# Executive Summary

# Ambient Groundwater Quality Study 1999-2019

### Dakota County, Minnesota

### Private Well Drinking Water Quality in Three Principal Drinking Water Aquifers:

### Prairie du Chien, Jordan and Unconsolidated Sediments

September 2020

## Introduction

More than 90 percent of Dakota County residents rely on groundwater for their water supply, whether it comes from a public water supplier or from a private drinking water well. Groundwater is the water found in pore spaces and cracks in soil and bedrock at various depths in aquifers below the ground surface. Aquifers store and transmit water. Water is pumped from water wells to homes and businesses for drinking and other uses.

Dakota County residents expect an abundance of clean water for drinking, however, the three principal drinking water aquifers in the county – the unconsolidated sediments, Prairie du Chien and the Jordan Aquifers (in order of depth) – are vulnerable to contamination and have been impacted by contaminants from both human activities and naturally-occurring, geologically sourced chemicals.

The Dakota County Ambient Groundwater Quality Study (Ambient Study or study) began in 1999 to establish a baseline of water quality conditions to which ongoing conditions could be compared over a 20-year period. The term “ambient groundwater” refers to the parts of the water resource that are affected by the general, routine use of chemicals and are not affected by localized pollutants or spills (MPCA, July 2019). The study evaluated groundwater conditions in wells across the County that were selected to represent all three principal drinking water aquifers, in a variety of land-use, soil, and geological settings. The objectives developed were to:

- Determine groundwater quality in private drinking water wells selected to be representative of conditions across the County,
- Determine changes in contaminants of health and environmental concern in drinking water aquifers over time,
- Determine influence of land use, chemical use, geology and water well construction on groundwater quality,
- Develop recommendations to improve drinking water quality,
- Gather information needed to assist with policy decisions.

Sampling a total of 77 private wells multiple times enabled the County to monitor long-term trends in groundwater contamination from human (anthropogenic) sources and activities, such as nitrogen fertilizer and herbicides commonly used on corn crops, and chloride from salt applied to roads for deicing, potassium fertilizer (potash) and water softeners. The well owners consented to the sampling and were provided an explanation of their results. The study also enabled the County to identify where the groundwater contains naturally- occurring contaminants, such as manganese or arsenic, and to monitor the County’s groundwater for industrial chemicals and Contaminants of Emerging Concern, such as per- and polyfluoroalkyl substances (aka PFCs, PFAS, or 3M chemicals), medications, personal care products, household products such as cleaners, and ingredients related to manufacturing.

This report summarizes the data collected from 1999 through 2019 and includes data from other sampling events and studies that occurred in the County, including the Hastings Area Nitrate Study (HANS), the MN Department of Agriculture's (MDA) Township Testing Program, the Wells and Increased Infant Sensitivity and Exposure Study (WIISE), and the Burnsville, Greenvale and Lakeville Focused Community Private Well Sampling.

In Minnesota, the Dakota County Ambient Groundwater Quality Study is a unique reference resource. While other studies may provide snapshots of water quality at a single point in time, the Ambient Study provides a chronicle of private drinking water well quality over 20 years. The Dakota County Ambient Study includes one of the most comprehensive sets of data about agricultural herbicides in private wells in the State.

## Key Findings

1. **Contaminant levels exceed health guidelines for both naturally occurring and anthropogenic chemicals in the principal aquifers used for drinking water.** Over the course of the study, sixty-two percent of the sampled wells contained concentrations of at least one chemical contaminant exceeding current Minnesota Department of Health (MDH) drinking water guidelines. Drinking water guidelines do not exist for every contaminant detected. Some wells had multiple chemicals detected that exceed a guideline. Anthropogenic compounds are largely detected in the central and eastern portion of the County where row crop agriculture is the dominant land use. For example, 38 percent of the wells in the study exceed the drinking water guidelines for nitrate as nitrogen (nitrate) or the discontinued herbicide cyanazine. Cyanazine was a weed killer used primarily on corn and soybean crops. The percent of wells that exceed an established drinking water guideline for a chemical are:

| Chemical | Percent of Wells Exceeding Drinking Water Guideline At Least Once between 1999-2019 |
|---|---|
| Manganese | 34 percent of wells sampled exceed the guideline of 0.100 mg/L (milligrams per liter or parts per million) |
| Nitrate | 31 percent exceed the guideline of 10 mg/L |
| Cyanazine breakdown products | 22 percent exceed the guideline of 1 µg/L (micrograms per liter or parts per billion) |
| Gross Alpha | 3 percent exceed the guideline of 15 pCi/L (picocuries per liter) |

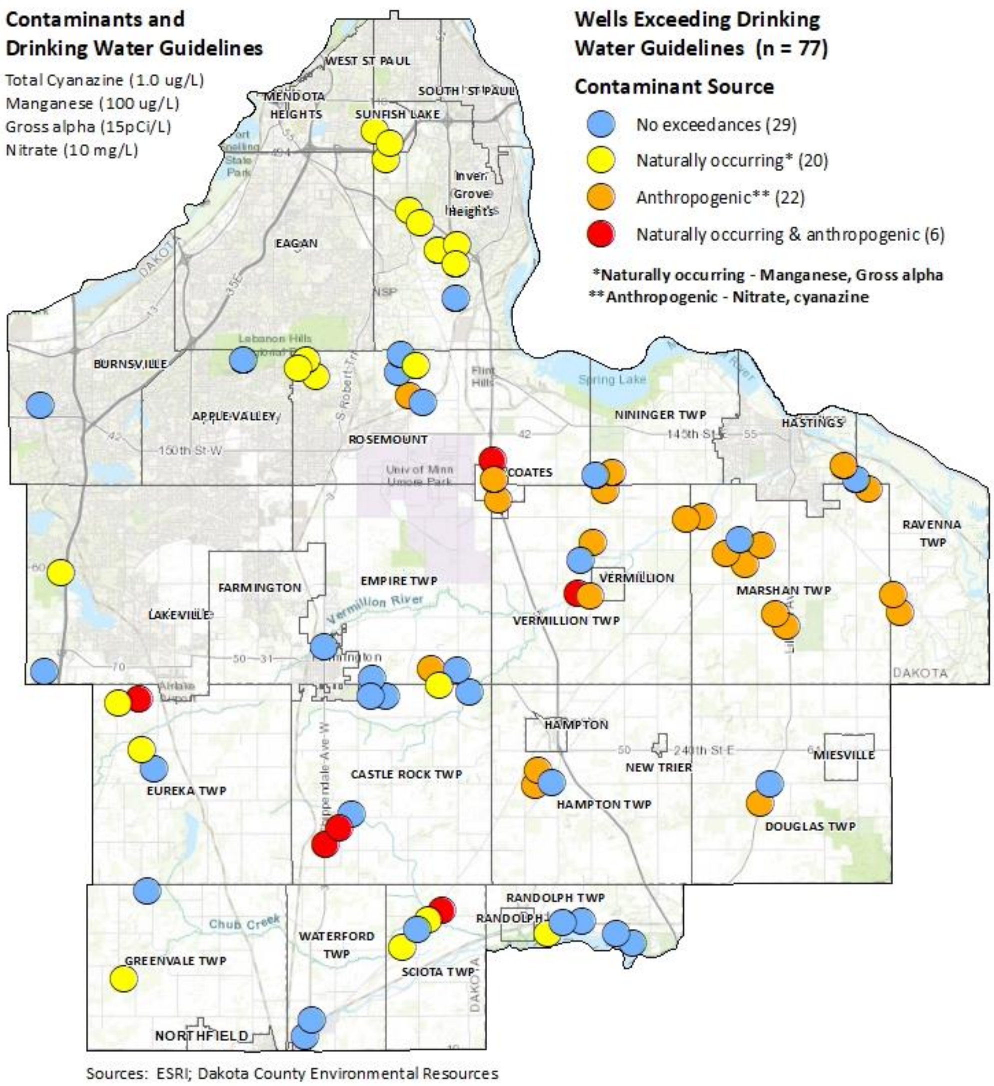


**Figure 1. Ambient Study Wells That Exceed Drinking Water Guidelines.**

2. **The occurrence and concentrations of anthropogenic contaminants in groundwater reflect land use and the depth of the specific well (Sections 4.1.4, 4.2.3, and 4.3.4).** Nitrate and herbicide levels are higher where row crop agriculture is the dominant land use, whereas chloride levels are highest in urbanized areas where the application of road salt for deicing and water softener use is widespread. Median nitrate and chloride concentrations are higher in shallow wells than in deeper wells. Concentrations of substances related to human activity, e.g., nitrate, chloride, sodium and herbicides, all generally decrease with well depth.

3. **Nitrate is the most commonly detected anthropogenic contaminant exceeding the drinking water guideline (Section 4.1.2).**

- Maximum nitrate results range from non-detect (less than (<) 0.2 mg/L) to 30.6 mg/L
- 31 percent of wells have exceeded the drinking water guideline of 10 mg/L at least once
- 23 percent of wells average (mean) nitrate exceeded 10 mg/L
- 21 percent of wells median nitrate exceeded 10 mg/L

4. **There are more wells with an upward trend for nitrate than a downward trend. (Section 4.1.3).** Summary of nitrate trends in the 77 study wells:

   - 17 percent of wells have a statistically significant upward trend
   - 4 percent of wells have a statistically significant downward trend
   - 79 percent of wells have stable nitrate levels; 14 percent of wells are stable above 10 mg/L

5. **In the central and eastern portions of Dakota County where row crop agriculture is the dominant land use, average nitrate levels of study wells exceed 10 mg/L and are increasing (Sections 4.1.3).** Wells in eastern, rural Dakota County, in the cities of Coates and Hastings and the townships of Douglas, Hampton, Marshan, Nininger, Ravenna and Vermillion have among the highest levels of nitrate observed in the study. The nitrate result in these wells is, on average, five times higher than the study wells located outside of this area. Seventy percent of these wells exceed the drinking water guideline of 10 mg/L and seventy-seven percent of wells with upward trends for nitrate are located in this area.

6. **The breakdown products of herbicides commonly applied to corn and soybean crops are the most frequently detected pesticides and are found in more than 70 percent of the wells tested (Section 4.2.2). Most herbicides concentrations are below the applicable drinking water guidelines except for the herbicide cyanazine.** The occurrence, concentrations, mobility and persistence of herbicides in groundwater is an important finding of this study. Herbicide compounds were detected in 73 percent of the wells. The herbicides and their breakdown products considered to be “in common detection” by the Minnesota Department of Agriculture (MDA) are the most widely detected — alachlor (73 percent of wells), metolachlor (65 percent of wells), atrazine (64 percent of wells) and acetochlor (56 percent of wells). Cyanazine is not in common detection status.

7. **The production and use of the herbicide cyanazine, common brand name Bladex, was discontinued in 2002; its breakdown products are still detected in 2019, in Ambient Study wells at levels that exceed the drinking water guideline (Section 4.2.7).** Breakdown products of cyanazine, a widely used corn herbicide discontinued in 2002, are found in 65 percent of the wells. Over the period of the study, the total concentration of cyanazine breakdown products <u>exceeded</u> the drinking water guideline of one microgram per liter (µg/L) at least once in 22 percent of the wells. The occurrence and frequency of detection, along with the concentration levels and trends, indicate that cyanazine contamination is moving deeper with time.

8. **Herbicide compound detections generally occur as mixtures with each other and with nitrate, and higher levels of nitrate are accompanied by an increase in the number of herbicide compounds. (Section 4.2.4).** Nitrate concentrations were positively correlated

with both the number and concentrations of herbicide breakdown products detected, indicating row crop agriculture as the contaminant source.

- 86 percent of the wells contained at least one herbicide compound. Fourteen percent had no herbicides.
- 71 percent of the wells contained two or more herbicide compounds
- 64 percent of the wells contained five or more herbicide compounds
- 10 percent of the wells had 20 or more compounds detected at least once over the sampling period.
- Over the period of the study a median of 15 different herbicide compounds were found in study wells with a median nitrate concentration greater than 3.0 mg/L
- 54 percent of the wells that exceeded the drinking water guideline for nitrate also exceeded the drinking water guideline for cyanazine

9. **Pesticides are detected in municipal wells in both the 2005-2006 and 2019 sample events (Section 4.2.8).** Total cyanazine was above the 2005 drinking water guideline in one City of Hastings municipal well in 2005. Pesticides were detected in 46 percent (13 of 28 wells) in 2005 and in 62 percent (8 of 13 wells) in 2019. Zero municipal wells exceeded guidelines in 2019.

10. **Manganese, a naturally occurring, geologically sourced contaminant, was detected above the drinking water guideline in 34 percent of the wells (Section 5.1.1).** One-third of the wells exceeded the drinking water guideline of 0.100 mg/L established for infants less than one year of age; 19 percent exceeded the drinking water guideline of 0.300 mg/L established for children older than 12 months and adults. Manganese does not correlate with aquifer, well casing depth or land use.

11. **Arsenic, another naturally occurring, geologically sourced contaminant, was detected in 39 percent of the wells, none over the drinking water guideline (5.1.2).** The maximum arsenic detected was 9.9 µg/L, the drinking water guideline is 10 is µg/L. Arsenic was detected in 31 percent of the study wells; no amount of arsenic is considered safe. Arsenic is positively correlated with manganese and iron..

12. **All three primary drinking water aquifers and well casing depth categories are susceptible to contamination (Section 3.2).** Anthropogenic contamination is found in all the aquifers tested; however, the recently recharged water present in the upper aquifers (unconsolidated sediments and Prairie du Chien) has the highest levels of these contaminants. The unconsolidated sediments and Prairie du Chien aquifers do not show statistical differences for any of the anthropogenic constituents: in these two aquifers, the levels of nitrate, chloride and herbicide breakdown compounds are similar and suggest that surface contaminants, largely introduced beginning in the 1950s, have migrated to a depth of approximately 330 feet. These contaminants are now at, or approaching, an approximate steady state or equilibrium with ongoing contamination from the surface. The study found that the well casing depth is a better indicator of vulnerability to surface contamination than is the aquifer in which a well is completed.

The Jordan aquifer does show statistically lower concentrations for all the anthropogenic constituents than either the unconsolidated or the Prairie du Chien aquifers because the Jordan is deeper and is below the Prairie du Chien. Where the bottom of the Prairie du Chien is confining, it can protect the Jordan by slowing the migration of contaminants to the Jordan where the water is older except in the few areas where groundwater is upwelling to the surface or the Prairie du Chien is absent. However, even the Jordan aquifer is susceptible to human use of nitrate; 25 percent of the wells in the Jordan and 24 percent in the deep well casing category have nitrate above 3.0 mg/L.

13. **Anthropogenic contaminants of emerging concern (CECs) are widespread at low levels (Section 4.9).** CECs, including per- and polyfluoroalkyl substances (PFAS), were detected in 79 percent of the wells, organic wastewater compounds were detected in 29 percent of the wells and pharmaceuticals were detected in 20 percent of the wells. The detections were below drinking water guidelines, where guidelines are established. Their presence, however, serves as an indicator of the susceptibility of the aquifers to surface contamination from diverse sources and the quick travel time from the surface to the water table. The health effects of consuming water with multiple contaminants are unknown.

**Summary of Anthropogenic Parameters in Ambient Study Wells detected above the laboratory method reporting level:**

- 97 percent contained chloride
- 83 percent contained nitrate
- 79 percent contained PFAS
- 73 percent contained herbicides
- 29 percent contained organic wastewater compounds
- 20 percent contained pharmaceuticals

14. **The age of well water and vertical recharge rates can be estimated using herbicide, nitrate and chloride results over time (Section 4.3.8).** The registration dates of herbicides and the timeframe for the widespread use of synthetic fertilizers and deicing salt are approximately known, which allows for an introduction year to be assigned to these substances. Analyzing data for herbicides, nitrate, sodium and chloride provides a method of estimating vertical recharge rates for the County's drinking water aquifers. These estimates can help with estimating when changes in land use practices at the surface will result in changes in the groundwater. The water in some of the study wells was a young as 8 years old.

    Figure 2 depicts the generalized flow of water and potential contamination from the land surface through the underlying material and aquifers to a well. The depth of a well is an important factor since, in general, deeper water is older and cleaner. When a chemical is applied to the land surface, it infiltrates through the aquifers to greater depths reaching deeper wells over time. The age of the water is the time between when the water infiltrated at the surface and when the water sample was collected from the well.

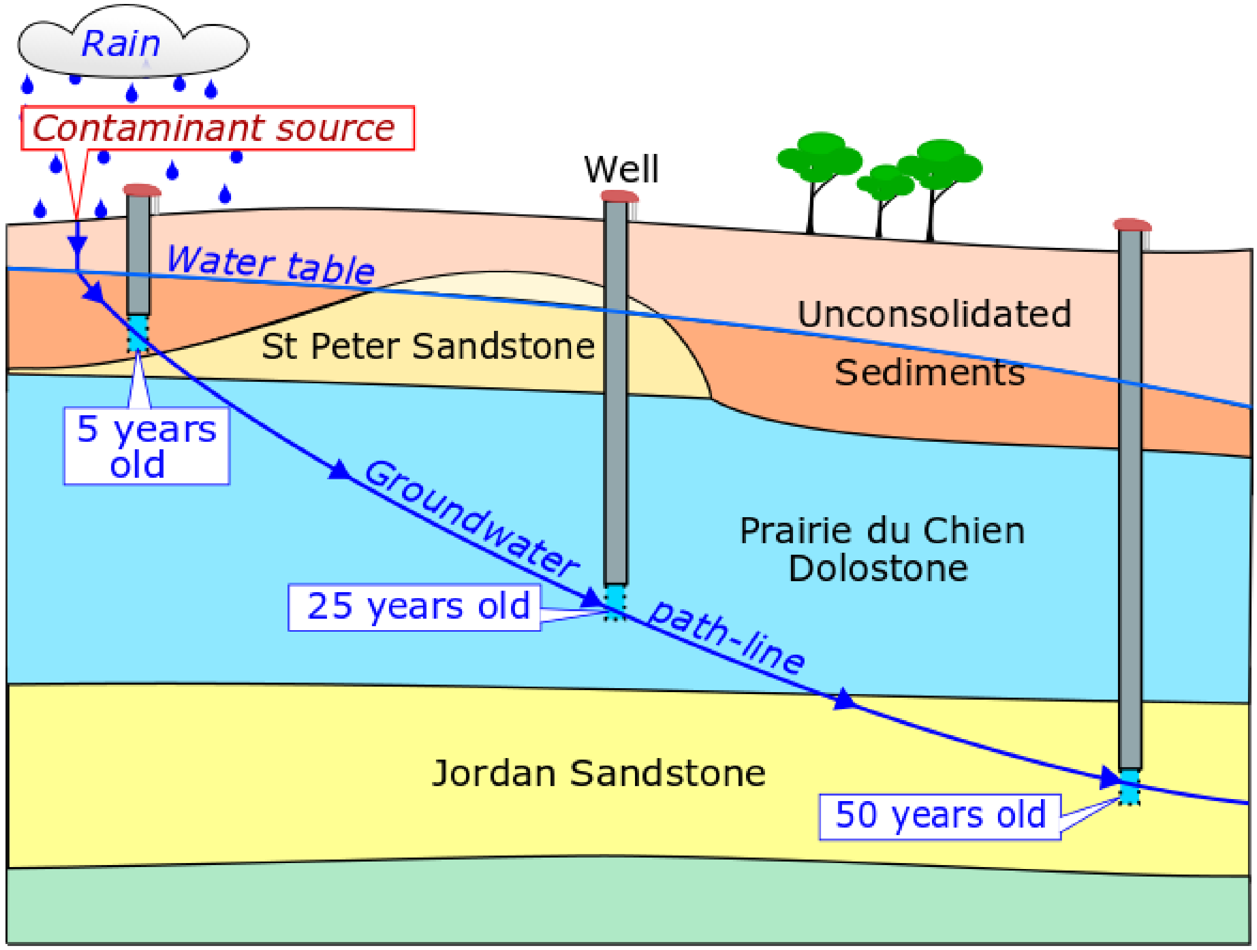


**Figure 2. Geologic Cross-Section and Simplified Contaminant Path to Wells.**

## Conclusions

The Ambient Study found that both anthropogenic and natural, geologically sourced contaminants are widespread in the drinking water aquifers: 62 percent of the wells tested exceed the drinking water guideline for one or more contaminants. Anthropogenic contaminants are persistent and moving deeper into the aquifers over time; with these contaminants, land use and well casing depth are the most important factors. By contrast, naturally occurring, geologically sourced contaminants—in particular, manganese—are widespread but difficult to predict.

Based on the County's groundwater conditions, drilling a deeper well to find "cleaner" water is a poor long-term strategy for a private well owner: anthropogenic contaminants like nitrate, herbicides, or chloride are migrating deeper, so a deeper well will be a temporary fix, and elevated manganese or other naturally-occurring contaminants may be found at any well depth. Better options are to prevent groundwater contamination wherever possible and to use appropriate water treatment where the groundwater is already contaminated.

While land use improvements limiting surface pollution sources may take decades to be fully effective, the sooner they are started, the sooner improvements will be seen. Land use changes implemented today to improve water quality will affect shallow wells first and deeper wells more slowly.

The Ambient Study has proved to be a useful framework to have in place for surveying the County's drinking water aquifers when CECs have been identified. Because of the existing Ambient Study well network, the County was able to conduct widespread sampling for PFAS, organic wastewater components, and pharmaceuticals when these became concerns. Vigilance and awareness are called for as new chemicals are introduced to the environment and new laboratory water testing capabilities make it feasible to detect more contaminants at very low levels.

Whether the contaminants are anthropogenic, naturally occurring, or newly identified, the Ambient Study provides a solid basis for well owner education and outreach, and a baseline of groundwater data for comparison as groundwater conditions change in the future.

## Recommendations

### Assistance and Education

- Increase and improve education and outreach efforts. Develop, implement, and update groundwater contamination maps, develop explanatory factsheets and other information on the County website to help inform private well owners and municipalities.
- To the extent appropriate and possible, collect demographic data to evaluate if water quality problems disproportionately impact specific populations and to address those inequities.
- Develop and implement a sampling schedule that will provide every well owner in the County the opportunity to have their well tested for nitrate, arsenic, manganese, lead and chloride and will also support the Agriculture Chemical Reduction Effort (ACRE) implementation. See the Dakota County Groundwater Plan for a description of the ACRE plan (to be published in fall of 2020).
- Communicate water test results and health risk.
- Ensure information for well owners is available in multiple languages and accessible formats.
- Develop a program promoting the installation and maintenance of household treatment systems (RO) where groundwater contaminants are elevated or exceed drinking water guidance.
- Develop opportunities to work with State and County public health departments to inform local health care providers on the existence and risks associated with elevated nitrate, manganese, arsenic and herbicide concentrations in private water supply wells.
- Support feasibility studies to determine if a rural water supply system or expansion of public water systems are practical.

### Agricultural Chemicals

- Work with MDA to ensure private well sampling schedules support implementation of the Groundwater Protection Rule and Nitrogen Fertilizer Management Plan.

- Partner with MDA to develop a long-term groundwater monitoring network to evaluate effectiveness of the Groundwater Protection Rule, the Nitrogen Fertilizer Management Plan and the Dakota County Agriculture Chemical Reduction Effort.
- Work with MDA and MDH to implement their response to cyanazine breakdown product contamination in Dakota County.

### Contaminants of Emerging Concern

- Work with MPCA to evaluate the source(s) of PFAS in groundwater beginning with an analysis of PFAS near WWTP biosolid application sites in Dakota County.
- When new CECs are identified that could be a risk for County residents, sample private wells to screen the County's drinking water supplies for detections and concentrations of the contaminant.

### Research and Analysis

- Work with state agencies, watershed organizations and others to further research groundwater and surface water interactions.
- Conduct research and analysis to determine the influence of irrigated agriculture on groundwater contaminated with nitrate and pesticides.
- Work with MDA, MDH and the City of Hastings to evaluate the threat to Hastings water supply for non-point agricultural chemicals. Expand sampling within the buried bedrock valley to better understand infiltration and groundwater flow.
- Retain a researcher to conduct an epidemiological analysis that would assess agricultural chemical contamination of drinking water (e.g., complex agricultural chemical mixtures) with health outcomes among Dakota County residents.
- Develop and implement a project to sample private wells for pathogens (viruses, bacteria and protozoan parasites), which MDH detected in 70 percent of non-community and community wells, statewide, as part of their recent pathogen study (MDH Pathogen Project).
- Evaluate impact of land application of sewage sludge and other biosolids on County groundwater quality.
    - Review published literature to identify characteristics of groundwater impacted by land application of sludge and biosolids vs. groundwater not impacted.
    - Identify known locations of sludge, biosolids, and manure applications.
    - With well owner permission, sample potentially impacted and presumably non-impacted wells for pathogens, PFAS, microplastics and organic wastewater compounds.