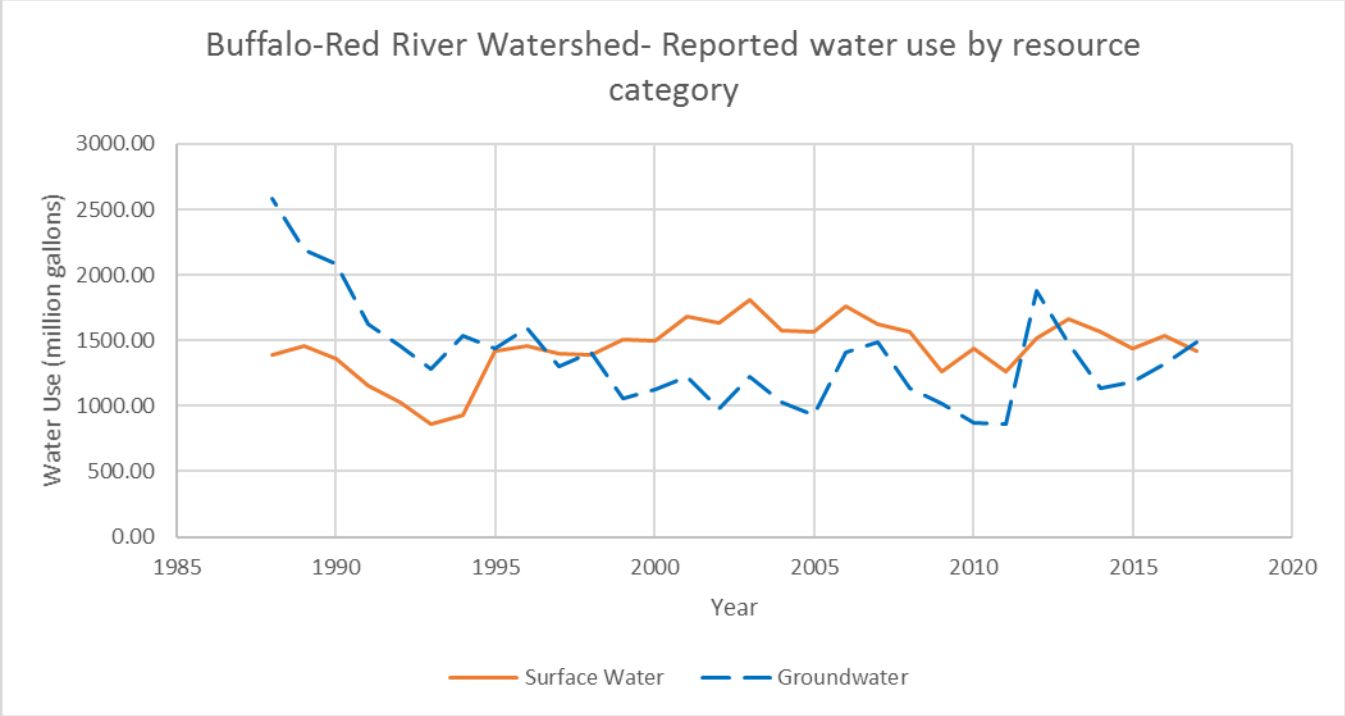


Figure 22: Reported Groundwater and Surface Water Use. Groundwater accounts for about 45-50 percent of permitted water use in the Buffalo Red River Watershed. In 1995, groundwater use decreased and surface water use increased. During that year, the City of Moorhead transitioned its primary water source from the Buffalo aquifer to the Red River.

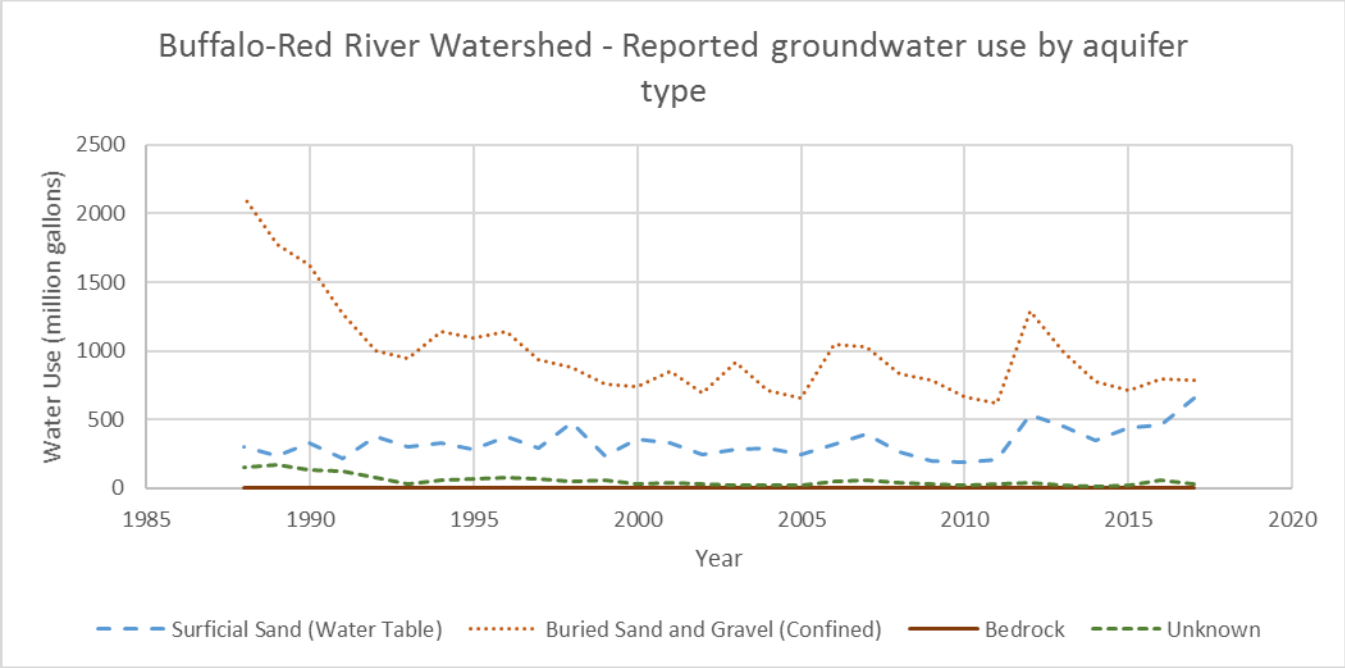


Figure 23: Water Use by Aquifer Type. Most permitted groundwater use is pumped from buried sand and gravel aquifers. The surficial sand aquifer is also a significant source. Bedrock aquifers account for less than 0.2 percent of permitted water use in the Buffalo Red River Watershed.

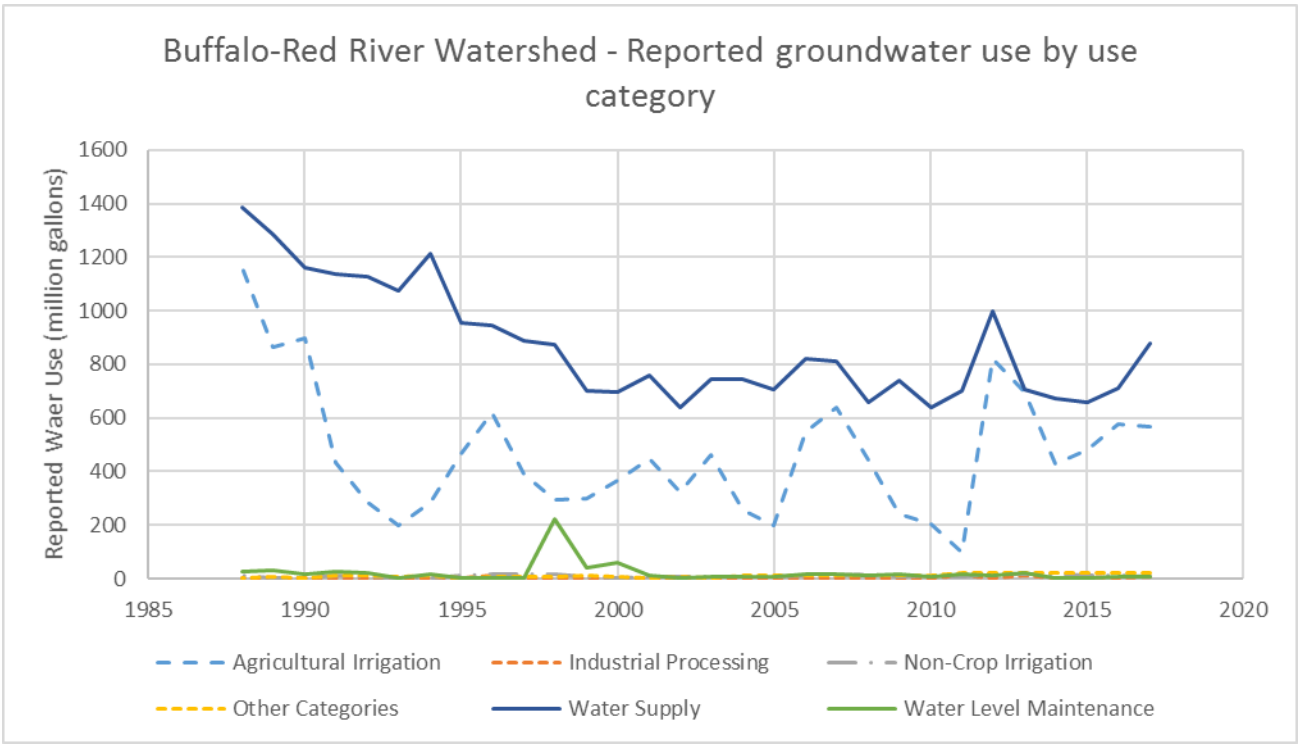


Figure 24: Reported groundwater use by Use Category. Water supply accounts for most groundwater use. Agricultural irrigation is also a significant water use. Irrigation use was high during the 1988-1989 and 2012 droughts.

Most groundwater use is used for water supply. Agricultural irrigation is the second largest water user. Table 8 [11] provides data from the Minnesota DNR Permitting and Reporting System (MPARS).

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

Table 8: Reported 2016 water use from DNR groundwater permit holders

Aquifer Use Categories	Water Supply	Agricultural Irrigation	Industrial Processing	Non-Crop Irrigation	Water Level Maintenance	Other Categories	Total (MGY)	Total (percent)
Surficial Sand (Water Table)	391.64	264.48	0.00	3.66	--	--	659.78	43.9
Buried Sand and Gravel (Confined)	475.42	302.07	5.46	5.63	--	19.14	807.73	53.8
Bedrock	2.37	--	--	--	--	--	2.37	0.2
Unknown	7.31	16.64	0.00	--	6.62	0.90	31.47	2.1
Total (MGY)	876.74	583.19	5.46	9.29	6.62	20.04	1501.3	--
Total (percent)	58.4	38.8	0.4	0.6	0.4	1.3	--	100.0

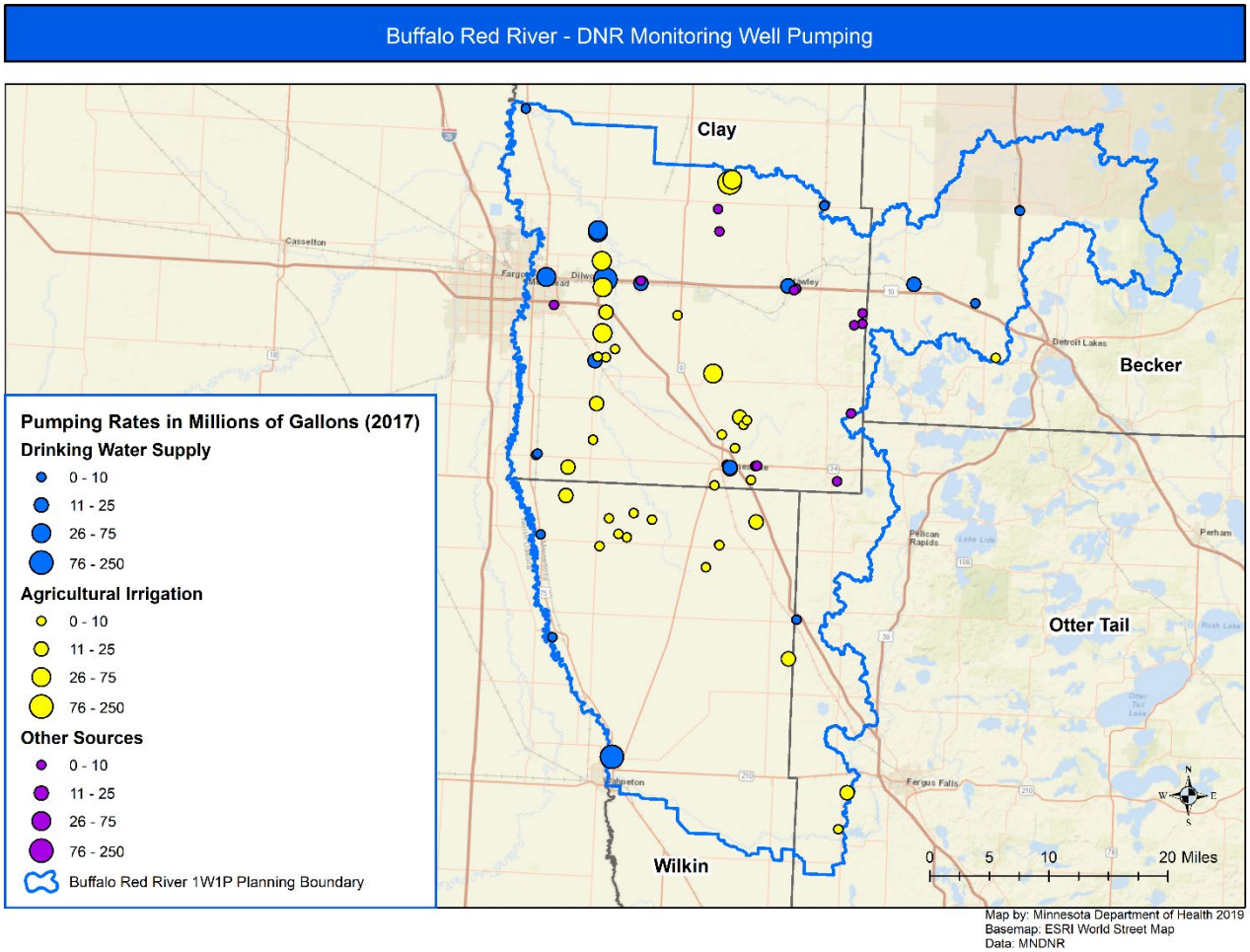


Figure 25: Buffalo Red River Watershed - Volume of permitted water use in the watershed for 2017 by well. The colors of circles correspond to the category of use for groundwater. The size of the symbol indicates volume pumped in million gallons.

Groundwater Level Monitoring

The DNR maintains a statewide groundwater level monitoring program using observation wells for the purpose of assessing the status of groundwater resources. The network provides valuable information to determine long-term trends, interpreting impacts of pumping and climate, planning for water conservation, evaluating water use conflicts, and inform other water management decisions.
Data over a multiple decade period of record are needed when assessing whether groundwater levels have changed. The DNR observation wells have a large range of length of record. One well has a water-level record extending back seventy years. Additional observation wells were recently installed within the past few years. The water level records from newer wells will be of great use in the future, but are not used in this report. The locations of DNR observation wells, their year of installation are shown in Figure 25.

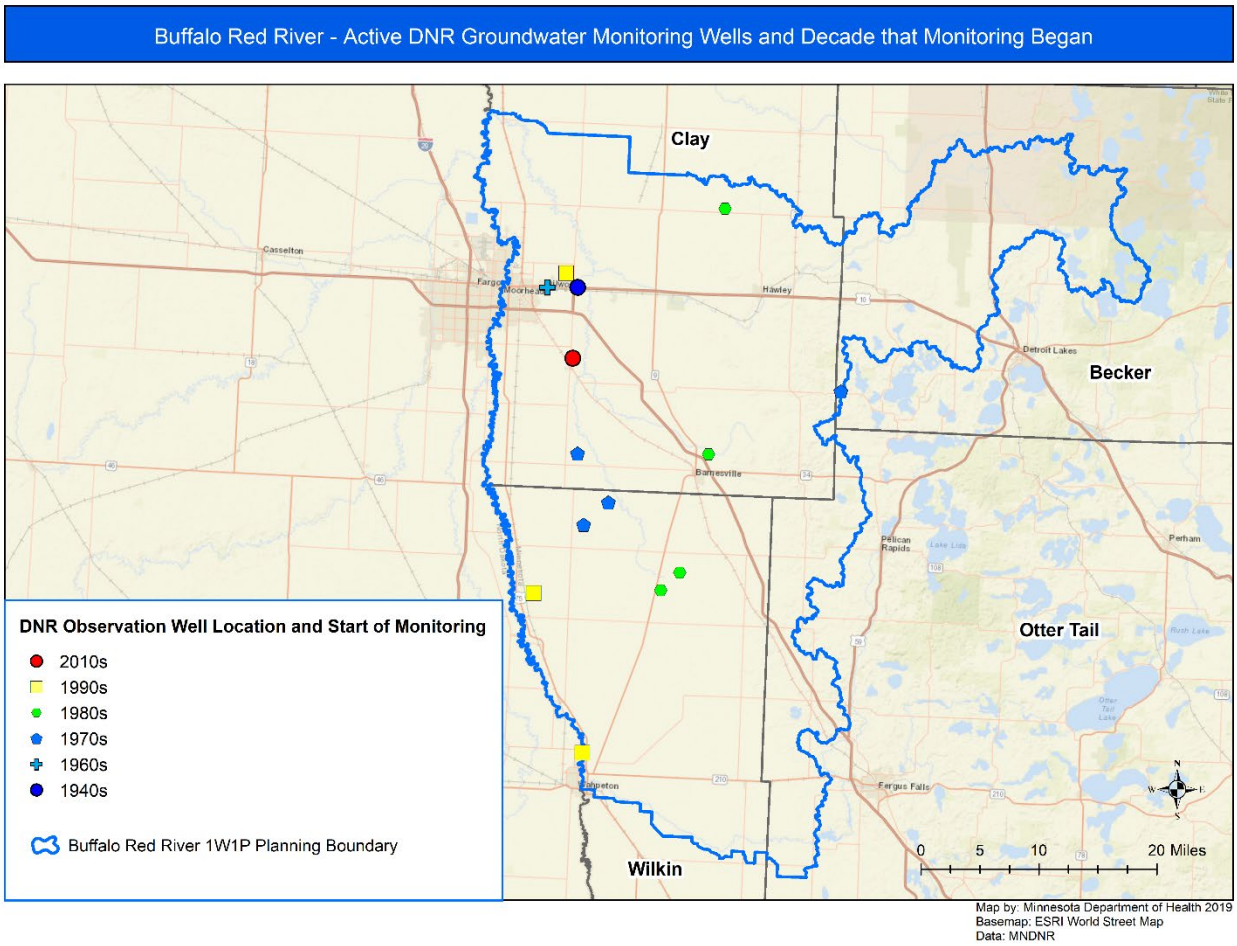


Figure 26: Buffalo Red River Watershed – Active DNR groundwater monitoring wells shown by decade monitoring started.

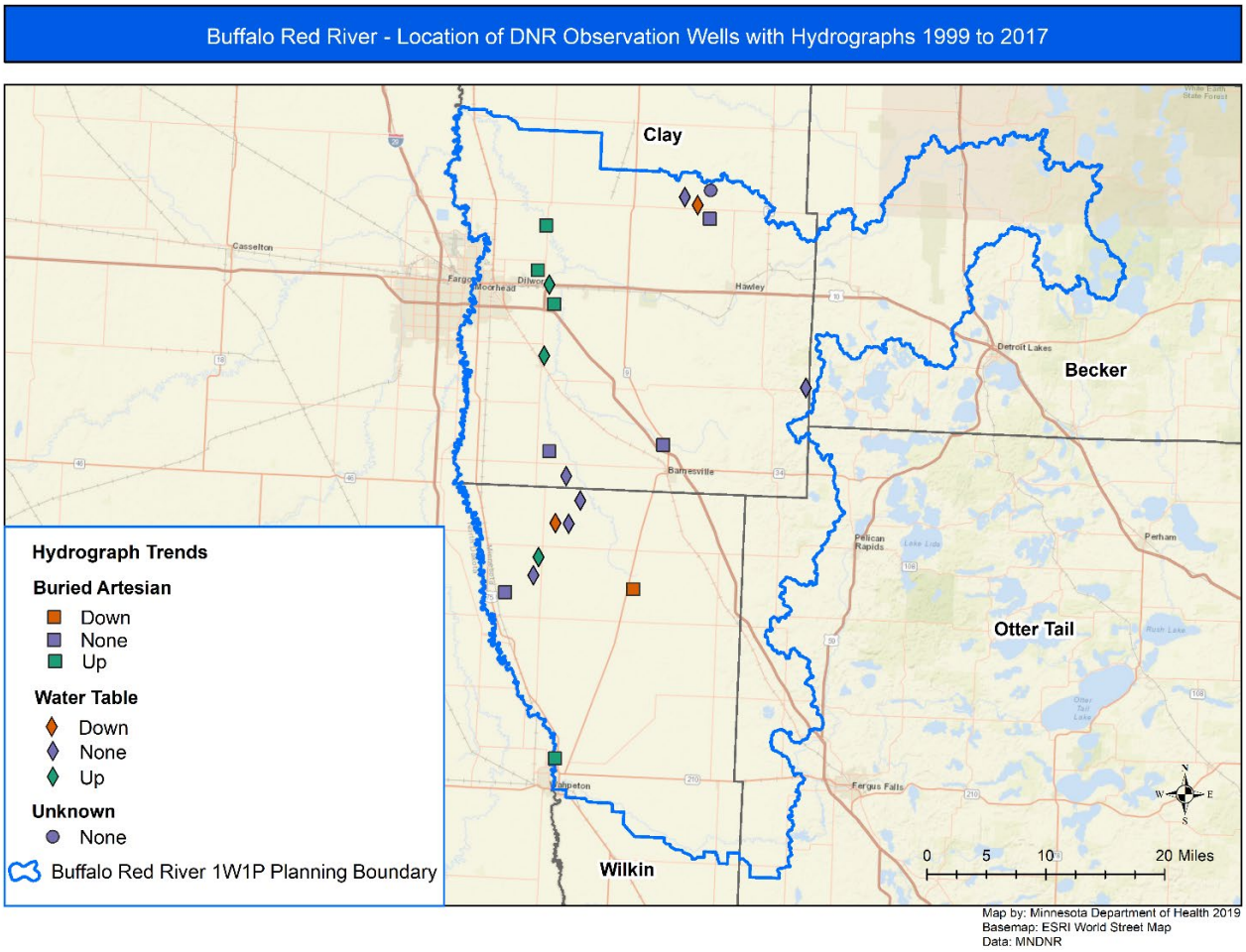


Figure 27: Buffalo Red River Watershed – 1997-2017 water level trend for DNR monitoring wells with sufficient water level data over that period of record.

Twenty-two observation wells with greater than twenty years of record were analyzed for water level trend by the Mann-Kendall non-parametric statistical method (Figure 26). The period from 1997 to 2017 was used for trend analysis in each well. Eleven wells are completed in the surficial sand (water table) aquifer, 10 wells are completed in the buried sand and gravel aquifer, and one well is in an unknown aquifer. (Most statistical methods assume a normal data distribution. Because hydrologic data typically do not have a normal distribution, non-parametric statistics are required). The trends were calculated using one data point per year, the lowest annual water level reading. The trends are meant to show a general direction of water levels over time and are shown in Figure 26. The Mann-Kendall method can indicate an upward trend, a downward trend or no trend. Seven of the hydrographs had an upward trend, 12 had no trend, and three had a downward trend. All of the wells in the northern portion of the Buffalo aquifer had an upward trend. This is due to the City of Moorhead's decision to move a lot of their water production from Buffalo aquifer groundwater to surface water in about 1995.
Figure 27 (a-c) Hydrographs from observation wells in the Buffalo aquifer. Water levels in the Buffalo aquifer declined after pumping started in the 1940s until 1995.During 1995 the City of Moorhead transitioned its water source from Buffalo aquifer groundwater to Red River surface water. Water levels in the Buffalo aquifer rebounded to predevelopment levels within a few years of this transition.

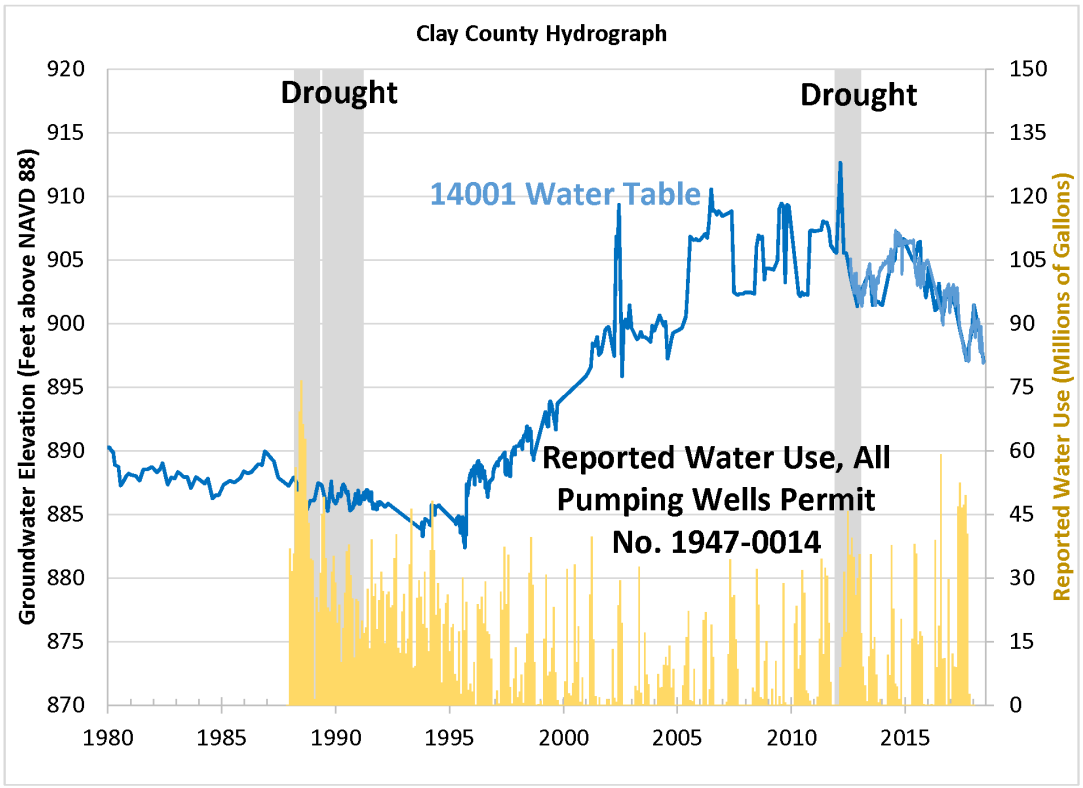


Figure 28a: Hydrograph of water level in water table well 14001.

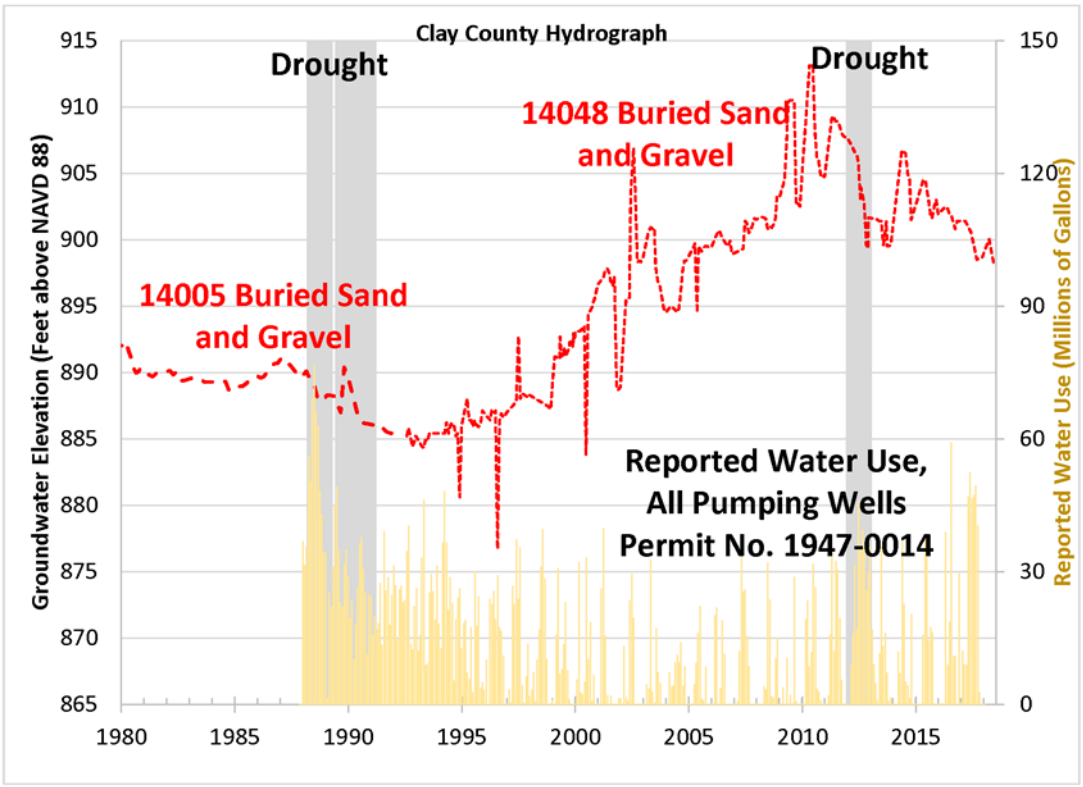
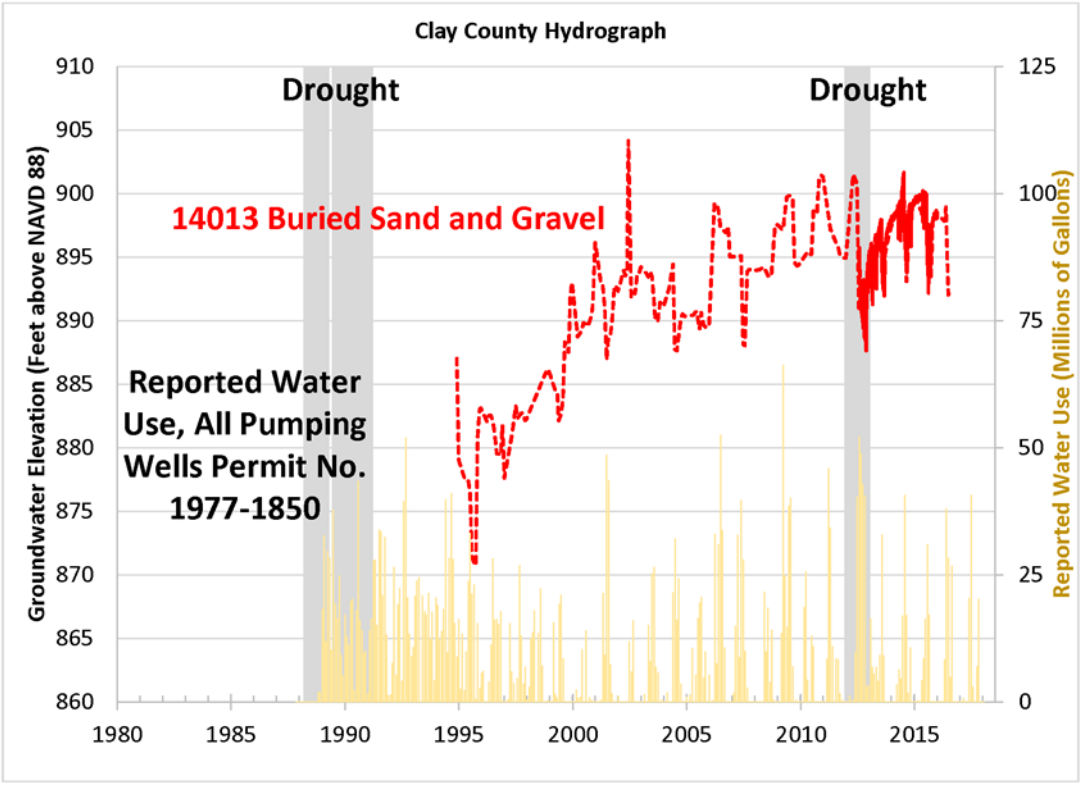


Figure 28b: Hydrograph of buried sand aquifer well 14048.



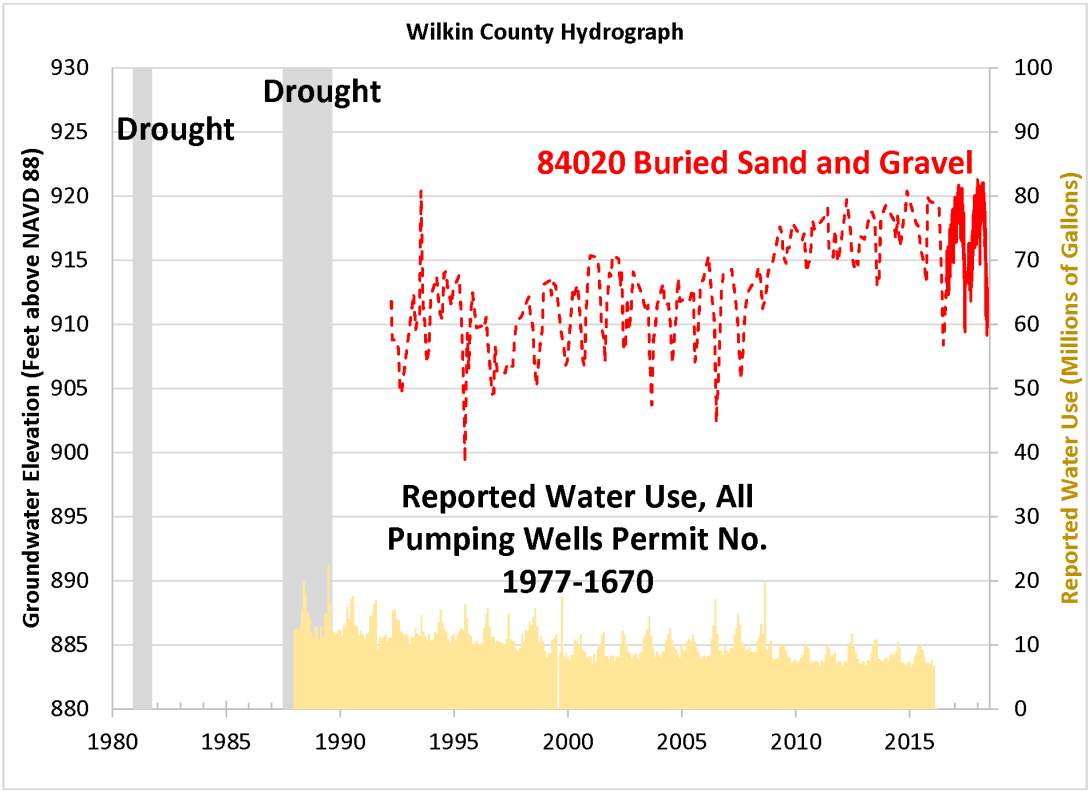


Figure 28c: Hydrograph of buried sand aquifer well 14013.

Figure 29: Hydrograph of observation well 84020. Water levels in this well vary seasonally with nearby groundwater pumping. Nearby pumping volume has declined from 1988 to 2017 and water levels have risen over the same period.

Groundwater Connected Natural Features at Risk

The BRRW boundary includes significant natural features, including surface waters that depend on groundwater to sustain them (Figure 30 through Figure 32). Groundwater appropriations and land-use changes can impact the health of these natural resources. If groundwater quantity or quality is degraded, these resources are at risk. Groundwater discharge areas and streams associated with the calcareous fens and the Upper Red River and Lawndale Creek are especially important resources in this watershed. The following features occur within the BRRW:

- Fifteen designated calcareous fens
- One designated trout stream and associated unnamed creeks
- Wetland complexes across the entire area
- Lakes that may be susceptible to changing aquifer levels
- Thirty-one kinds of native plant communities connected to groundwater
- Thirteen state-listed endangered, threatened, or special concern plant and animal species connected to groundwater.

Rare Natural Features Connected with Groundwater in the Buffalo Red River Watershed

Rare natural features (Figure 30 and Figure 31) contribute to the health of the habitat and environment. Some even contribute directly to local economies in the form of recreation—including hunting/fishing, wildlife viewing, and camping. Rare natural features can include species of rare plants and animals as well as native plant communities (habitats). These resources are at risk if groundwater quantity or quality is disrupted.

There is one restored, designated trout stream in the BRRW, Lawndale Creek and associated unnamed creeks. These streams are dependent on a constant supply of cold, oxygen-rich groundwater from springs or discharge areas. These streams are unique, and offer excellent recreation opportunities for fishing. Because surrounding land use changes and water appropriations can easily affect them, trout streams are waters designated by the DNR and protected from harm by law (Minnesota Rule 6264.0050). Trout streams found in the Buffalo River watershed include:

- Lawndale Creek (H-026-056-009-005-006)
- Lawndale Creek (H-026-056-009-005-006-B001)
- Unnamed Creek (H-026-056-009-005-006-001)
- Unnamed Creek (H-026-056-009-005-006-002)
- Unnamed Creek (H-026-056-009-005-006-003)
- Unnamed Creek (H-026-056-009-005-006-004)

There are fifteen designated calcareous fens in the BRRW, Table 9. The Buffalo River Watershed has twelve of these and the Upper Red River Watershed has three.

Fen Site Name	Watershed
Anderson WPA	Buffalo
Anna Gronseth Prairie - Akron 10	Red
Barnesville Swamp Tansem 18 NW	Buffalo
Barnesville Swamp Tansem 18 SW	Buffalo
Barnesville Swamp Tansem 7 a	Buffalo
Barnesville Swamp Tansem 7 b	Buffalo
Barnsville Swamp Humboldt 1	Buffalo
Felton Prairie Flowing 24	Buffalo
Hamden 36	Buffalo
Haugtvedt WPA South Unit	Buffalo
Rothsay Prairie - Prairie View 33	Buffalo
Rothsay Prairie Tanberg 16	Buffalo
Rothsay Prairie Tanberg 9	Buffalo
Rothsay WMA - Akron 4	Red
Town Hall Prairies	Red

Table 9: The fifteen designated calcareous fens in the Buffalo Red River Watershed

Calcareous fens are very rare prairie wetlands that only occur in 10 states and are fed by a constant supply of cool, calcium rich groundwater that supports a unique set of plants and animals. These calcareous fens support six of the rare plants and at least one of the rare animals found in the Buffalo and Upper Red River watersheds. Calcareous fens are protected from harm under Minnesota Statute (103G.223). When they decline it is a signal that some element or process of the groundwater system is not functioning well.

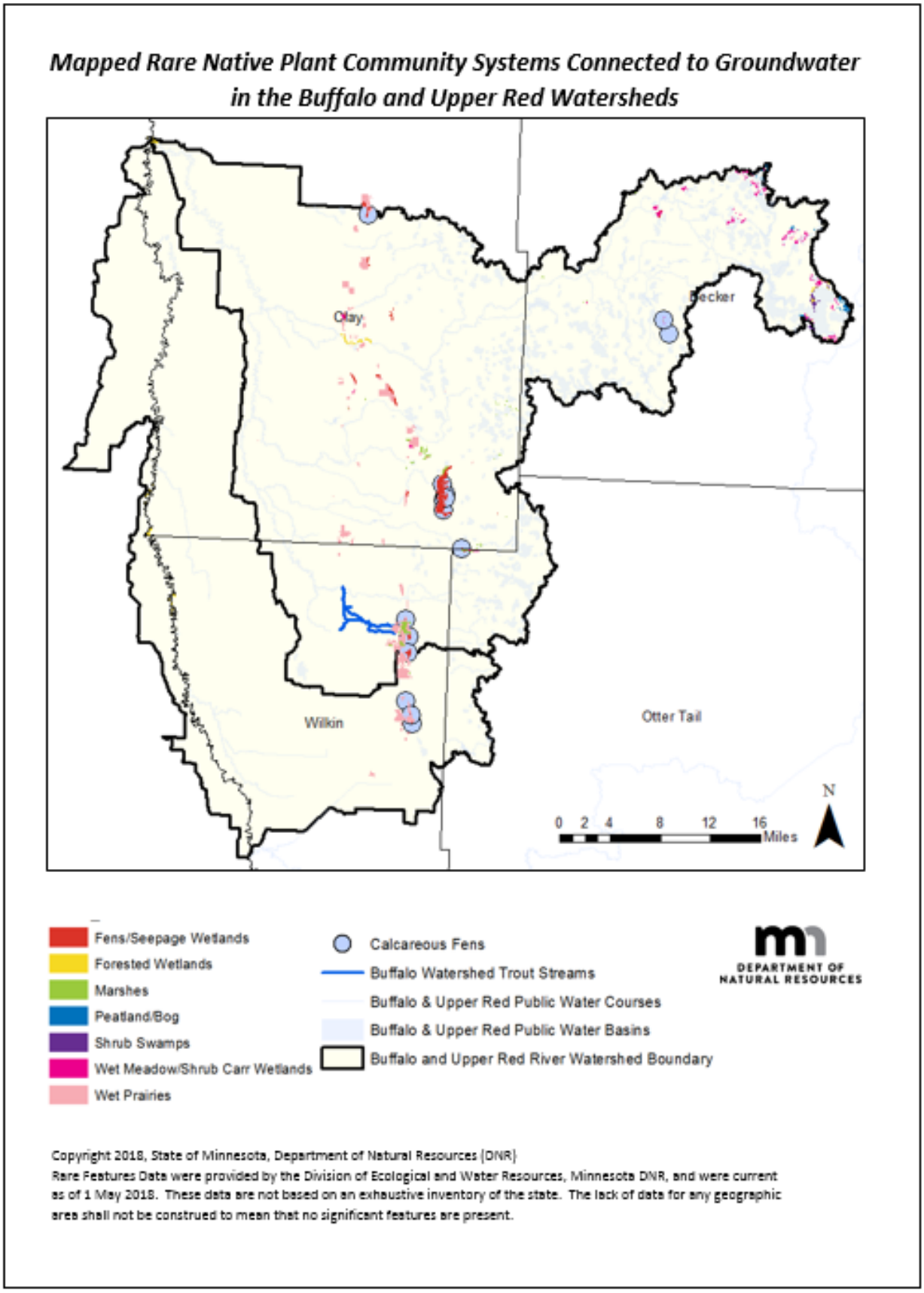


Figure 30: Buffalo Red River Watershed - Native Plant Communities Connected with Groundwater

There are 31 kinds of native plant communities associated or dependent on groundwater in the BRRW. They range from forested communities such as rich tamarack swamps and floodplain forests, to open communities such as wet prairies and rich fens. Ten of the these communities are considered critically imperiled or imperiled, ten are considered imperiled to vulnerable, and one is considered vulnerable to apparently secure. Thirteen of the 33 native plant communities associated with or dependent on groundwater are considered apparently secure or secure. To learn more about Conservation Status Ranks for Native Plant Community Types and Subtypes (http://files.dnr.state.mn.us/natural_resources/npc/s_ranks_npc_types_&_subtypes)

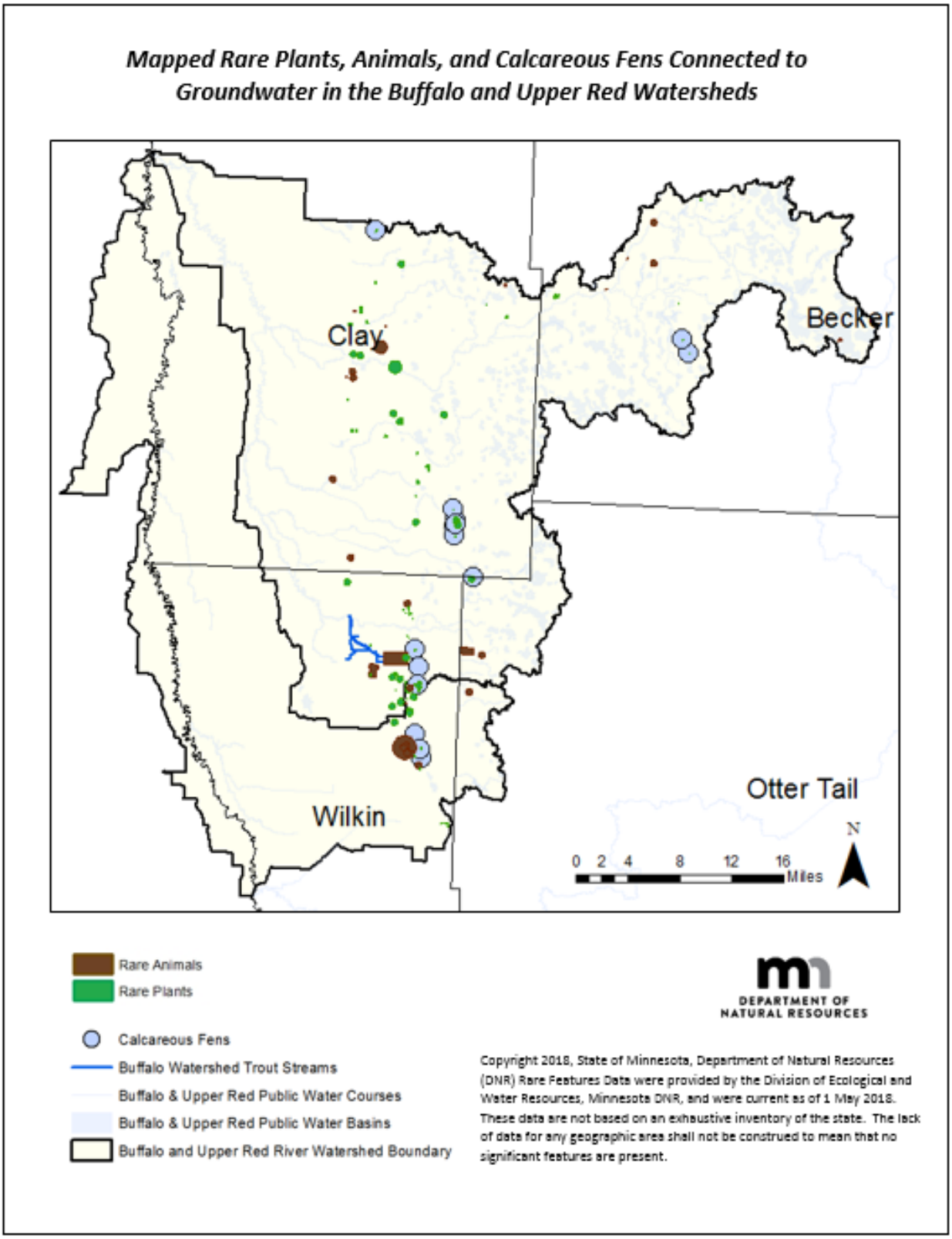


Figure 31: Buffalo Red River Watershed - Rare Plants, Animals, and Native Plant Communities Connected with Groundwater

There are 13 species of birds, fish, amphibians, reptiles, mussels, and plants that are either endangered, threatened, special concern, watch list, or a state listed "Species In Greatest Conservation Need," that are dependent on habitats with groundwater or groundwater discharge areas in the BRRW. A detailed

list of native plant communities and rare features is available in the Additional Resources section at the end of the report in Table 14 through Table 17.

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

Groundwater Flow Dominated Lakes

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

1. Lakes dominated by surface water inflow and outflow resulting from a large ratio of contributing surface watershed area to lake area.
2. Lakes dominated by groundwater inflow and outflow resulting from a smaller ratio of contributing surface watershed area to lake area (10 or less). This lake type is often landlocked with no surface outlet. Although for the purposes of this GRAPS report, the lake level 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 31). One-hundred-thirty-three of the 586 lakes in the BRRW have a watershed to lake area ratio of 10 or less and are considered groundwater-dependent lakes. Large-scale groundwater pumping near a lake will likely have more impact on groundwater-dominated lakes than on surface water dominant lakes.

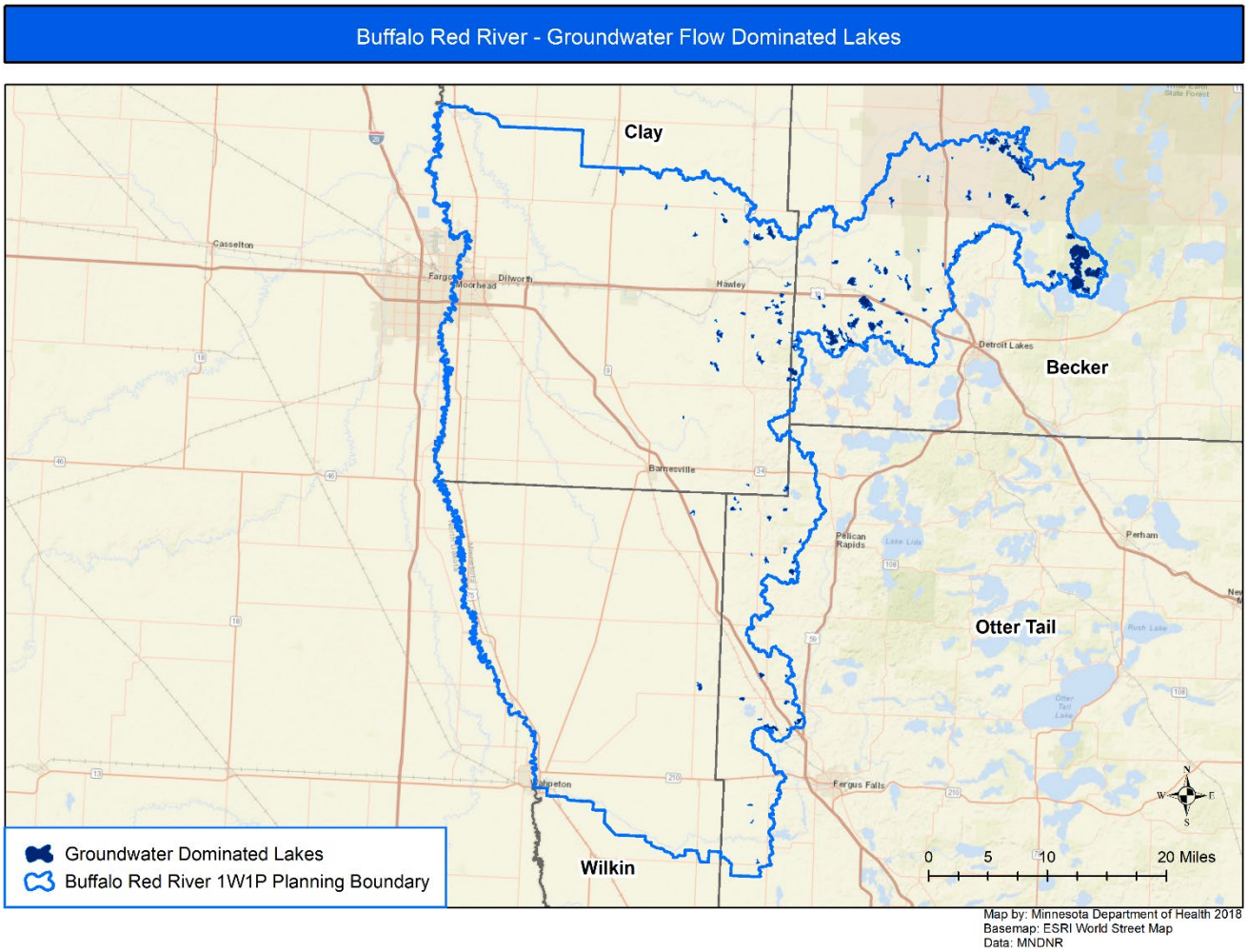


Figure 32: Groundwater-dominated lakes in the Buffalo Red River Watershed. These lake have a watershed to lake are ration of 10 or less. Most lakes are in the eastern portion of the watershed in the highland area, which is part of the Alexandria moraine.

How to Address Groundwater Quantity Issues

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

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

There are a variety of strategies to help meet water conservation and recharge goals. The type of strategy used depends on the primary factor affecting quantity in the area in question. Strategies include: conservation easements, cropland management, education and outreach, irrigation water management and land use planning and management. (Table 13) provides a more comprehensive list of specific actions the BRRW can take to conserve water and promote recharge.

Buffalo Red River Watershed Strategies and Actions to Restore and Protect Groundwater

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

Tips for Prioritizing and Targeting Strategies and Actions

Determine Your Goal

You may decide to address an issue because of known instances or threats in an area, or maybe you are working in a geographic area because of jurisdiction or some other factors. The Actions and Strategies Table (Table 13) will help you focus on the goal, for instance, reducing nitrate in groundwater. Then you will need to decide, using the table, if you would like to focus on conservation easements, outreach and education, nutrient management, or some other strategy.

Match the Right Action with the Right Location

The Actions and Strategies Table (Table 13) will help you determine where the actions would be most effective. For instance, an activity that reduces nitrate in groundwater may be more valuable in sensitive areas or vulnerable wellhead protection areas. Or, if you are focused on a limited geography, the table will help you determine what actions are applicable to that area. Considering the sensitivity combined with the presence of drinking water wells and vulnerable wellhead protection areas can help further focus efforts. In another example, factors such as the presence of groundwater dependent features and a concentration of large appropriation wells can help determine where efforts to promote conservation and recharge would be most effective.

Know the Pollution Sensitivity

Groundwater quality is impacted by both point and non-point source pollution. These potential contaminant sources need to be managed according to the pollution sensitivity of the aquifer (Figure 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 13) identifies the multiple benefits that could result from implementing the action.

Leverage Other Programs and Practices

Utilize existing Federal and State programs that are already working in the BRRW to conserve land, prevent erosion and protect or improve surface water quality. Many of the practices that are being implemented have a benefit for groundwater. You can further target some of these efforts based on the information provided in this report to maximize the benefits by protecting groundwater. (Table 13) includes a column that identifies which agencies can assist with a specific action; the listed agencies typically have some type of program in place that you can leverage. The Descriptions of Supporting Strategies section of this report lists existing programs and resources for each of the suggested strategies.

Emphasize Protection

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

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

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

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

Strategies and Actions for Buffalo Red River Watershed

This section provides a table of strategies and actions local partners in the BRRW 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 32 provides a visual representation of the relationship between goals, supporting strategies, and recommended groundwater actions. Note that each goal is supported by many supporting strategies, and each supporting strategy may have a variety of recommended groundwater actions.

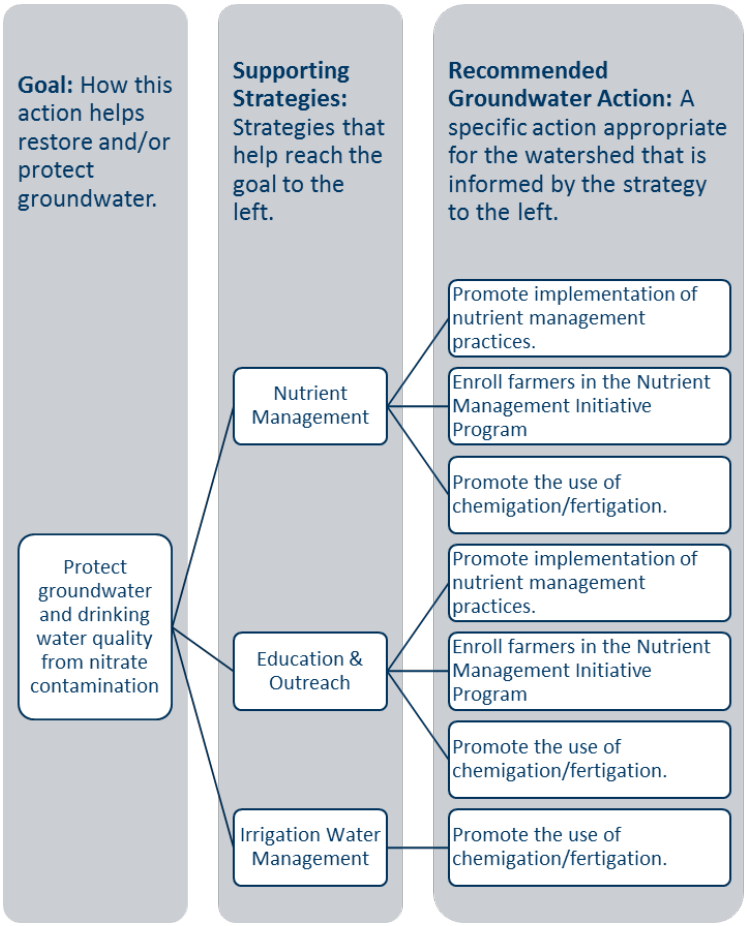


Figure 33: Visual representation of the relationship between goals, supporting strategies, and recommended groundwater action.

How to Use the Table of Actions and Strategies

The Table of Actions and Strategies (Table 13) is designed so that you can find actions and strategies related to whatever your priorities may be when it comes to restoring and protecting groundwater. There are a variety of columns to facilitate the following:

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

The following list defines what each of the columns in Table 13 represent:

- **Goal:** How the action in this row helps restore and/or protect groundwater. The goals have been sorted alphabetically as much as possible. Each goal identifies the main objective—such as whether it protects groundwater quality or sustains the amount of water available—and includes a keyword to explain how the goal is achieved. For example, a goal that is listed as 'Protect Groundwater and Drinking Water Quality: Closed Landfills' can be interpreted as: Protect groundwater and drinking water quality from landfill contamination.
- **Supporting Strategies**: Identifies and links you to general strategies that help accomplish the goal for the action in this row. Each strategy is hyperlinked to a section of the report that provides more information about the strategy and connects you with existing tools and programs that may assist you in implementing this strategy or implementing actions related to this strategy.
- **Recommended Groundwater Action**: A specific action you can take to help achieve the goal to the left in the row and is informed by the strategy to the left in the same row.

- **Target _____ Co.:** The 'X's' denote which counties should consider using the action described in the corresponding row. An 'X' denotes the action would be most beneficial for that county. The addition of the counties helps to further prioritize and target where recommended groundwater actions should be implemented, narrowing the focus from a larger subwatershed to a specific geographic area. For example, many of the subwatersheds identify the need to work with irrigators; by adding the additional filter of counties, you are able to eliminate specific counties that do not have irrigators, targeting where implementation should occur. It also works as a quick reference to identify groundwater actions specific to the county in which you work.
- **HUC-10s Involved**: This column denotes which HUC-10 subwatershed(s) within the BRRW to consider using the action described in the corresponding row. There are 19 HUC-10s within the watershed. Table 12 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 10: HUC 10 subwatersheds within the Buffalo Red River Watershed

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Upper Pelican River	Upper Pelican	0902010307
Bois de Sioux River	Bois de Sioux	0902010105
Lower Buffalo River	Lower Buffalo	0902010607
Upper Buffalo River	Upper Buffalo	0902010601
City of Wahpeton-Red River	Wahpeton Red	0902010404
Rabbit River	Rabbit	0902010104
Lower Pelican River	Lower Pelican	0902010308
Little Pine Lake-Otter Tail River	Little Pine	0902010302
Wolverton Creek	Wolverton	0902010403
Headwaters Otter Tail River	Headwaters Otter Tail	0902010301
Deerhorn Creek	Deerhorn	0902010603
South Branch Wild Rice River	SB Wild Rice	0902010810
South Branch Buffalo River	SB Buffalo	0902010606
Whiskey Creek	Whiskey-Red	0902010402
Stony Creek	Stony	0902010605
City of Fargo-Red River	Fargo Red	0902010405
Whiskey Creek	Whiskey-Buffalo	0902010604
County Ditch No 31	Ditch 31	0902010401

[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*).

HUC-10 Name	Reference Name in Implementation Table	HUC-10 Number
Otter Tail River	Otter Tail	0902010310
Middle Buffalo River	Middle Buffalo	0902010602

Summary of Key Findings and Issues

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

Key Groundwater Quality Findings and Issues

- **Nitrate** – less than one percent of tested drinking water wells had levels at or above the SDWA standard of 10 mg/L.
  - MDA ambient monitoring well in Wilkin County recorded the highest nitrate result at 11.8 mg/L in the surficial aquifer. The sample exceeded the SDWA standard.
  - MDA TTP sampled almost 622 drinking water wells for nitrate in 10 townships in the BRRW. Nitrate exceedances were detected in Elkton and Riverton Townships in Clay County where row crop production combined with vulnerable geology has resulted in samples exceeding the SDWA standard.
  - MPCA ambient monitoring wells had no nitrate exceedances.
- **Arsenic** – approximately 30 percent of tested 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.
- **Pesticides –** seven pesticides were detected in the MDA monitoring well, but not at concentrations above human-health based drinking water standards or reference values.
- **DWSMAs** cover approximately 9,100 acres in the watershed. Fourteen of the 17 community public water suppliers are engaged in the wellhead protection planning process or are implementing their plans. Of the 14 systems with approved plans, the vulnerability varies across the watershed from low to high. One of the approved wellhead protection plans exhibit a high vulnerability in all or part of their DWSMA and is considered vulnerable to contamination from the land surface, with all others exhibiting moderate or low vulnerability.
  - The Moorhead Buffalo Aquifer North and South WHPAs are conjunctive delineations, meaning a strong connection exists between the groundwater capture zone for a well and surface water runoff for the land surface area intersected by the capture zone.
  - Nearly 80 percent of the people living in the watershed get their drinking water from a community public water supply system.
- **Private wells** – there are 2935 private drinking water wells with known locations ranging from 20 ft. to 468 ft. deep.
- **Flood events** can threaten the safety and availability of drinking water by washing pathogens and chemical contamination into source aquifers. Clay County has the greatest number of wells at risk within the 100 year flood zone.
- **Animal feedlots – t**here are 232 active feedlots in the watershed with the greatest concentration in Clay County. Clay County is the only delegated county in the watershed that manages the feedlot program locally. All others rely on the MPCA to administer the feedlot rule.
- **Row crop agriculture** accounts for nearly 73 percent of land cover in the watershed. In areas with high pollution sensitivity, agricultural inputs can contaminate the underlying aquifer.
- **SSTS** are found throughout the watershed. Information reported by counties indicate Wilkin County has the highest number of failing SSTS at one to two per 1,000 acres. Ottertail County reported a higher number of failing SSTS, however many of the failing systems are outside of the watershed.
- **Contaminated sites –** there are 227 active tank sites that could leak chemicals into the environment and cause localized groundwater pollution if not properly managed. The risk to groundwater is greatest in areas of high pollution sensitivity.

- One closed landfill with a known groundwater contamination plume is found within the watershed.

Key Groundwater Quantity Findings and Issues

- The BRRW depends on the sand and gravel aquifers, both surficial (water table) and buried (confined) for drinking water. Groundwater is generally more available in the eastern portion of the watershed where the aquifer is better connected to recharge from the lands surface.
- Groundwater accounts for approximately 50 percent of the total appropriated water use within the watershed.
  - Water supply is the largest groundwater user at just over 58 percent, followed by irrigation at nearly 39 percent.
- All calculated trends from the DNR observation wells in the BRRW reported seven of the hydrographs had an upward trend, 12 had no trend, and three had a downward trend, indicating water use has remained consistent or experienced reduced demand in most wells over the period of record.
  - All of the wells in the northern portion of the Buffalo aquifer had an upward trend. This is due to the City of Moorhead's decision to move a lot of their water production from Buffalo aquifer groundwater to surface water in about 1995.
- BRRW has 15 designated calcareous fens and one designated trout stream and associated unnamed creeks.
- One-hundred-thirty-three of the 586 lakes in the watershed have a watershed to lake ratio of 10 or less and are considered groundwater dependent lakes, susceptible to changing aquifer levels.
- Wetland complexes across the entire watershed are susceptible to changing aquifer levels.
- Thirty-one kinds of native plant communities and 13 state-listed endangered, threatened, or special concern plant and animal species connected to groundwater that are at risk to changing aquifer levels and degraded groundwater quality.

Table of Actions and Strategies to Restore and Protect Groundwater

Table 11: Actions and Strategies to Restore and Protect Groundwater

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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 21)* *Drinking Water Wells Map (Figure 16)*						
Protect Private Well Users: Well Testing	Education and Outreach	Make information available to private well users about local drinking water quality and well testing. Host a well testing clinic or provide resources to well users to have their water tested for: ▪ Coliform Bacteria (every year) ▪ Nitrate (every other year) ▪ Arsenic (at least once) ▪ Lead (at least once) ▪ Manganese (at least once)	X	X	X	X	All	MDH Well MGMT	Prioritize areas with a high density of private wells, high pollution sensitivity, and/or where there are known groundwater contaminants. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *Arsenic Map (Figure 21)* *Drinking Water Wells Map (Figure 21)* *Nitrate Map (Figure 17)*						
Protect Private Well Users: Manage Wells **Protect Groundwater and Drinking Water 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 21)*						
Protect Groundwater and Drinking Water	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 21)* *DWSMA Map (Figure 11)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Quality: Well Sealing															
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 Land Use Planning and Management	▪ Identify MPCA closed landfill locations and groundwater areas of concern in comprehensive land use plans, zoning maps and ordinances. Identifying the location will help assure drinking water and public health implications are considered when evaluating future growth or development near these sites. ▪ Consult and review the MPCA Closed Landfill Program to make sure any proposed changes in zoning districts or new land use planning proposals are not in conflict with the State Closed Landfill Plan. ▪ Contact the MPCA Closed Landfill Program for current information and any concerns or changes to the groundwater area of concern when considering land use changes or developments near the area. Request to 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.				X	SB Buffalo Whiskey-Buffalo	MPCA CLP Land Manager	*Closed Landfill Map (Figure 25)*						
Protect Groundwater and Drinking Water	Contaminant Planning and Management	▪ Identify leaky and active tank sites in your area in comprehensive land use plans, zoning maps and ordinances. Identifying these locations will help assure drinking		X			Middle Buffalo Whiskey-Buffalo	MPCA Tanks Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Quality: Leaky Tanks	Land Use Planning and Management	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.					Stony Wolverton Fargo-Red		*Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Tank & Leak Site Map (Figure 24)*						
Protect Groundwater and Drinking Water Quality: Feedlots	Contaminant Planning and Management	Prioritize feedlot inspections, regardless of size, in areas of greatest risk to pollution, to minimize the loss of nitrate and harmful bacteria.	X	X	X		Upper Buffalo Middle Buffalo Stony Whiskey-Buffalo OtterTail	MPCA Feedlot Program	*Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs.* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*						X
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	X	X	X		Upper Buffalo Middle Buffalo Stony Whiskey-Buffalo OtterTail	MPCA Feedlot Program	Focus in areas with high pollutions sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*			X	X		X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
		from nitrate loss. Follow the UMN Extension guidelines, including no summer application and fall application only after soil temperature is below 50 degrees.													
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		Upper Buffalo Middle Buffalo Stony Whiskey-Buffalo OtterTail	MPCA Feedlot Program	Focus in areas with high pollution sensitivity and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Active Feedlot Map (Figure 23)*			X	X		X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote implementation of nutrient management practices to improve farm profitability and reduce nitrogen loss. Practices include: ▪ Improve nitrogen efficiency by practicing the 4 R's of nitrogen stewardship (right source, right rate, right timing, and right place) ▪ Adopt and use of the UMN 'Best Management Practices for Nitrogen use in Minnesota ▪ Properly credit nitrogen sources (soil/manure tests, past crops, & mineralization) ▪ Implement comprehensive nutrient management plans to improve nitrogen	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)*						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
		crediting, equipment calibration, and record keeping ▪ Spoon feed nitrogen to sync with plant growth through side dressing and split fertilizer application													
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Increase the number of farmers enrolled in the Nutrient Management Initiative Program to evaluate alternative nutrient management practices.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach Cropland Management	Identify programs and opportunities for growers to test and implement new nitrogen practices, innovative technology or cropping systems that protect groundwater quality that prevent or reduce nitrogen loss. (E.g. Cover Crops, Alternative Crops, Precision Ag / New Technologies, Nutrient Management Initiative, etc.)	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)*	X		X		X	X
Protect Groundwater and Drinking Water Quality: Nitrate	Nutrient Management Education and Outreach	Promote the adoption of cover crops for scavenging nutrients under row crops.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, irrigated row crops, highly vulnerable DWSMAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Drinking Water Wells Map (Figure 21)*	X		X	X	X	X

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin Co.	HUC-10s Involved	Lead Agency that can assist	Tip(s) for Targeting & *Helpful Maps*	*Benefit: Habitat*	*Benefit: GWCF*	*Benefit: Soil Health*	*Benefit: Erosion*	*Benefit: Carbon*	*Ben: Nutrient Runoff*
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water Management	Promote the use of chemigation/fertigation to synchronize nitrogen application to crop demand.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 27)*						X
Protect Groundwater and Drinking Water Quality: Nitrate	Education and Outreach Nutrient Management Irrigation Water Management	Host an irrigation water-testing clinic to determine nitrate concentrations in raw water to calculate the irrigation water nitrogen crediting formula.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on irrigators in areas with high pollution sensitivity, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Monitoring Wells/Pumping (Figure 27)*						X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Nutrient Management Cropland Management	Promote the benefits of farming using soil health principles that increase soil moisture holding capacity, organic matter, and nutrient cycling.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	NRCS Field Office	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:**	Education and Outreach Nutrient Management	Contact state and federal agency resource partners and coordinate opportunities for local field days, training and outreach for farmers, co-ops, and crop consultants. Focus on alternative nitrogen management practices, soil health, and second crops.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 6)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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	Cropland Management						Whiskey-Buffalo OtterTail		*Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)*						
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides	Education and Outreach Cropland Management Integrated Pest Management	Promote the benefits of crop diversity and rotation, which include high yields for each crop in the rotation, pest and weed control, and enhanced soil fertility.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus on areas with high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their township testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Nitrate in Wells Maps (Figure 17)* *Pesticides Map (Figure 20)*		X	X	X	X	X
Protect Groundwater and Drinking Water Quality: Nitrate **Protect Groundwater and Drinking Water Quality:** Pesticides **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Provide information on best practices for turf management to the public. Include information on fertilizer application, crediting for grass clippings, lawn watering and herbicide and pesticide application.		X			Fargo Red	UMN Lawns & Turfgrass MGMT Team	Focus in MS4 communities and residential developments with high pollution sensitivity, along with highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*			X	X	X	X
Protect Groundwater and Drinking Water Quality: Pesticides	Education and Outreach Integrated Pest Management	Promote the adoption and use of MDA's water quality BMPs for agricultural pesticides and insecticides.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program.						X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
							Whiskey-Buffalo OtterTail		*Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						
Protect Groundwater and Drinking Water Quality: 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		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MDA Pesticide & Fertilizer Division	Focus in areas of pesticide detection in MDA's monitoring wells, along with areas of high pollution sensitivity, highly vulnerable DWMSAs, and vulnerable townships identified by MDA through their Township Testing program. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Township Testing Map (Figure 18)* *Pesticides Map (Figure 20)*						
Protect Groundwater and Drinking Water Quality: SSTS	SSTS Management	▪ Enforce state and locally adopted SSTS ordinances for the protection of groundwater and drinking water sources. ▪ Evaluate existing SSTS ordinances and identify opportunities to enhance groundwater protection. Activities may include adding a Point of Sale requirement to trigger a SSTS inspection during real estate transactions. ▪ Improve SSTS records by obtaining information on treatment system; age, type and function to understand potential risks to groundwater.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 21)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach	Educate citizens about SSTS including: ▪ The basic principles of how a septic system works ▪ How to operate the system efficiently and effectively	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo	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.						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
	SSTS Management	▪ Risks to human health and the environment ▪ Financial options to repair or replace failing or non-compliant system					Stony Whiskey- Buffalo OtterTail		*Drinking Water Wells Map (Figure 21)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: SSTS	Education and Outreach SSTS Management	Host local SSTS training and workshops for area contractors and citizens regarding SSTS technology, compliance, and maintenance.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey- Buffalo OtterTail	MPCA SSTS Field Staff	Focus in areas with high pollution sensitivity, highly vulnerable DWSMAs, and areas with a density of SSTS. You can use the Well Density Map as an imperfect surrogate for SSTS density. *Drinking Water Wells Map (Figure 21)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection (WHP)	Education and Outreach Cropland Management Land Use Planning and Management	Serve on WHP planning teams to assist public water suppliers with planning and implementation activities to address land use planning concerns.	X	X		X	Lower Buffalo Middle Buffalo SB Buffalo Upper Buffalo Whiskey - Buffalo Fargo Red Wahpeton Red Ditch 31 Whiskey – Red Wolverton	MDH SWP Unit	*Wellhead Protection Plan Development Status (Figure 10)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water Quality: Wellhead Protection	Land Use Planning and Management	Integrate WHP plan strategies into local plans, such as the 1W1P and land use plans.	X	X		X	Lower Buffalo Middle Buffalo SB Buffalo Upper Buffalo Whiskey - Buffalo	MDH SWP Unit	*DWSMA Map (Figure 11)*						

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
							Fargo Red Wahpeton Red Ditch 31 Whiskey – Red Wolverton								
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		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water: Pharmaceuticals	Education and Outreach	Keep unused/unwanted medications out of drinking water supplies by educating the public about available safe and secure drop box locations at law enforcement facilities and pharmacies.	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	MPCA Hazardous Waste Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						
Protect Groundwater and Drinking Water: Contaminants of Emerging Concern (CEC)	Education and Outreach	Enhance Minnesotans' understanding of CEC's by communicating the health impacts and exposure potential of emerging contaminants in drinking water. Outreach and Education Grants are available through the MDH CEC Initiative. See Outreach and Education Grants (www.health.state.mn.us/divs/eh/risk/guidan	X	X	X		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo	MDH CEC Program	Focus on areas with high pollution sensitivity and highly vulnerable DWMSAs *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*						

Goal	Supporting Strategy	Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
		ce/dwec/outreachproj.html) for opportunities.					OtterTail								
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		Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail	DNR Ecological & Water Resources	Focus in areas with high pollution sensitivity. *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)*						
Protect Groundwater and Drinking Water Quality Water Sustainability	Education and Outreach	Develop a 'drinking water protection' page on the SWCD or county website or other communication tools that can be used to share information with citizens on what they can do to protect both public and private sources of drinking water. Include information about the connection between surface and groundwater, well sealing and water conservation. Dakota County's webpage Water Quality (https://www.co.dakota.mn.us/Environment/WaterQuality/WellsDrinkingWater/Pages/default.aspx) is a good example.	X	X	X	X	All	MDH Well MGMT & SWP Unit	N/A						
Protect Groundwater and Drinking Water Quality Water Sustainability	Land Use Planning and Management	Develop ordinances, overlay districts, performance standards, etc. to further protect drinking water and groundwater connected features from future land use impacts for their long-term sustainability and use.	X	X	X	X	Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail Ditch 31 Whiskey-Red	MN Assoc. of Counties	Focus in areas with high sensitivity, highly vulnerable DWSMAs and groundwater connected natural features *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)*		X				

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
							Deerhorn								
Protect Groundwater and Drinking Water Quality Water Sustainability	Land Use Planning and Management	Incorporate basic groundwater and drinking water information into local comprehensive plans and ordinances including: ▪ Local geology and aquifer information ▪ The sources of drinking water and the pollution sensitivity of public and private wells ▪ Maps of state approved WHP areas ▪ Groundwater dependent natural features ▪ Contaminant areas of concern ▪ Other local information needed to consider and protect groundwater and drinking water resources in local land use planning decisions	X	X	X	X	Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail Ditch 31 Whiskey-Red Deerhorn	MDH SWP Unit	*Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *Tank & Leak Site Map (Figure 24)*						
Groundwater Sustainability: Water Conservation	Land Use Planning and Management	Plan for future population growth by reflecting drinking water quality and quantity issues in land use plans. Use planning tools such as setbacks, performance standards, conditional use permits, zoning districts, etc. that protect aquifer health and yield.				X		MN Assoc. of Counties	Prioritize highly vulnerable DWSMAs and areas of high water use: *DWSMA Map (Figure 11)* *Monitoring Wells/Pumping (Figure 27)*		X				
Protect Groundwater and Drinking Water Quality	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 at greatest risk to flooding: *Drinking Water Wells and Flood Risk (Figure 12)*						
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: *Drinking Water Wells and Flood Risk (Figure 12)*						
Protect Groundwater and Drinking Water Quality	Working Lands Initiative	Explore incentivizing the adoption of perennial crops for improved water quality.				X	Whiskey - Buffalo	BWSR	Target the piloted subwatersheds identified in the Working Lands Initiative final report.	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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, RIM Reserve for wellhead protection, and CREP.	X	X	X	X	Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail Ditch 31 Whiskey-Red Deerhorn	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 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)* *Monitoring Wells/Pumping (Figure 27)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *RIM Easements Map (Figure 34)*	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	Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail Ditch 31 Whiskey-Red Deerhorn	FSA	Prioritize private lands with existing CRP contracts, along with state and federal easement, such as RIM and DNR and USFW habitat easements. Target areas of known groundwater dependent features, areas of high pollution sensitivity, and highly vulnerable DWSMAs. *RIM Easements Map (Figure 34)* *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* *Pollution Sensitivity Map (Figure 6)* *DWSMA Map (Figure 11)*	X	X	X	X	X	X

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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: 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			Fargo Red	MPCA MS4 Program	Prioritize MS4 communities, target highly sensitive areas, and highly vulnerable DWSMAs. *Pollution Sensitivity Map (Figure 6)* *DWSMA Map (Figure 11)*	X	X		X		X
Protect Groundwater and Drinking Water Quality: Nitrate **Groundwater Sustainability:** Water Conservation	Education and Outreach Irrigation Water Management	Promote and encourage the adoption of irrigation water management BMPs that increase water conservation and decrease conditions for nitrogen loss beyond the root zone by utilizing: ▪ Irrigation water scheduling to control the volume, frequency, and application of irrigation water ▪ Conversion to low flow pressure irrigation nozzles ▪ Proper timing of irrigation through the use of online tools that identify local climate, growing degree days (GDD) and evapotranspiration (ET) conditions ▪ Test irrigation water and take credit for nitrate present as a fertilizer source		X			Lower Buffalo	MDA Pesticide & Fertilizer Division	Prioritize areas of high water use intensity by agricultural irrigators, highly sensitive areas, and highly vulnerable DWSMAs. *Monitoring Wells/Pumping (Figure 27)* *Pollution Sensitivity Map (Figure 6)* *Pollution Sensitivity Wells (Figure 9)* *DWSMA Map (Figure 11)*		X		X		X
Groundwater Sustainability: 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.	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			Fargo Red	DNR Ecological & Water Resources	N/A		X				

Goal	Supporting Strategy	▪ Recommended Groundwater Actions	Target Becker Co.	Target Clay Co.	Target Ottertail Co.	Target Wilkin 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*
Groundwater Sustainability: Water Conservation	Land Use Planning and Management Education and Outreach	Assist farmers with a water appropriation permit by developing a water resource plan that identifies water conservation measures that improve water use efficiencies and reduce water demand.	X	X	X	X	All	DNR Ecological & Water Resources	Prioritize areas of high water use intensity by agricultural irrigators. *Monitoring Wells/Pumping (Figure 27)*		X				X
Water Sustainability: Recharge **Water Sustainability: Rare or Declining** Habitats	Land Use Planning and Management	Promote and increase the adoption of recharge BMPs including wetland construction/restoration, perennial establishment, riparian buffers, and conservation easements.	X	X	X	X	Lower Buffalo Upper Buffalo Middle Buffalo SB Buffalo Stony Whiskey-Buffalo OtterTail Ditch 31 Whiskey-Red Deerhorn	DNR Ecological & Water Resources	Target areas near sensitive features and groundwater fed lakes. *GWC Plants, Animals, Native Plant Communities Map (Figure 31)* *Mapped Native Plant Communities (Figure 30)* Groundwater Dominated Lakes Map *(Figure 32)*	X	X	X	X	X	X

Descriptions of Supporting Strategies

Working Lands Initiative

A BWSR initiative that explored incentivizing planting perennial crops to improve water quality. This initiative developed a detailed plan that identified pilot watersheds that are expected to result in the greatest water quality improvement and exhibit readiness to participate based on a number of criteria. The minor watershed of Whiskey Creek was selected based on the excessive nutrient, bacteria levels and sediment that it contributes to the Buffalo River. The City of Barnesville's DWSMA extends outside of the city limits in the watershed; it is considered moderately vulnerable to contamination. Whiskey Creek itself is impaired for aquatic life (turbidity) and aquatic recreation (E. coli).
Through the landowner surveys, over 30 percent of respondents indicated a very likely willingness to planting perennial or cover crops if higher payments were awarded. Additionally, tax benefits and compensation for lost crop production also ranked high. BWSR's Working Lands Watershed Restoration Program (www.bwsr.state.mn.us/planning/WLWRP/wlwrp.html) provides additional information on the program, including the final report.

Conservation Easements

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

Existing Programs and Resources

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

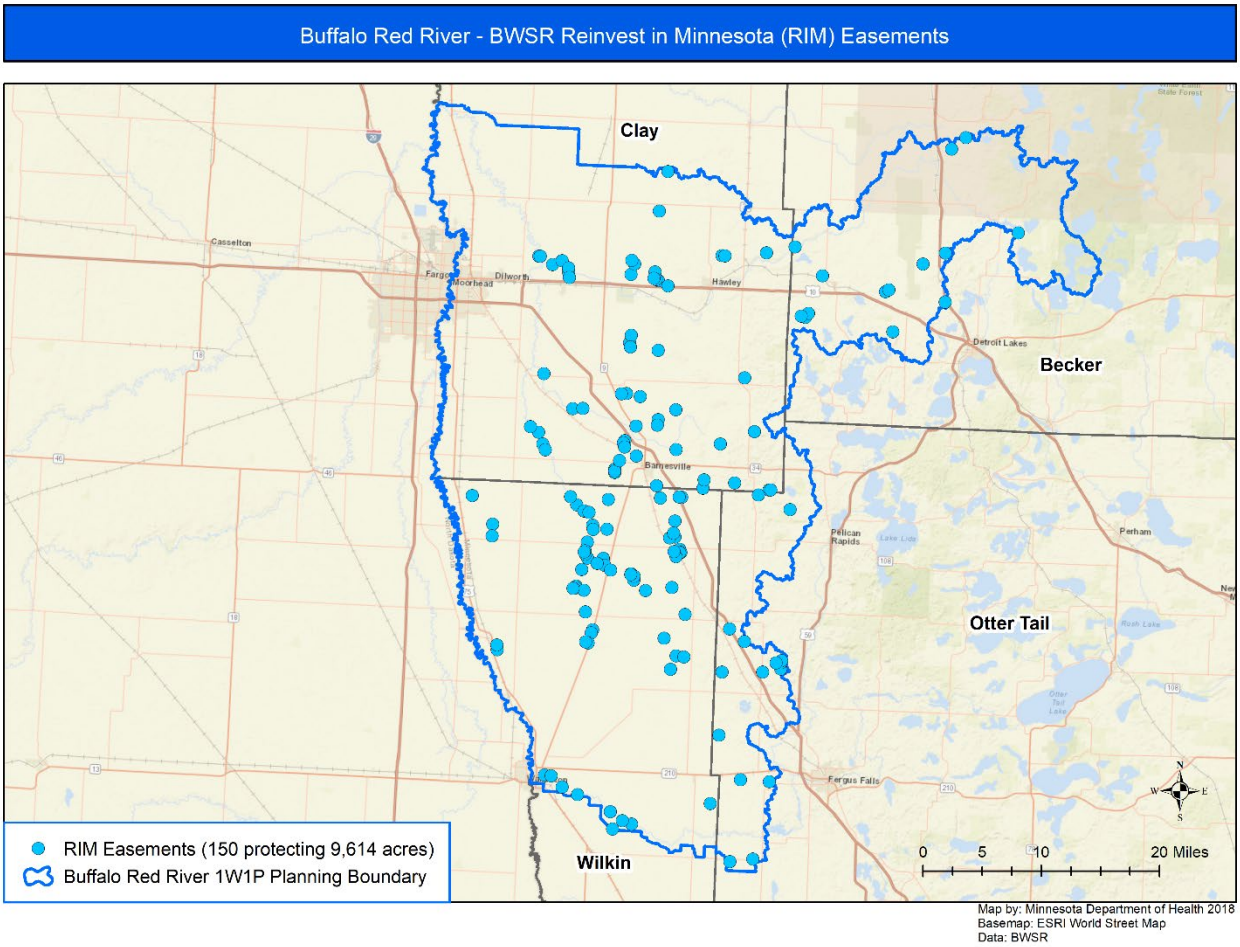


Figure 34: Buffalo Red River Watershed – BWSR RIM easements

Contaminant Planning and Management

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

Existing Programs and Resources

- MDA **What's in My Neighborhood? Agricultural Interactive Mapping** (www.mda.state.mn.us/chemicals/spills/incidentresponse/neighborhood.aspx): A tool that tracks and maps spills of agricultural chemicals and sites contaminated with agricultural chemicals.
- MPCA **Manure Management** (https://www.pca.state.mn.us/quick-links/feedlot-nutrient-and-manure-management): Resources such as fact sheets, guidelines, computer tools and forms for feedlot nutrient and manure management.
- MPCA **Tank Compliance and Assistance Program--Storage Tanks** (https://www.pca.state.mn.us/waste/storage-tanks): A program that provides information and assistance to tank owners and others regarding technical standards required of all regulated underground storage tanks and aboveground storage tank systems.
- MPCA **Closed Landfill Program** (https://www.pca.state.mn.us/waste/closed-landfill-program): A voluntary program to properly close, monitor, and maintain Minnesota's closed municipal sanitary landfills.

- MPCA **Feedlots** (https://www.pca.state.mn.us/quick-links/feedlot-program): Information about feedlot rules, permits, and management.
- MPCA **What's in My Neighborhood** (https://www.pca.state.mn.us/data/whats-my-neighborhood)**:** An online tool for searching information about contaminated sites and facilities all around Minnesota.
- UMN Extension **Manure Management in Minnesota** (www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.
- USDA & NRCS **Manure Management in Minnesota** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.
- MDH Contaminants of **Emerging Concern** (www.health.state.mn.us/communities/environment/risk/guidance/dwec/index.html): A program that investigates and communicates the health and exposure potential of contaminants of emerging concern (CECs) in drinking water.

Cropland Management

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

Existing Programs and Resources

- MDA **The Agricultural BMP Handbook for Minnesota** (www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- NRCS **Conservation Stewardship Program** (www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/csp/): A voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner.
- NRCS **Environmental Quality Incentives Program** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/programs/financial/eqip/): A program that provides financial and technical assistance to agricultural producers so they can implement structural and management conservation practices that optimize environmental benefits on working agricultural land.
- NRCS **Cover Crops** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/?cid=nrcs142p2_023671): Provides information, fact sheets, and tools about cover crops.
- NRCS **Soil Health** (https://www.nrcs.usda.gov/wps/portal/nrcs/main/mn/soils/health/): Provides information about the basics and benefits of soil health.
- **Midwest Cover Crop Council** (mccc.msu.edu/statesprovince/minnesota/): Provides resources to help with technical support and answer questions from a local perspective at no cost.
- MDA **Minnesota Agricultural Water Quality Certification Program** (www.mda.state.mn.us/awqcp): A voluntary program for farmers to implement conservation practices to protect water quality.

Education and Outreach

Educate landowners, private well users, and other stakeholders about how their actions impact groundwater quality and quantity. Provide information about potential health risks related to groundwater quality. Identify actions individuals, households, and partner agencies can take to sustain

groundwater and protect or improve drinking water quality. Some ideas include managing household hazardous waste, maintaining household septic systems, and household water conservation measures. For educational materials and programs related to a specific topic, go to the strategy about that topic. For example, go to 'nutrient management' to learn more about potential education opportunities regarding reducing nitrogen use. The list below provides some additional tools that may be helpful.

Existing Programs and Resources

- Metropolitan Council **Water Conservation Toolbox** (https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Guidance-Planning-Tools/Water-Conservation/Toolbox.aspx): Information about how residents and businesses, suppliers, learners, and communities can conserve water.
- Minnesota Rural Water Association **Source Water Protection Resources** (www.mrwa.com/sourcewater.html): Resources to help public water suppliers develop plans to use local community resources to protect drinking water quality.
- MPCA **Waste** (https://www.pca.state.mn.us/waste): Information about managing waste, recycling, composting, and preventing waste and pollution.
- MPCA **Manual for Turfgrass Maintenance with Reduced Environmental Impacts** (https://www.pca.state.mn.us/sites/default/files/p-tr1-04.pdf): Practical advice for those who manage turfgrass (golf courses and athletic fields excluded).
- MDH **Wells Laws and Rules** (www.health.state.mn.us/divs/eh/wells/rules/index.html): Minnesota State Well Code (MR 4725.0050 – 4725.7605).
- MDH **Wells and Borings—Well Management Program** (www.health.state.mn.us/divs/eh/wells/index.html): Information about proper well construction, maintenance, testing, and sealing.
- MDH **Wellowner's Handbook** (www.health.state.mn.us/communities/environment/water/docs/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/communities/environment/water/contaminants/arsenic.html): Information about arsenic in Minnesota.
- MDH **Water Treatment Units for Arsenic Reduction** (www.health.state.mn.us/communities/environment/water/docs/wells/waterquality/arsenictreat.pdf)
- MDA **Waste Pesticide Collection Program** (https://www.mda.state.mn.us/chemicals/spills/wastepesticides.aspx): Information about the safe disposal of unwanted and unusable pesticides from farms and area businesses.
- MPCA **Managing Unwanted Medications** (https://www.pca.state.mn.us/living-green/managing-unwanted-medications)**:** Information about the safe disposal of unwanted or unused medications from households.

Integrated Pest Management

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

Existing Programs and Resources

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

Irrigation Water Management

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

Existing Programs and Resources

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

Land Use Planning and Management

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

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

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

Existing Programs and Resources

- **Association of Minnesota Counties** (www.mncounties.org/): A voluntary, non-partisan statewide organization that helps provide effective county governance to Minnesotans. The Association works closely with the legislative and administrative branches of government in seeing that legislation and policies favorable to counties are enacted.
- DNR **Water Supply Plans** (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/eandc_plan.html)**:** Provides information about Minnesota public water supply plans.
- DNR **MPARS (MNDNR Permitting and Reporting System)** (www.dnr.state.mn.us/mpars/index.html): DNR is the permitting authority for high capacity water use.
- DNR **Sustainability of Minnesota's Groundwaters** (www.dnr.state.mn.us/waters/groundwater_section/sustainability/index.html): Resources to help promote the sustainable use of groundwater, including a statement of issues and needs, as well as factsheets.

- DNR **Water Conservation** (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/conservation.html): Provides tips and tools for promoting water conservation at home, public water supply systems, and other environments.
- **League of Minnesota Cities** (https://www.lmc.org): Promotes excellence in local government through effective advocacy, expert analysis, and trusted guidance for all Minnesota cities.
- MPCA **Condition Groundwater Monitoring** (https://www.pca.state.mn.us/water/condition-groundwater-monitoring).
- MPCA **Stormwater and Wellhead Protection** (stormwater.pca.state.mn.us/index.php/Stormwater_and_wellhead_protection): Guidance and recommendations for determining the appropriateness of infiltrating stormwater in a Drinking Water Supply Management Area.
- MPCA **Minnesota Stormwater Manual** (stormwater.pca.state.mn.us/index.php/Main_Page): A manual to help the everyday user better manage stormwater.
- MPCA **Enhancing Stormwater Management in Minnesota** (https://www.pca.state.mn.us/water/enhancing-stormwater-management-minnesota): Information about standards and tools for minimal impact designs for stormwater management.
- MPCA **Stormwater** (https://www.pca.state.mn.us/water/stormwater): MPCA regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems, construction activities, and industrial facilities.
- MDH **Source Water Protection** (www.health.state.mn.us/divs/eh/water/swp/): MDH works with communities to protect the source(s) of their drinking water.
- DNR and Minnesota Geological Survey **County Geologic Atlas Program** (www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html): Provides additional information on the groundwater resources and hydrogeology of the watershed through maps and reports of geology, groundwater, pollution sensitivity, and special studies.
- MPCA **Household Hazardous Waste** (www.pca.state.mn.us/waste/household-hazardous-waste-managers-and-operators): Resources for HHW managers and operators, education resources, searchable by county HHW facilities.
- MDH **Flood Precautions for Private Water Wells** (www.health.state.mn.us/communities/environment/water/wells/natural/floodprecautions.html)

Nutrient Management

This strategy addresses both nutrient and manure management.
Nutrient management concepts are centered on applying crop fertilizer or manure using the right source, right rate, right time, and right place (NRCS Codes 327, 340, 345, 393, 590, 656).
Manure management targets the collection, transportation, storage, processing, and disposal of animal manure.

Existing Programs and Resources

- MDA **Nutrient Management** (www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt.aspx). MDA is the lead state agency for all aspects of pesticide and fertilizer environmental and regulatory functions. This page provides information on nutrient management programs, reports, publications, factsheets, and related external sources.
- MDA **Nutrient Management Initiative Program in Minnesota** (www.mda.state.mn.us/nmi): The program assists farmers and crop advisers in evaluating alternative nutrient management practices for their fields.

- MDA **Township Testing Program** (www.mda.state.mn.us/townshiptesting): The program tests private wells for nitrate and pesticides in areas of the state with the greatest potential for nitrate and pesticide contamination.
- MDA **Nitrogen Fertilizer Best Management Practices** (www.mda.state.mn.us/nitrogenbmps): Provides nitrogen BMPs for various areas within Minnesota.
- MDA **Minnesota Nitrogen Fertilizer Management Plan** (www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan.aspx): The state's blueprint for preventing or minimizing impacts of nitrogen fertilizer on groundwater.
- MDA **Ag Chemicals & Fertilizers** (www.mda.state.mn.us/chemicals.aspx): Promotes proper use, handling, and safety of agriculture chemicals and fertilizers.
- MDA **Monitoring & Assessment for Agricultural Chemicals in the Environment** (www.mda.state.mn.us/chemicals/pesticides/maace.aspx): Information about agricultural chemical monitoring and assessment programs and additional resources.
- UMN Extension **Nutrient Management** (www.extension.umn.edu/agriculture/nutrient-management/): The page focuses on helping farmers and agriculture professionals optimize crop production using appropriate nutrient inputs while minimizing effects on the environment.
- UMN Extension **Best Management Practices for Nitrogen Use in Southeastern Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08557-southeastMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Best Management Practices for Nitrogen Use in South-Central Minnesota** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/docs/08554-southcentralMN.pdf): Information about best management practices for nitrogen application.
- UMN Extension **Nitrogen Application with Irrigation Water: Chemigation** (www.extension.umn.edu/agriculture/nutrient-management/nitrogen/nitrogen-application-with-irrigation-water-chemigation/): Information about risks, benefits, and methods.
- UMN Extension **Crop Calculators** (www.extension.umn.edu/agriculture/nutrient-management/crop-calculators/): Use crop calculators to help determine needed nutrients.
- UMN Extension **Nutrient/Lime Guidelines** (http://www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/). Guidelines for corn, fruit crops, vegetables crops, lawns, turf, gardens, soybeans, sugar beets, wheat, and more.
- NRCS **Nutrient Management Planning** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023693): Information about nutrient management policy and tools for developing nutrient management plans.
- MDA **The Agricultural BMP Handbook for Minnesota (PDF)** (www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf): A literature review of empirical research on the effectiveness of 30 conservation practices.
- Nutrient Stewardship **What are the 4Rs** (www.nutrientstewardship.com/4rs): Information about the 4Rs of Nutrient Stewardship.
- MPCA **Manure Management** (https://www.pca.state.mn.us/quick-links/feedlot-nutrient-and-manure-management): Resources such as fact sheets, guidelines, computer tools, and forms for feedlot nutrient and manure management.
- UMN Extension **Manure Management in Minnesota** (www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-management-basics/manure-management-in-minnesota/): Information about manure characteristics, application, and economics.

- USDA & NRCS **Manure Management in Minnesota** (www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/ecoscience/nutrient/?cid=nrcs142p2_023688): Basic manure management information.

SSTS Management

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

Existing Programs and Resources

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

Making Sense of the Regulatory Environment

State agencies and programs play a variety of roles in restoring and protecting groundwater. Understanding the groundwater-related authorities and resources available at the state level and leveraging strengths of local water resource professionals are key to implementing effective groundwater protection strategies. Figure 35 provides a very basic introduction into the roles Minnesota state agencies have for groundwater.

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

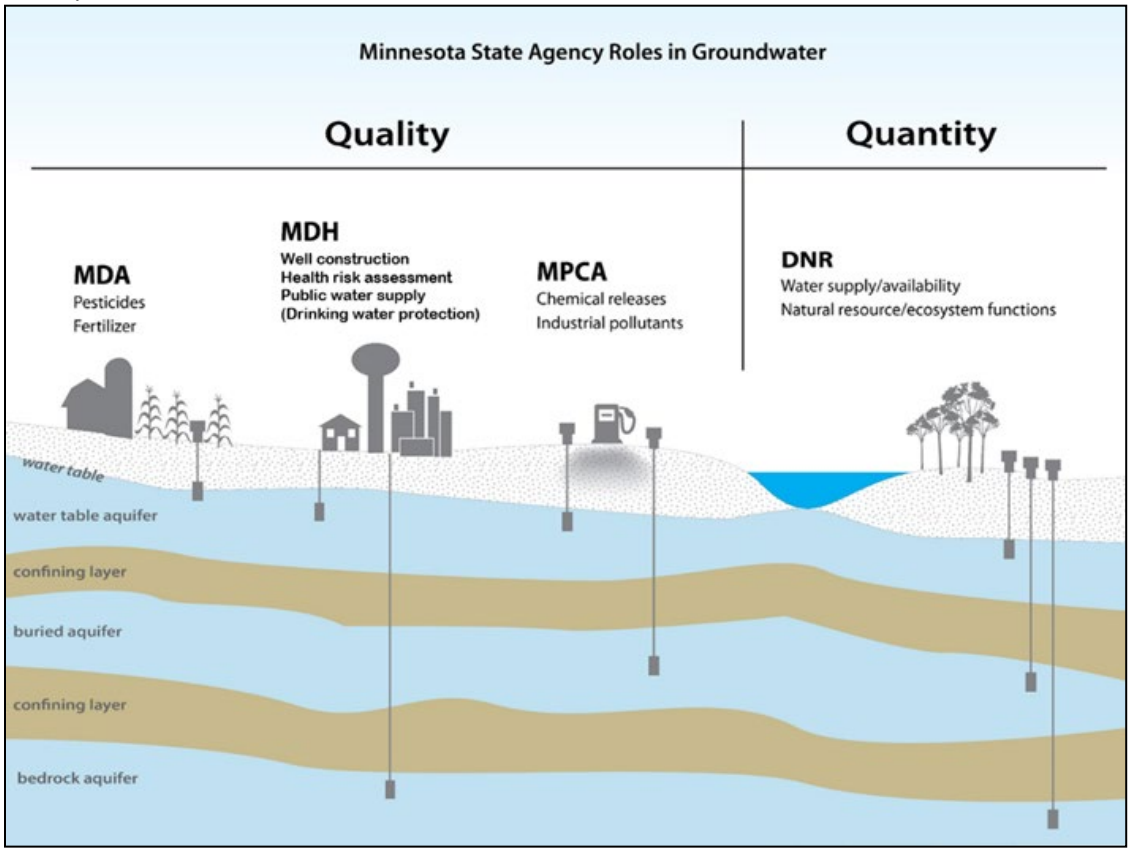


Figure 35: Minnesota State Agency Roles in Groundwater

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

Figure 35 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.

	Ongoing Implementation	Monitoring and Assessment	Watershed Characterization & Problem Investigation	Restoration and Protection Strategy Development	Comprehensive Watershed Management Plan
BWSR	Funding and technical assistance for locally implemented watershed restoration and protection projects	Monitor progress of local implementation goals	Conservation targeting tools (e.g.,. Environmental Benefits Index) BMP guidance (e.g., drainage water management)	Participate on interagency watershed teams developing WRAPS (with all agencies)	Comprehensive Watershed Management Planning (One Watershed, One Plan) Local water and watershed plans
MNDNR	Appropriations and Public Waters Permitting Shoreland and floodplain management Technical assistance for projects	Stream flow Fish and plants (lakes) Mercury in fish tissue Aquifer levels (with Met Council)	Stream hydrology and geomorphology (support MPCA) Small scale watershed modeling and groundwater level modeling County Geologic Atlas	Advise on conservation actions based on holistic view of watershed health (hydrology, geomorphology, connectivity, biology, water quality)	Input on local conservation actions informed by statewide plans for prairies, forests, etc. Water supply planning and groundwater management areas (with Met Council)
MDH	Funding for source water protection, contaminants of emerging concern Well sealing cost share	Source water and finished drinking water Bacteria monitoring on Lake Superior beaches	Guidance for contaminants of emerging concern Data analysis and modeling to support WHPA delineation and vulnerability assessments for public water supplies	Source water protection planning (identification of problems, issues, and opportunities) Well construction management	Guidance for infiltration in DWSMAs Source water protection planning (local measures and strategies)
PFA	Loans and grants for water infrastructure projects based on priorities set by MDH and PCA				
MPCA	NPDES permit programs, SSTS compliance Grants for Clean Water Partnership, Great Lakes Restoration, stormwater and wastewater treatment (PFA)	Water chemistry (surface and groundwater) Fish and macroinvertebrates (streams) Surface water assessment grants	Stressor Identification for biological impairments Watershed Modeling (8-HUC) TMDLs Civic engagement	Stakeholder agreement on broad watershed restoration and protection strategies (WRAPS) WRAPS report – includes implementation table TMDLs to EPA	Provide WRAPS for incorporation into local plans Input on management strategies informed by statewide nutrient plan
MDA	Ag BMP loans MN Agricultural Water Quality Certification Program Implement Pesticide and Nitrogen Fertilizer Management Plans	Pesticides in surface and groundwater Nitrate in groundwater	Research/evaluation on ag sources, practices and solutions Technical assistance on ag sources and practices, BMP demonstration/evaluation sites Stressor ID for pesticides	Ag practices and management options, nitrogen fertilizer and pesticide use Participate on interagency teams developing WRAPS Vegetative cover	Input on management strategies informed by pesticide and nitrogen fertilizer management plans
Metropolitan Council	Technical assistance and demonstration projects	Lake, stream, river monitoring: flow, chemistry, biology Effluent monitoring (WWTPs) Impervious surface and land cover assessments	Modeling and trend assessments (surface water) Pollutant load calculations Groundwater mapping and characterization	Participate in WRAPS and local water planning teams Master water supply plan Groundwater management areas (with DNR)	Participate in review of local water and watershed plans (metro area); local water supply plans; and comprehensive land use plans (metro area)

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

Appendices

List of Acronyms

BMP	Best Management Practices
BWSR	Board of Soil and Water Resources
CAFO	Concentrated Animal Feeding Operation
CRP	Conservation Reserve Program
DWSMA	Drinking Water Supply Management Area
EPA	United States Environmental Protection Agency
GRAPS	Groundwater Restoration and Protection Strategies
HUC	Hydrologic Unit Code
IPM	Integrated Pest Management
MCL	Maximum Contaminant Level
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MWI	Minnesota Well Index
NRCS	United States Department of Agriculture Natural Resources Conservation Service
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
PFA	Public Facilities Authority
QBAA	Quaternary Buried Artesian Aquifer
QWTA	Quaternary Water Table Aquifer
RIM	Reinvest in Minnesota Program
SSTS	Subsurface Sewage Treatment System
SDWA	Safe Drinking Water Act
SWCD	Soil and Water Conservation District
TTP	MDA Township Testing Program
UMN	University of Minnesota Extension
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WIMN	What's in My Neighborhood
WHP	Wellhead Protection
WHPAS	Wellhead Protection Areas
WRAPS	Watershed Restoration and Protection Strategy

Glossary of Key Terms

Aquifer

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

Aquifer Vulnerability

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

Community Public Water Supply System

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

Drinking Water Supply Management Area (DWSMA)

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

Groundwater recharge

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

Hydrologic Unit Code (HUC)

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

Maximum Contaminant Level (MCL)

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

Protection

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

Pollution Sensitivity

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

Public Water System

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

Restoration

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

Source (or Pollutant Source)

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

Source Water Protection

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

Transient Noncommunity System

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

Water Budget

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

Water Table

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

Wellhead Protection (WHP)

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

Wellhead Protection Area (WHPA)

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

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Additional Resources

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

Type of Information	Where you can get more information
Aquifer Vulnerability	For information on aquifer vulnerability ratings DWSMA, please contact MDH or the public water supplier in question. ▪ health.drinkingwater@state.mn.us ▪ 651-201-4700
Groundwater Quality Data	Find water-related monitoring data on Minnesota streams, lakes, wells, Superfund Program, closed landfills, other remediation sites, open landfills, data from MDA, MPCA, and USGS. ▪ Environmental Quality Information System (EQuIS) (https://www.pca.state.mn.us/quick-links/environmental-quality-information-system-equis) ▪ Environmental data (https://www.pca.state.mn.us/environmental-data) ▪ Groundwater (https://www.pca.state.mn.us/water/groundwater)
Drinking Water Annual Reports	MDH has issued a report regarding the state of drinking water in Minnesota each year since 1995. These reports provide test results, an overview on the role of the Department's drinking water program in monitoring and protecting drinking water, and an examination emerging issues. ▪ Drinking Water Protection Annual Reports (www.health.state.mn.us/divs/eh/water/com/dwar/)
DWSMA maps and Shapefiles	PDF maps and shape files of the DWSMAs can be downloaded from the MDH website. ▪ Source Water Assessments (www.health.state.mn.us/divs/eh/water/swp/swa/) ▪ Maps and Geospatial Data (www.health.state.mn.us/divs/eh/water/swp/maps/index.htm)
Point Source Pollution	Visit the following sites for more information on point source pollution: ▪ Nonpoint Source Pollution (oceanservice.noaa.gov/education/kits/pollution/03pointsource.html) ▪ Point Source Pollution (www.mncenter.org/point-source-pollution.html) ▪ Water Permits and Forms (https://www.pca.state.mn.us/water/water-permits-and-forms)
Well Construction and Use Data	Most of the construction and use data pertaining to wells in the state is housed in the Minnesota Well Index (MWI), an online database. All of the key data in the MWI is also available in spatial datasets, designed for use in geographic information systems (GIS). The Minnesota Geological Survey and MDH work together to maintain and update the data in the Index. MWI provides basic information, such as location, depth, geology, construction and static water level, for many wells and borings drilled in Minnesota. It by no means contains information for all the wells and borings and the absence of information about a well on a property does not mean there is no well on that property. ▪ Welcome to the **Minnesota Well Index (MWI)** (www.health.state.mn.us/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.

Type of Information	Where you can get more information
	▪ health.drinkingwater@state.mn.us ▪ 651-201-4700

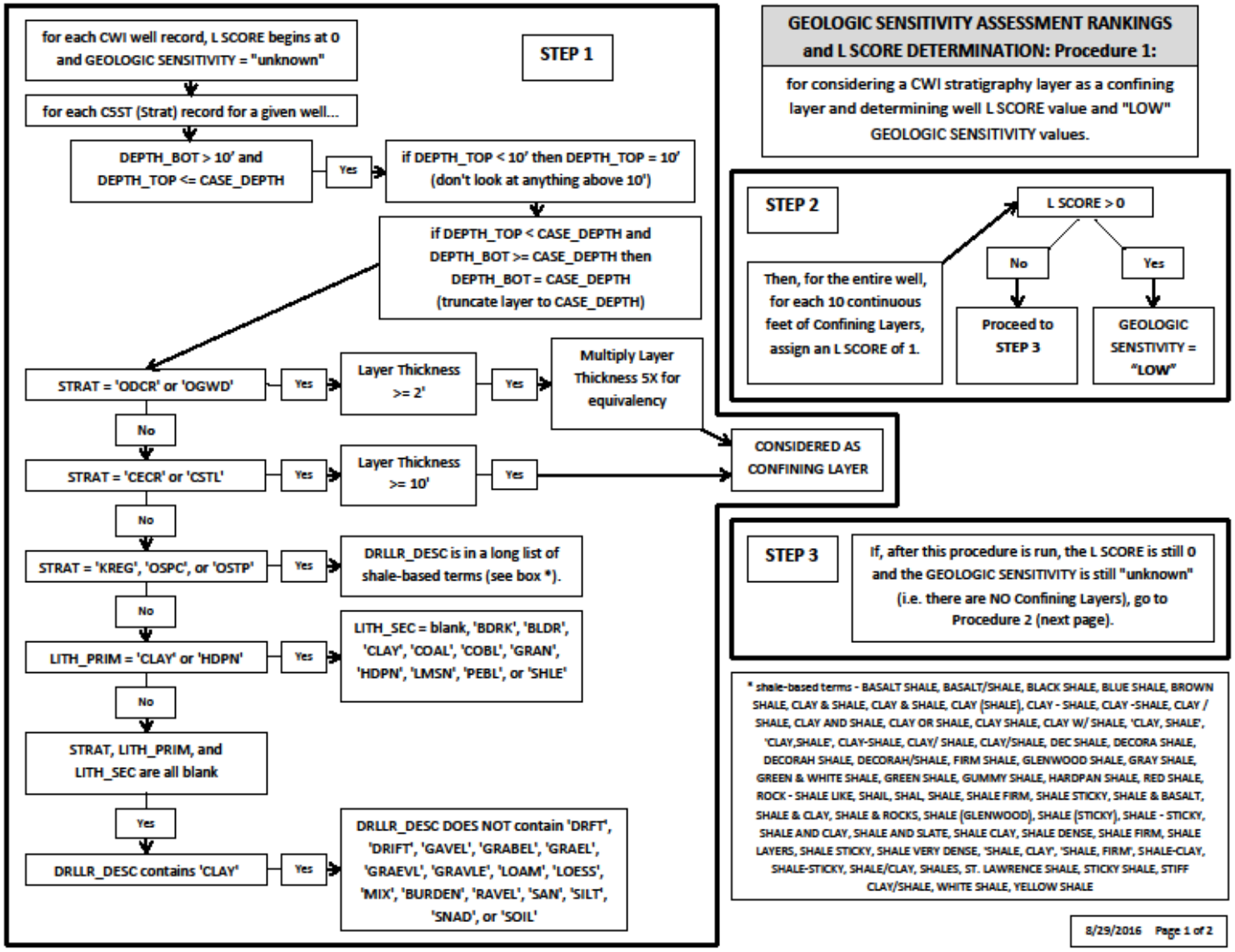

Figure 37: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9)

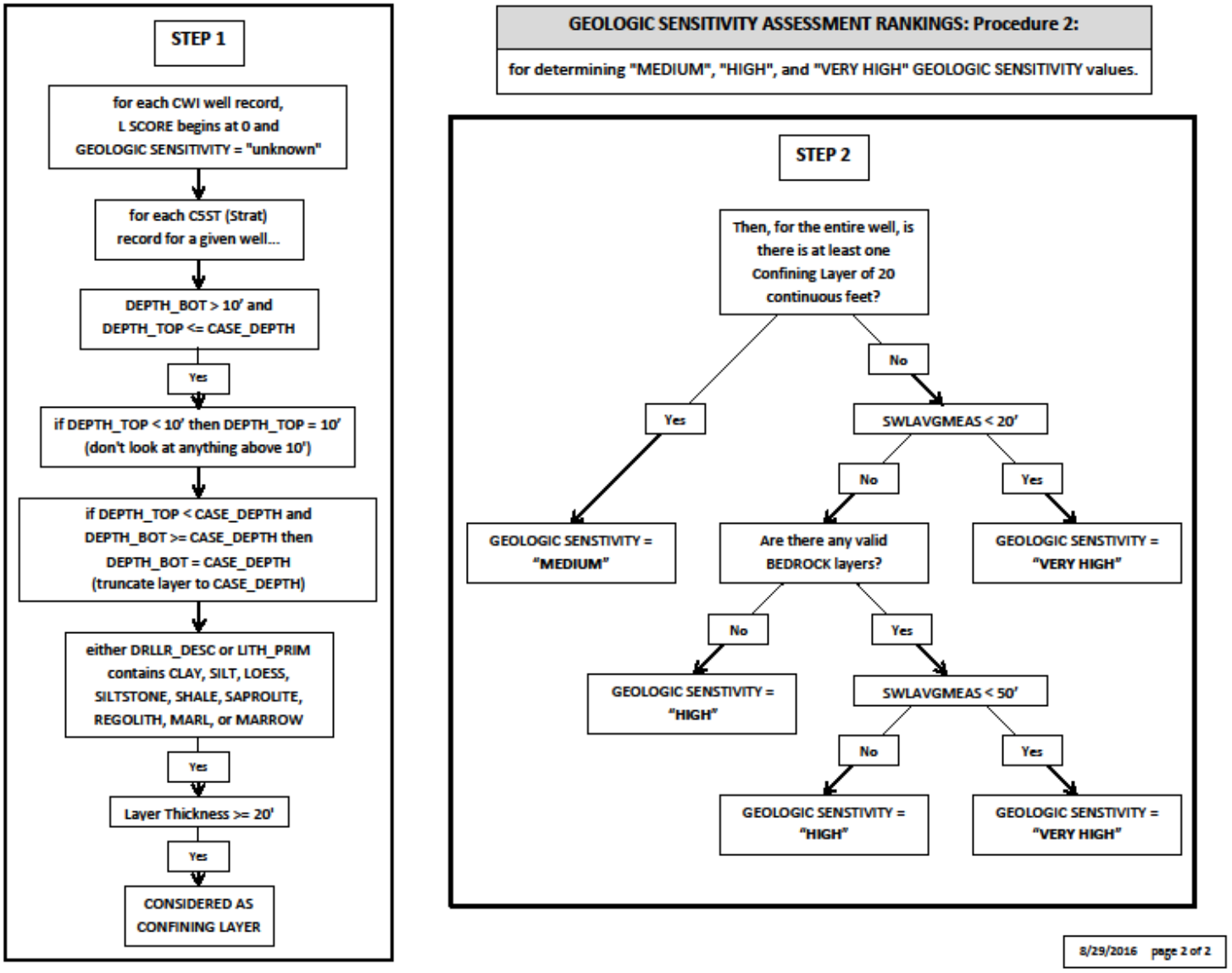

Figure 38: Sensitivity Assessment and Calculation for Pollution Sensitivity of Wells (Figure 9) continued

Table 12: Rare Species Connected with Groundwater in the Buffalo Red River Watershed[14]

Scientific Name	Common Name	Species Class	Listing Status[15]	AQUATIC (Y OR N)	WETLAND (Y OR N)	General Habitat Type
Rare Plant: Carex sterilis	Sterile Sedge	Semi-aquatic Graminoid	THR	N	Y	Calcareous fens that are mineral rich
Rare Plant: *Cladium mariscoides*	Twig-rush	Semi-aquatic Graminoid	SPC	N	Y	Fens: prairie rich, northern rich, and calcareous are preferred fen types
Rare Plant: Eleocharis quinqueflora	Few-flowered Spikerush	Semi-aquatic Graminoid	SPC	N	Y	Calcareous fens; mineral rich wetlands; sparsely vegetated wet graminoid fens, pond and lake shores
Rare Plant: *Fimbristylis puberula var. interior*	Hairy Fimbristylis	Semi-aquatic Graminoid	END	N	Y	Calcareous fens; small mineral-rich groundwater fed wetlands
Rare Plant: *Rhynchospora capillacea*	Hair-like Beak-rush	Semi-aquatic Graminoid	THR	N	Y	Calcareous fens; spring fens; groundwater maintained, mineral rich systems
Rare Plant: *Scleria verticillata*	Whorled Nut-rush	Semi-aquatic Graminoid	THR	N	Y	Cold, calcium-rich groundwater fed wetlands; margins of shallow pools in calcareous fens
Rare Plant: *Cypripedium candidum*	Small White Lady's-slipper	Semi-aquatic Flower	SPC	N	Y	Occurs in Calcareous fens, which are groundwater dependent
Rare Amphibians: *Anaxyrus cognatus*	Great Plains Toad	Amphibian	SPC; SGCN	Y	Y	Flooded fields, temporary and semi-permanent wetlands provide breeding sites.
Rare Reptiles: *Heterodon nasicus*	Plains Hog-nosed Snake	Snake	SPC; SGCN	N	Y	Dry prairie with adjacent wetlands where amphibians may be foraged; may need wetlands for overwintering

[14] Last Updated 01/17/2019

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

Scientific Name	Common Name	Species Class	Listing Status[15]	AQUATIC (Y OR N)	WETLAND (Y OR N)	General Habitat Type
Rare Bird: *Coturnicops noveboracensis*	Yellow Rail	Bird	SPC; SGCN	N	Y	Dependent on open rich fens, wet meadow, and wet prairie; requires very narrow range of water depth (~2-10 cm)
Rare Bird: *Phalaropus tricolor*	Wilson's Phalarope	Bird	THR; SGCN	N	Y	Wet prairie or rich fen habitats; grass or sedge-dominated wetlands; requires very shallow water associated with these open, wet habitats
Rare Mussel: *Lasimigona compressa*	Creek Heelsplitter	Mussel	SPC; SGCN	Y	N	Mostly in headwaters. Populations are susceptible to lower water table or decline groundwater input that affect stream permanence. Creeks, small rivers, and the upstream portions of large rivers with sand, fine gravel, or mud substrates.

Tables 13-16[16] show the documented wetland native plant communities connected to groundwater in the Buffalo Red River Watershed.

Table 13: Buffalo Red River Watershed – Documented wetland native plant communities dependent on sustained groundwater discharge

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank[17]
Fens and Seepage Wetlands		
OPp91	Prairie Rich Fen	S3
OPp93a	Calcareous Fen (Northwestern)	S2
WMs83a	Seepage Meadow/Carr	S3

Table 14: Buffalo Red River Watershed documented wetland native plant communities dependent on groundwater associated with consistently high water tables

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
FPn82	Northern Rich Tamarack Swamp (Western Basin)	S4/S5

[16] Updated 01/17/2019

[17] S1=Critically Imperiled; S2=Imperiled; S3=Vulnerable to Extirpation; S4=Apparently Secure; Uncommon but not Rare; S5=Secure, Common, Widespread, and Abundant

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
FPn82b	Extremely Rich Tamarack Swamp	S4
WFn55	Northern Wet Ash Swamp	S3/S4
WFn55b	Black Ash - Yellow Birch - Red Maple - Basswood Swamp (Eastcentral)	S3
WFn64	Northern Very Wet Ash Swamp	S4
Shrub Swamps		
OPn81	Northern Shrub Shore Fen	S5
OPn81a	Bog birch – Alder Shore Fen	S5
FPn73a	Alder – (Maple – Loosestrife) Swamp	S5
Wet Meadow/Shrub Carr Wetlands		
OPn92a	Graminoid Rich Fen (Basin)	S4
OPn92b	Graminoid – Sphagnum Rich Fen (Basin)	S4
Peatland/Bog		
APn91a	Low Shrub Poor Fen	S5
APn91b	Graminoid Poor Fen (Basin)	S3
Marshes		
MRn83	Northern Mixed Cattail Marsh	S2
MRn83b	Cattail Marsh (Northern)	S2
MRn93	Northern Bulrush – Spikerush Marsh	S2/S3
MRp83a	Cattail – Sedge Marsh (Prairie)	S1
MRp83b	Cattail Marsh (Prairie)	S1

Table 15: Buffalo Red River Watershed documented wetland native plant communities dependent on groundwater associated with water tables that are high for some portion of the growing season

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
Forested Wetlands		
FFn57	Northern Terrace Forest	S3
FFn57a	Black Ash – Silver Maple Terrace Forest	S3
Wet Meadow/Shrub Carr Wetlands		

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
WMn82	Northern Wet Meadow/Carr	S4/S5
WMn82a	Willow - Dogwood Shrub Swamp	S5
WMn82b	Sedge Meadow	S4/S5
Wet Prairies		
WPn53	Northern Wet Prairie	S2/S3
WPn53a	Wet Seepage Prairie (Northern)	S2
WPn53b	Wet Brush-Prairie (Northern)	S3
WPn53c	Wet Prairie (Northern)	S3
WPn53d	Wet Saline Prairie (Northern)	S2
WPs54b	Wet Prairie (Southern)	S2

Table 16: Buffalo Red River Watershed wetland native plant communities not highly dependent on groundwater

Native Plant Community Code	Native Plant Community Name	Conservation Status Rank
WMs92a	Basin Meadow/Carr	S2
APn81b	Poor Tamarack – Black Sprue Swamp	S4

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