



INITIAL TOWNSHIP TESTING OF NITRATE
IN PRIVATE WELLS
MORRISON COUNTY 2013 SUMMARY

April 2015

Minnesota Department of Agriculture
Pesticide and Fertilizer Management Division

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EXECUTIVE SUMMARY

In 2013, six townships in Morrison County were selected for nitrate sampling as a pilot project. Results from five of the townships showed that 10 percent of samples were at or greater than the 10 mg/L drinking water standard for nitrate. Results from Agram township showed that 52 percent of sampled wells were at or greater than 10 mg/L and results from Belle Prairie township showed that 18 percent were at or greater than 10 mg/L. Whereas, results from Bellevue, Buh, Culdrum and Swan River townships showed between 11-12 percent of sampled wells were at or greater than 10 mg/L.

Future work that will be considered by the Minnesota Department of Agriculture (MDA) includes the following: 1) resampling wells that had high nitrate results (greater than or equal to 5 mg/L) to verify high nitrate levels; 2) performing well site visits, when possible, to rule out well construction issues and obvious point sources of nitrate, such as septic systems, livestock, etc.; and 3) increasing efforts to obtain well log information for participating wells so that nitrate results and the aquifer designation can be compared in a more comprehensive fashion.

This pilot project conducted in Morrison County will be used to guide future work as the MDA plans to offer nitrate tests to approximately 70,000 private well owners within approximately 250 to 280 townships, between 2013 and 2019. The actual number of townships may vary based on detailed county specific information. As of April 2014, 22 townships in four counties are completed.

INTRODUCTION

The MDA is currently updating the 1990 Nitrogen Fertilizer Management Plan (NFMP). The NFMP is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. One of the goals of the NFMP is to minimize or mitigate the source of pollution from nitrogen fertilizer. Updating the NFMP provides an opportunity to restructure the County's and the State's strategies for reducing nitrate contamination of water resources, with more specific, localized accountability for nitrate contamination associated with row crop agricultural production.

To effectively manage nitrate contamination of water resources it is appropriate to focus on areas of greatest risk. Testing of water from private wells for nitrate is one method for identifying areas and wells at greatest risk. For this, the MDA has developed the "Township Testing Program". In the Township Testing Program the MDA works with local partners (counties and Soil and Water Conservation Districts) to collect and analyze water samples from private drinking water wells within townships that either had high nitrate results previously or exist in an area with high aquifer vulnerability and a high percentage of row crop production.

BACKGROUND

In many rural areas of the state, nitrate is one of the most common contaminants in Minnesota's groundwater, and in some areas of the state (e.g., the Central Sands which is a 14 county area in central Minnesota), a significant number of wells have high nitrate levels.

Nitrate is a naturally occurring, water soluble molecule that is made up of nitrogen and oxygen. Although nitrate occurs naturally, it can also originate from man-made sources such as fertilizer, animal manure and human waste. Nitrate is a concern because it can have a negative effect on human health at elevated levels. The U.S. Environmental Protection Agency (USEPA) has established a drinking water Maximum Contaminant Level (MCL) of 10 mg/L for nitrate as nitrogen (U.S. EPA, 2009) in municipal water systems. The Minnesota Department of Health (MDH) has also established a Health Risk Limit (HRL) of 10 mg/L for private drinking water wells in Minnesota.

Nitrogen present in groundwater can be found in the forms of nitrite and nitrate. Nitrite concentration is commonly less than the reporting level of 0.01 mg/L, resulting in negligible contribution to the nitrate plus nitrite concentration (Nolan and Stoner, 2000). In the environment, nitrite generally converts to nitrate, which means nitrite occurs very rarely in groundwater. Measurements of nitrate plus nitrite as nitrogen and measurements of nitrate as nitrogen will hereafter be referred to as "nitrate."

NITRATE FATE AND TRANSPORT

Nitrate is considered a conservative anion and is highly mobile in many shallow coarse-textured groundwater systems. Once in groundwater nitrate is often considered very stable and can move large distances from its source. Nitrate in groundwater may be converted to nitrogen gas in the absence of oxygen and the presence of organic carbon, through a natural process called denitrification. Denitrification occurs when oxygen levels are depleted and nitrate becomes the primary oxygen source for microorganisms. Shallow groundwater in coarse-textured soils (glacial outwash) generally has low concentrations of organic carbon and is well oxygenated, so denitrification is often limited in these conditions. As a result areas like Morrison County with extensive glacial outwash aquifers and intensive row crop agriculture are particularly vulnerable to elevated nitrate concentrations. However, geochemical conditions can be highly variable within an aquifer or region and can also change over-time (MPCA, 1998).

GEOLOGY AND HYDROGEOLOGY

The geology in Morrison County is heavily influenced by glacial till and outwash plains. Glacial outwash is relatively coarse-textured (i.e. sandy) compared to other glacial deposits such as till and drift deposits. Coarse-textured deposits allow contaminants from the surface to travel rapidly to the water table aquifers. The Superior Lobe and Rainy lobe are the main source of glacial deposits in this area (MPCA, 1998). A statewide geomorphology layer produced by the Minnesota Geological Survey and the University of Minnesota at Duluth (MDNR, 1997) shows the extent of glacial deposits in Figure 1. This geologic feature is present in some portion of every township in Morrison County.

This same geology layer (Figure 1) was used to classify the state into aquifer sensitivity ratings. There are three ratings for aquifer sensitivity: low, medium and high (Table 1). The ratings are based upon guidance from the Geologic Sensitivity Project Workgroup's report "Criteria and Guidelines for Assessing Geologic Sensitivity in Ground Water Resources in Minnesota" (DNR, 1991) (Figure 2).

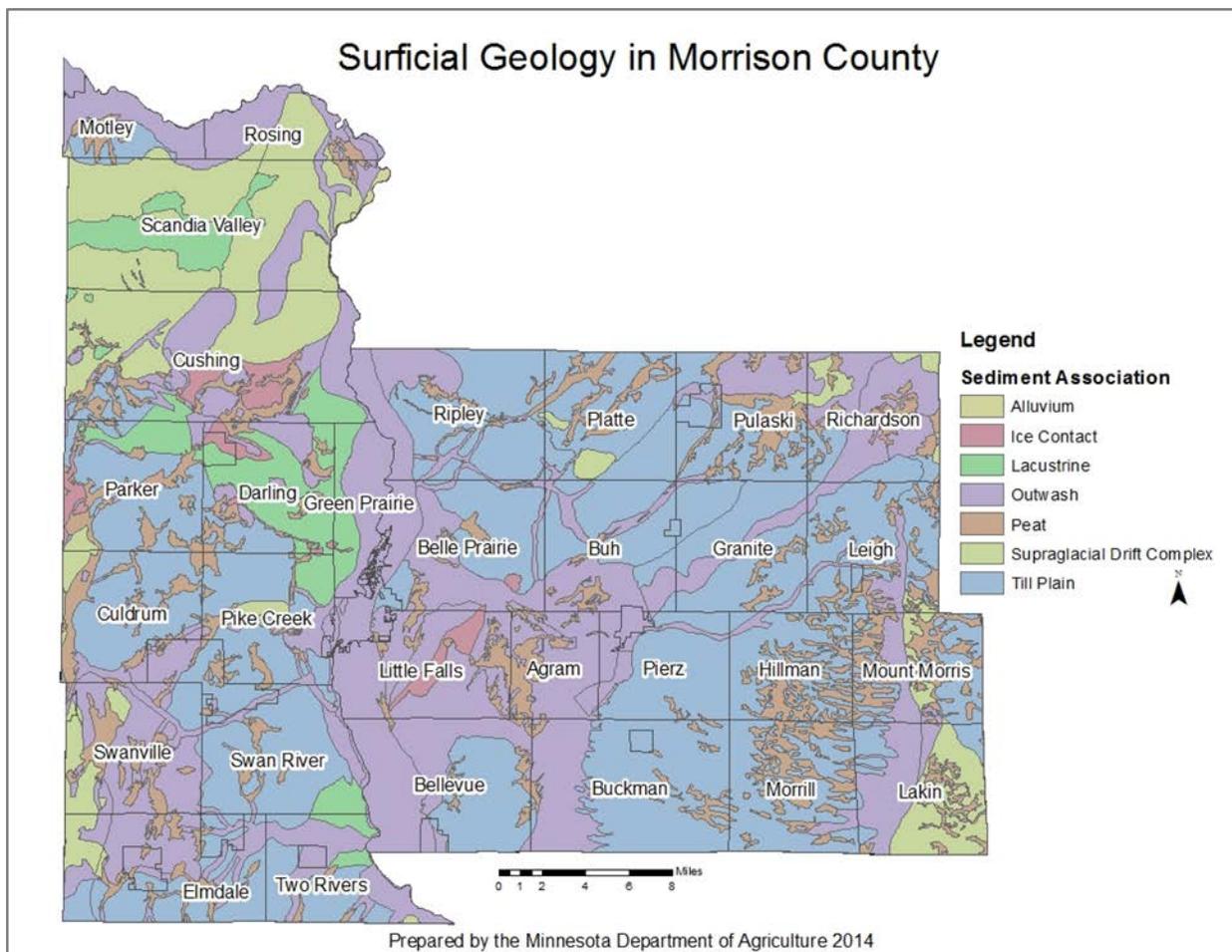


Figure 1. Statewide Geomorphology Layer, Sediment Association, Morrison County

Table 1. Vulnerability Ratings Based on the Geomorphology of Minnesota, Sediment Association Layer

Sediment Association	Sensitivity/Vulnerability Rating
Alluvium, Outwash, Ice Contact, Peat, Terrace, Bedrock: Igneous, Metamorphic, and Sedimentary	High
Supraglacial Drift Complex, Lacustrine	Medium
Till Plain	Low

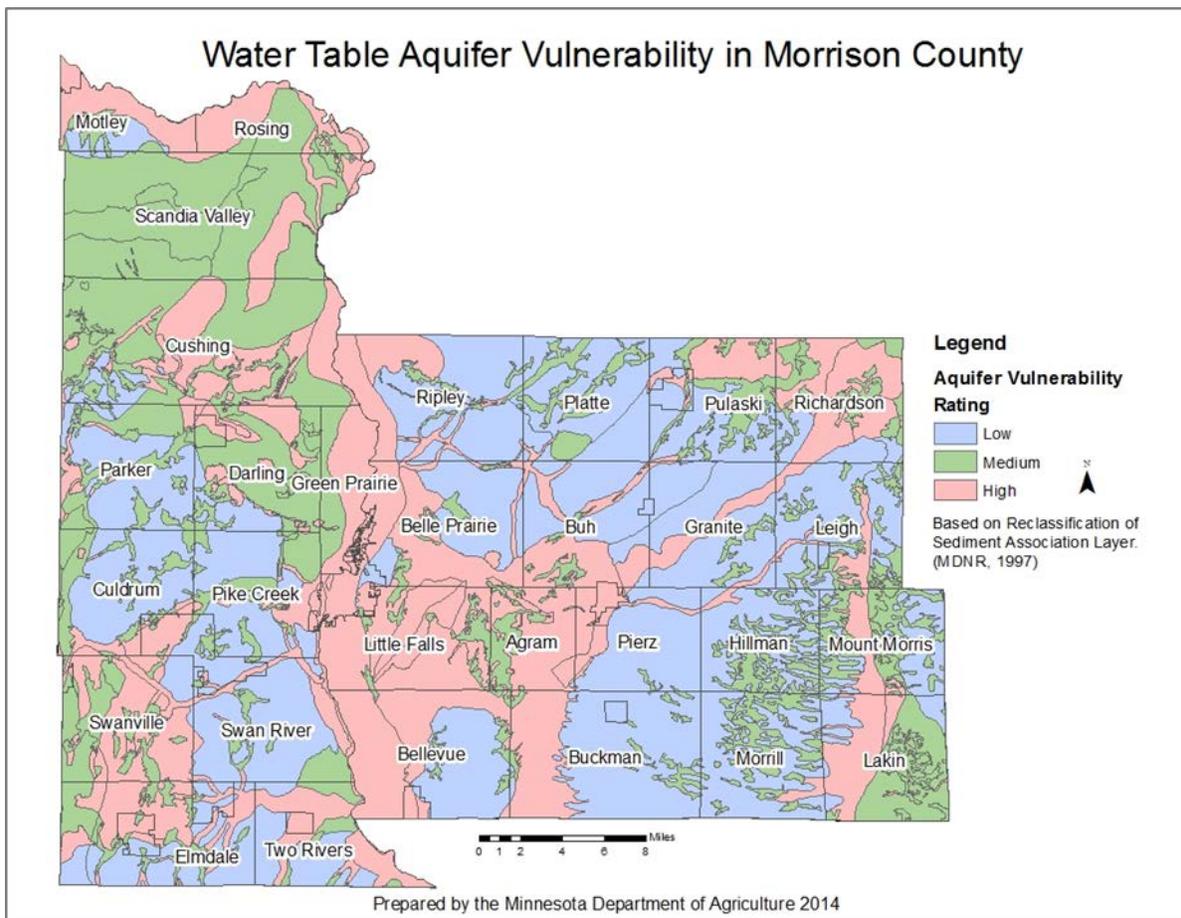


Figure 2. Water Table Aquifer Vulnerability for Morrison County

GEOLOGIC ATLAS

A County Geologic Atlas is a systematic study of a county’s geologic and groundwater resources. The atlas defines aquifer properties and boundaries, as well as the

connection of aquifers to the land surface and to surface water resources (MGS, 2014). This information is essential to sustainable management of groundwater resources and can help with activities such as monitoring, appropriation, permitting, remediation, and well construction.

A complete geologic atlas consists of two parts:

- Part A (prepared by Minnesota Geological Survey (MGS)), which includes the water well database and 1:100,000 scale geologic maps showing properties and distribution of sediments and rocks in the subsurface, and
- Part B (developed by the Department of Natural Resources (DNR) Division of Waters) which includes maps of water levels in aquifers, direction of groundwater flow, water chemistry, and sensitivity to pollution.

The Morrison County Geologic Atlas Part A was finalized in June 2104 by the MGS.

COUNTY WELL INDEX

The County Well Index (CWI) is a database system developed by the Minnesota Geological Survey and the Minnesota Department of Health (MDH) for the storage, retrieval, and editing of water-well information. The database contains basic information on well records (e.g. location, depth, static water level) for wells drilled in Minnesota. The database also contains information on the well log and the well construction for many private drinking water wells. The CWI is instrumental in the development of the Geologic Atlas described in the previous section. The CWI is the most comprehensive Minnesota well database available, but contains only information for wells in which a well log is available. Most of the records in CWI are for wells drilled after 1974, when water-well construction code required well drillers to submit records to the MDH. The CWI does contain data for some records obtained by the MGS through the cooperation of drillers and local government agencies for wells drilled before 1974 (MGS, 2014).

According to the County Well Index, within these 6 townships there are 1,348 “located” wells (those with location field-verified by MDH, MGS or other local partner):

Sixty-three percent are completed in a Quaternary Buried Artesian Aquifer (QBAA) and are 75 feet deep on average.

- QBAA designation is given to wells in which the static water level is within or above 10 feet of clay anywhere above the screened portion of the well (personal communication, Bob Tipping). The 10 feet or more of clay between the land surface and well screen provides a level of protection from nitrate contamination.

- Twenty-three percent are completed in the shallow Quaternary Water Table Aquifer (QWTA) and are 56 feet deep on average.
 - QWTA wells are defined as having less than 10 feet of confining material (clay) between the land surface and the well screen (GWMAP 1998). When there is less than 10 feet of clay, it allows surface contaminants to travel more quickly to the water table aquifers. In general, shallower wells completed in the QWTA may be more susceptible to nitrate contamination.
- Less than five percent of the wells were given a Quaternary undifferentiated designation. The undifferentiated designation means that there is not enough information in the associated well log to determine any more detail than a Quaternary deposit.
- Precambrian aquifers are utilized in only three percent of the wells. The average depths for the Precambrian aquifer wells range from 122 to 300 feet deep.
- Nine percent of wells are undesignated.

NITRATE PROBABILITY MAPPING

The Minnesota Department of Health (MDH) has developed nitrate probability maps to assist in local water quality planning efforts. These maps identify areas of a county with relatively high, moderate, and low probability of having elevated nitrate concentrations in ground water. The goal of nitrate probability mapping is to help protect public and private drinking water supplies, help prevent further contamination by raising awareness and assist in local planning and prevention. The map is shown in Figure 3. The nitrate probability map is similar in appearance compared to the updated aquifer vulnerability map; however it shows less area categorized in the high rating. Morrison County's report was published in 2002 and can be accessed here:

<http://www.health.state.mn.us/divs/eh/water/swp/nitrate/nitratemaps.html>

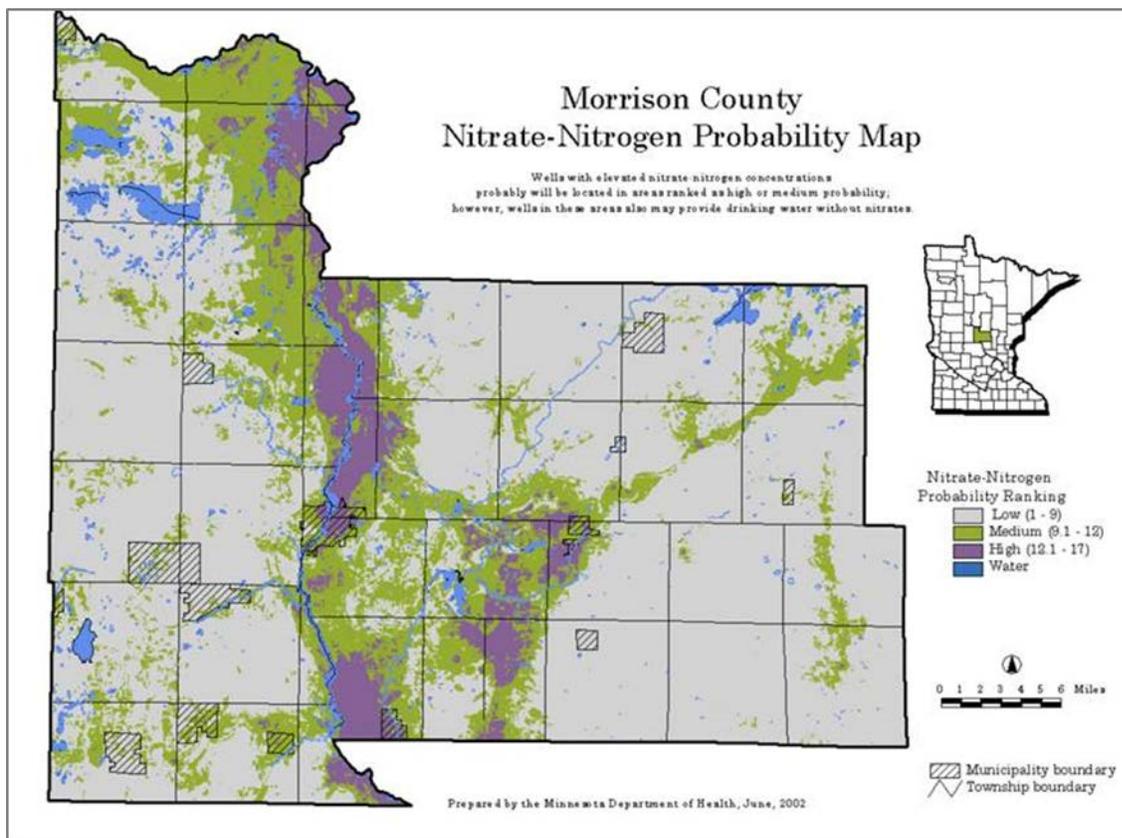


Figure 3. Morrison County Nitrate-Nitrogen Probability Map

MDA PRIVATE WELL MONITORING

The Minnesota Department Agriculture has two primary approaches to monitoring for nitrate in private drinking water wells. The first approach is to use a statistically designed private well regional network that incorporates more than one county into a region. The Central Sands Private Well network is considered a regional network; it includes a 14 county area in the central area of Minnesota. Results are considered to reflect levels of nitrate contamination across the region. The second approach is monitoring on a township level, the Township Testing program. The two approaches are discussed separately below.

CENTRAL SANDS PRIVATE WELL NETWORK RESULTS

In the spring of 2011, a total of 1555 private drinking water wells were sampled for nitrate concentrations (Figure 4 and Table 2). Homeowners from 14 counties were systematically selected to participate in this project and had their private well water tested for free. Overall, results from the 14 counties combined showed that 88 percent

of the 1555 wells had nitrate concentrations less than 3 mg/L, seven percent ranged from 3-9.9 mg/L and five percent of wells had concentrations greater than or equal to 10 mg/L (Kaiser, 2012). However, Morrison County results showed a higher percentage of wells greater than or equal to 10 mg/L compared to other counties in the Central Sands Private Well Network. Because of this, Morrison County was given a high priority in the Township Testing Program.

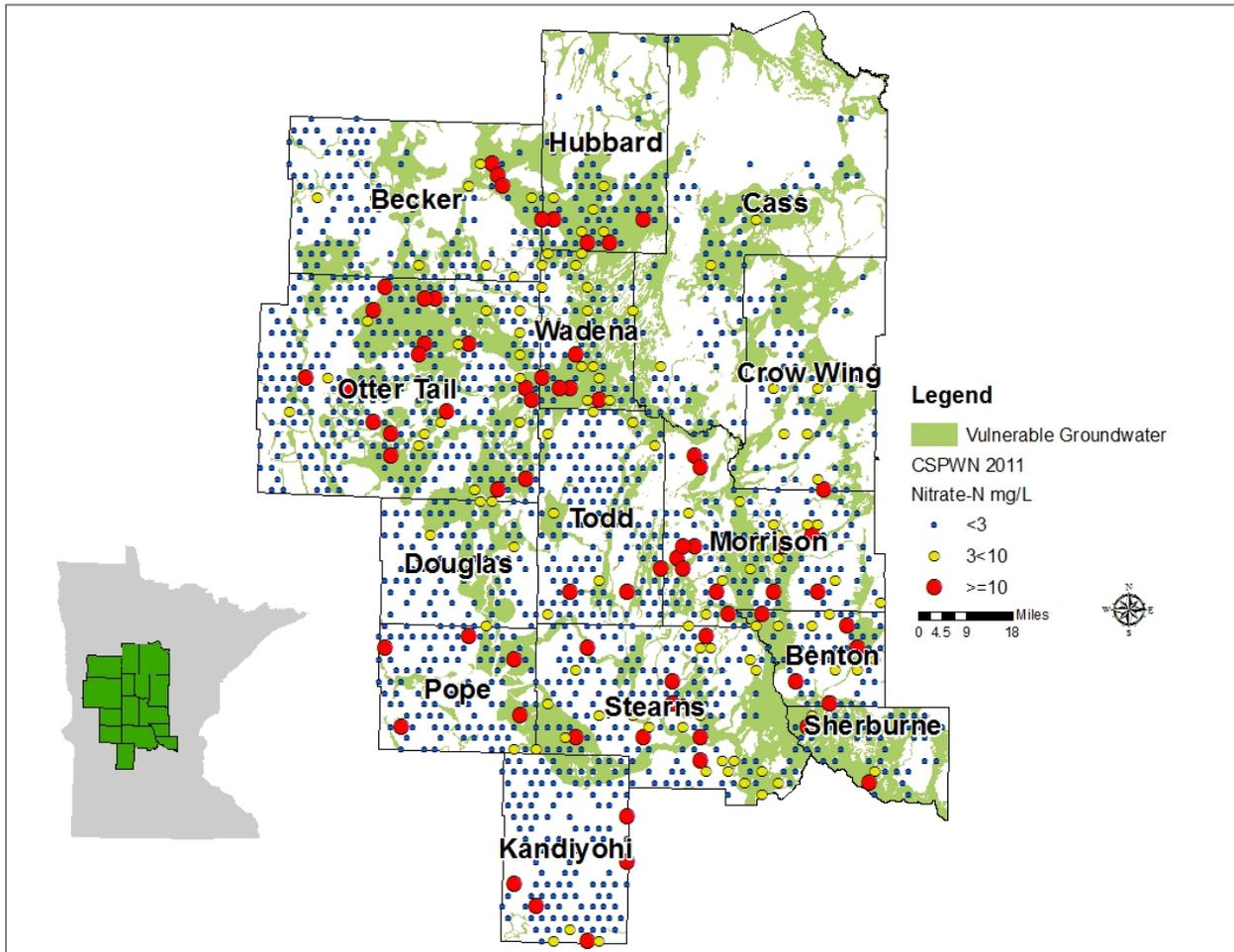


Figure 4. Central Sands Private Well Network 2011 Sampling Event

Table 2. Central Sands Private Well Network 2011 Results

County	Number of Samples	2011 Results					
		Nitrate-N mg/L			Percent		
		Min	Median	Max	<3 (mg/L)	3<10 (mg/L)	≥10 (mg/L)
Becker	123	<.03	<.03	15.4	93%	5%	2%
Benton	57	<.03	<.03	15.6	79%	12%	9%
Cass	82	<.03	<.03	9.5	96%	4%	0%
Crow Wing	66	<.03	<.03	8.3	92%	8%	0%
Douglas	90	<.03	<.03	8.8	94%	6%	0%
Hubbard	65	<.03	<.03	29.3	85%	8%	8%
Kandiyohi	117	<.03	<.03	38.7	93%	3%	4%
Morrison	124	<.03	<.03	33.9	78%	11%	11%
Ottertail	320	<.03	<.03	32.7	90%	4%	5%
Pope	93	<.03	<.03	35.0	94%	1%	5%
Sherburne	42	<.03	<.03	40.0	91%	5%	5%
Stearns	167	<.03	<.03	49.8	82%	13%	4%
Todd	137	<.03	<.03	81.0	93%	5%	2%
Wadena	72	<.03	0.09	49.2	75%	17%	8%
Average	1,555 <i>total samples</i>	<.03	0.01	31.9	88.6%	6.8%	4.6%

For more information about the Central Sands Private Well Network, please visit: <http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/characterizingnitrates.aspx>.

TOWNSHIP TESTING

The MDA is currently updating the 1990 Nitrogen Fertilizer Management Plan (NFMP). The NFMP is the state’s blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. Updating the NFMP provides an opportunity to

restructure county and the state strategies for reducing nitrate contamination of groundwater, with more specific, localized accountability for nitrate contamination from agriculture. In order to effectively reduce nitrate contamination of groundwater resources, it is necessary to identify areas of concern. Areas of concern tend to be fairly localized and therefore township boundaries were selected for nitrate testing. Factors such as aquifer vulnerability, row crop production and previous nitrate results will be used to prioritize townships for sampling. Townships with at least 30 percent of the area characterized with vulnerable groundwater and at least 20 percent of the area in row crop production are shown in Figure 5. Areas in orange are considered most vulnerable to nitrate contamination of groundwater. This map serves as a starting point for planning sample locations and is modified based on local expertise.

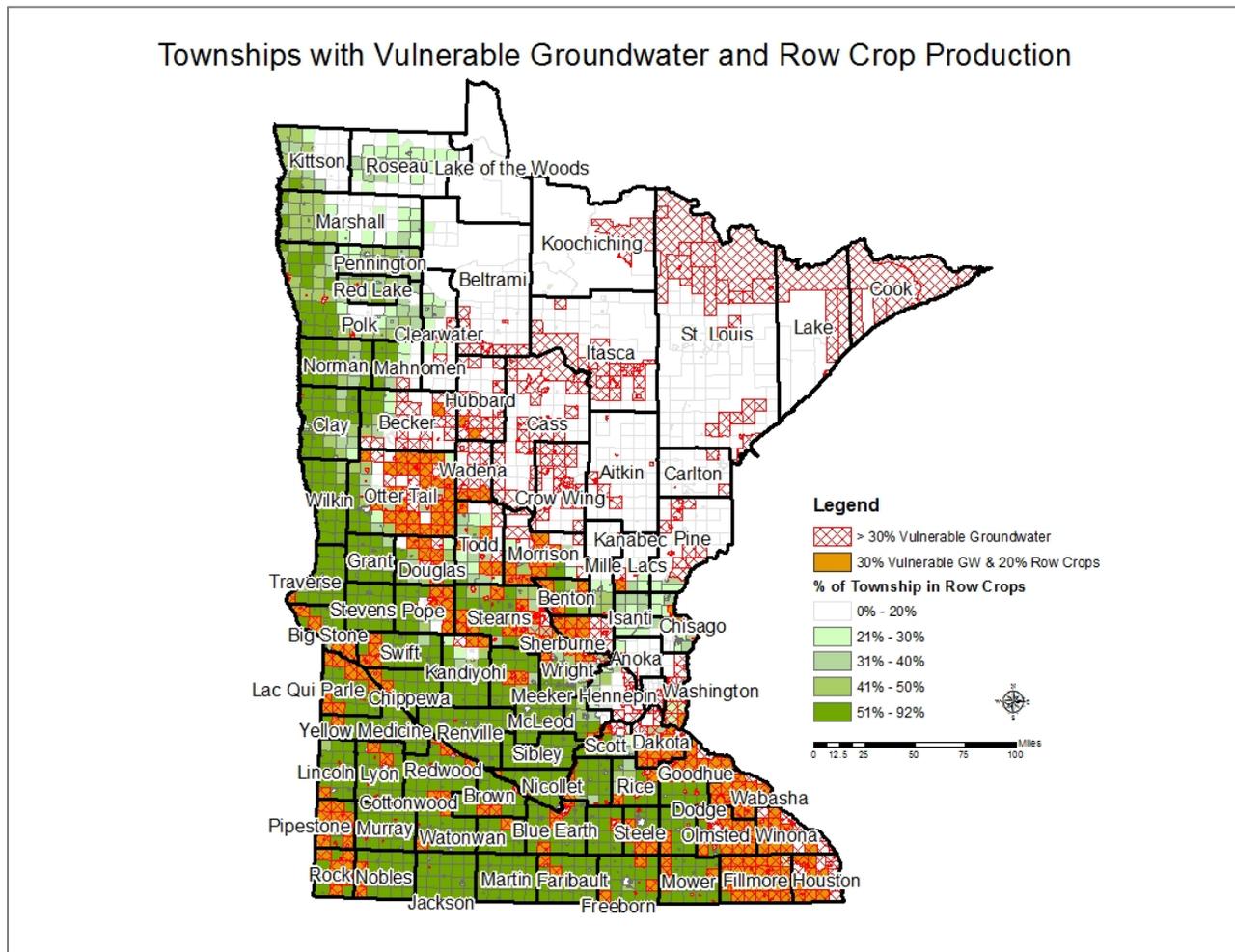


Figure 5. Townships with Vulnerable Groundwater and Row Crop Production

METHODS

Buh and Culdrum townships were chosen for sampling based on the high results from the Central Sands Private Well Network. Agram, Belle Prairie, Bellevue, and Swan River townships were chosen based on other criteria including local Soil and Water Conservation District (SWCD) expertise, vulnerable groundwater, and row crop production.

The goal of this program is to sample most available wells in the selected townships. Most households with private wells received an invitation letter to participate in the free nitrate testing. Homeowners with private wells that agreed to participate were sent a free water sample kit (by a certified lab) which included a survey about their well, sample bottle, sample instructions and a pre-paid mailer. Homeowners were asked to fill out the well survey, fill the sample bottle and mail the sample to the certified lab in the prepaid mailer. Once the sample was analyzed, the lab sent homeowners their results in the mail. The selected townships included: Agram, Belle Prairie, Bellevue, Buh, Culdrum and Swan River.

RESULTS

Approximately 525 well owners returned water samples for analysis across the six townships (Figure 6). On average, 33 percent of households in these townships responded to the free nitrate test offered by the MDA (Table 3). The results of the township nitrate sampling are displayed in Figure 4. The summary statistics are presented in two formats: all well construction types are shown in Table 4 and all well construction types except hand dug wells are shown in Table 5. Hand dug wells are often very shallow, just skimming the water table, and therefore are much more sensitive to surface water contamination (feedlot runoff), point source pollution (such as sewage from septic systems), or chemical spills. Visually, there is a difference in the results when hand dug wells are removed, however, a statistical comparison showed there was no significant difference (p -value > 0.05) between the two groupings, with or without hand dug wells. The following paragraphs will summarize the statistics in Table 5, which does not include hand dug wells.

The minimum values for each township are less than the detection limit which is <0.03 mg/L. The high values range from 28.2 to 43.7 mg/L, with Bellevue Township having the highest result. Median values range from <0.03 to 10.2 mg/L, Agram Township having the highest median value. The 90th percentiles range from 9.4 to 20.5 mg/L, with Agram Township having the highest value.

Results from each township showed that at least 10 percent of samples were greater than 10 mg/L, except Swan River which was nine percent. Agram Township results showed that 52 percent of wells were greater than 10 mg/L and Belle Prairie Township

results showed that 17 percent were greater than 10 mg/L. Whereas, Bellevue, Buh, Culdrum and Swan River townships results showed that between 11-12 percent of wells were greater than 10 mg/L. Previous sampling of 124 wells in Morrison County showed that 11 percent of wells were at or over 10 mg/L (Kaiser, 2012). This data suggests Agram and Belle Prairie townships are more impacted than the other nearby townships. Agram Township had both the highest percent of vulnerable groundwater and highest percent of row crop production compared to the other two townships (Table 6).

These results contrast findings from a 2010 USGS report on nitrate concentrations in private wells in the glacial aquifer systems across the upper United States in which less than 5 percent of sampled private wells had nitrate concentrations greater than 10 mg/L (Warner and Arnold, 2010). The differences in the study findings may be due to the higher row crop areas in the selected townships. Both studies indicate that nitrate concentrations can vary considerably over short distances

Table 3. Township Population, Households, Sample Kit Distribution and Return Rate

Township	2012 Population	2012 Households	Kits Sent	Samples Returned	Return Rate
Agram	574	198	188	109	58%
Belle Prairie	1080	431	449	101	22%
Bellevue	1096	390	406	135	33%
Buh	524	199	227	52	23%
Culdrum	478	172	172	58	34%
Swan River	751	269	261	70	27%
Total	4503	1659	1703	525	33% *

* Represents the average return rate

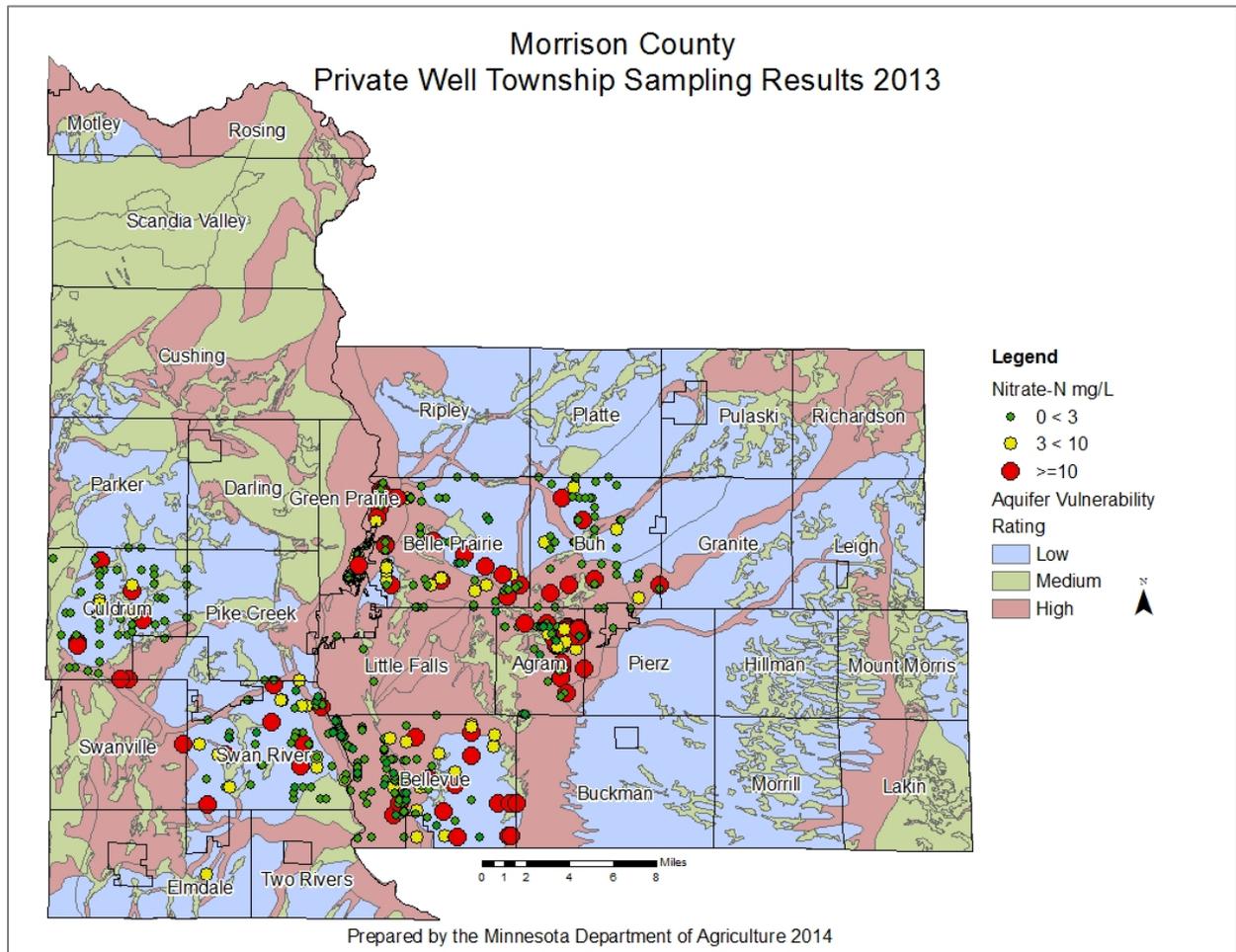


Figure 6. Morrison County Private Well Township Sampling Results 2013

Table 4. Morrison County Township Sampling Summary Statistics Including All Well Types

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		Min	Max	Mean	50th (Median)	75th	90th	95th	99th	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L
Nitrate as Nitrogen mg/L or parts per million (ppm)																			
Agram	109	<DL	40.8	9.8	10.2	16.7	20.5	23.0	36.1	36	16	65	63	57	33%	15%	60%	58%	52%
Belle Prairie	101	<DL	39.0	4.8	0.2	7.4	15.7	27.0	37.4	66	17	28	26	18	65%	17%	28%	26%	18%
Bellevue	135	<DL	43.7	3.7	<DL	1.3	11.1	28.9	39.4	108	12	22	20	15	80%	9%	16%	15%	11%
Buh	52	<DL	31.2	2.8	<DL	1.5	12.6	15.3	31.0	42	4	9	8	6	81%	8%	17%	15%	12%
Culdrum	58	<DL	28.2	2.9	<DL	1.7	11.7	18.0	27.7	46	4	10	9	8	79%	7%	18%	16%	14%
Swan River	70	<DL	40.9	3.7	<DL	4.5	12.5	17.5	39.9	50	12	16	12	8	71%	17%	23%	17%	11%

< DL stands for less than a detectable limit. This means results are less than 0.03 mg/L. The 50th percentile (75th, 90th, 95th, and 99th) is the value below which 50 percent (75%, 90%, 95%, and 99%) of the observed values fall.

Table 5. Morrison County Township Sampling Summary Statistics without Hand Dug Wells

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		Min	Max	Mean	50th (Median)	75th	90th	95th	99th	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L	<3 mg/L	3<10 mg/L	≥5 mg/L	≥7 mg/L	≥10 mg/L
Nitrate as Nitrogen mg/L or parts per million (ppm)																			
Agram	109	<DL	40.8	9.8	10.2	16.7	20.5	23.0	36.1	36	16	65	63	57	33%	15%	60%	58%	52%
Belle Prairie	98	<DL	39.0	4.5	0.1	7.2	14.7	24.4	34.5	65	16	27	25	17	66%	16%	28%	26%	17%
Bellevue	133	<DL	43.7	3.7	<DL	<DL	12.5	28.9	39.5	107	11	22	20	15	80%	8%	17%	15%	11%
Buh	49	<DL	31.2	2.9	<DL	1.1	12.9	15.9	31.2	39	4	9	8	6	80%	8%	18%	16%	12%
Culdrum	57	<DL	28.2	2.7	<DL	1.3	11.9	18.1	27.8	46	4	11	8	7	81%	7%	19%	14%	12%
Swan River	65	<DL	40.9	3.1	<DL	3.6	9.4	17.1	37.9	48	11	14	9	6	74%	17%	22%	14%	9%

< DL stands for less than a detectable limit. This means results are less than 0.03 mg/L. The 50th percentile (75th, 90th, 95th, and 99th) is the value below which 50 percent (75%, 90%, 95%, and 99%) of the observed values fall.

Table 6. Township Nitrate Results Summary Related to Vulnerable Groundwater and Row Crop Production

Township	Total Wells*	Percent Vulnerable Geology	Percent Row Crop Production	Percent of Wells* Nitrate-N \geq 10 mg/L	90th Percentile* Nitrate-N mg/L
Agram	109	76%	40%	52%	20.5
Belle Prairie	98	53%	36%	17%	14.7
Bellevue	133	55%	50%	11%	12.5
Buh	49	39%	50%	12%	12.9
Culdrum	57	10%	35%	12%	11.9
Swan River	65	14%	46%	9%	9.4

* Does not include known hand dug wells

WELL SETTING AND CONSTRUCTION

WELL OWNER SURVEY

The well owner survey, sent out with the sampling kit, provided additional information about private wells that were sampled. The survey included questions about the well construction, depth and age, and questions about nearby land use. Survey questions can be found in Appendix A. It is important to note that well information was provided by the well owners and may be approximate or potentially erroneous. The following section is a summary of information gathered from the well owner survey (complete well survey results are located in Appendix B, Tables 8-22).

The majority of wells in each township are located on “rural” property. Agram Township has a high percentage of lake homes (40 percent) compared to the other townships that have none or very small amounts. Approximately 79 percent of wells in these six townships are of drilled construction. Agram Township has the lowest percentage (70%) of drilled wells, followed by Belle Prairie and Bellevue. Those same three townships also have the highest percentage of sand-point wells.

By design, sand point (drive-point) wells are completed at shallower depths than drilled wells. Whichever type of casing is installed, it must be watertight and extend at least 15 feet below the ground surface. These wells are also usually installed in sandy soils where there are no thick confining units such as clay. A confining layer can create a physical barrier so nitrate cannot move from the surface to deeper portions of the aquifer. These factors make sand point wells more vulnerable to surface contamination. Most wells in these townships are less than 100 feet deep. The well age seems to be evenly distributed between the ranges of 0-10, 11-20, 21-40, and over 40 years old. Well age does not seem to be as much of a factor in nitrate concentrations as the depth of the well seems to be.

Agram Township was so much different than the other townships that a more detailed look at the data and its spatial distribution was needed. Utilizing a geographic information system (GIS), it was determined that 76 of the 109 Agram samples were taken from a 1.5 square mile area around one lake.

WELL LOGS

In some cases, well owners were able to provide Unique Well Identification Numbers for their wells. When the correct Unique IDs are provided, a well log can be used to identify the aquifer designation for the well. In this case, 58 wells were identified in the CWI and well logs were obtained (Table 7).

In Agram Township, 17 well logs were obtained from the CWI. Four of the wells were identified as water table wells and three of those exhibited nitrate concentrations greater than or equal to 10 mg/L. Thirteen were completed in buried sand and gravel aquifers and three of these were greater than or equal to 10 mg/L.

In Belle Prairie Township, eight well logs were obtained from the CWI. Four of the wells were completed in the QWTA, two of which exhibited nitrate concentrations greater than 10 mg/L. Four wells were completed in buried aquifers protected by clay confining units and one of those was greater than 10 mg/L.

In Bellevue townships 18 wells logs were obtained. Three of the wells were completed in the QWTA and none of them were over 10 mg/L. Fifteen were completed in a buried aquifer and one of those was above 10mg/L.

There were only 15 well logs in total obtained for Buh, Culdrum and Swan River Township. None of the wells with well logs had nitrate concentrations over 10 mg/L.

Table 7. Aquifer Designation and Nitrate Results

Township	Aquifer Designation	Wells by Aquifer	Ave Depth (Feet)	Number			Percent		
				<3	3< 10	≥10	<3	3< 10	≥10
				Nitrate-N mg/L					
Agram	Water Table	4	53	1	0	3	25%	0%	75%
	Quaternary Buried	13	68	7	3	3	54%	23%	23%
Belle Prairie	Water Table	4	71	1	1	2	25%	25%	50%
	Quaternary Buried	4	377	2	1	1	50%	25%	25%
Bellevue	Water Table	3	52	3	0	0	100%	0%	0%
	Quaternary Buried	15	79	12	2	1	80%	13%	7%
Buh	Quaternary Buried	4	75	3	1	0	75%	25%	0%
Culdrum	Quaternary Buried	2	53	2	0	0	100%	0%	0%
Swan River	Water Table	1	40	1	0	0	100%	0%	0%
	Precambrian wells	1	504	1	0	0	100%	0%	0%
	Quaternary Buried	7	74	5	2	0	71%	29%	0%
Total	All	58	131	38	10	10	66%	17%	17%

* The aquifer designations were obtained from well logs in the CWI database.

QWTA = Quaternary Water table Aquifer

QBAA = Quaternary Buried Artesian Aquifer

POTENTIAL NITRATE SOURCE DISTANCES

The following response summary relates to isolation distances of potential point sources of nitrate that may contaminate wells. This information was obtained from the well surveys completed by the homeowner (complete well survey results are located in Appendix B at the end of this document, Tables 8-22).

- On average, 26 percent of the well owners in Buh, Culdrum and Swan River townships responded that they have livestock (greater than 10 head of cattle or other equivalent) on their property.
- In Agram, Belle Prairie and Bellevue townships, only six percent of well owners had livestock on their property.
- Few well owners across all townships store more than 500 pounds of fertilizer on their property.
- Most wells are greater than 300 feet from an active or inactive feedlot or an agricultural field.
- The majority of wells are greater than 50 feet away from septic systems.

SUMMARY

Using aquifer (groundwater) vulnerability and row crop production as an indicator for nitrate contamination seems to be a useful tool in targeting nitrate sampling. Results from five of the six townships in this pilot project showed that 10 percent of samples were at or greater than 10 mg/L (which is the Maximum Contaminant Level (MCL)). Evaluation of this data suggests Agram Township and Belle Prairie Township are more impacted than the other townships sampled in Morrison County. Agram Township in particular is of concern with 52 percent of samples greater than 10 mg/L. Agram Township had the highest percent of vulnerable groundwater compared to the other townships and a much higher percentage of lake homes.

Future work that may be considered by the MDA includes the following: 1) resampling wells that had high nitrate results (greater than or equal to 5 mg/L) to verify high nitrate levels; 2) performing well site visits, when possible, to rule out well construction issues and obvious point sources of nitrate, such as septic systems, livestock, etc.; and 3) increasing efforts to obtain well log information for participating wells so that the nitrate results and the aquifer designation can be compared in a more comprehensive fashion.

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Private Well Survey Questions

1. What setting did the water sample come from? Please choose only one.
Answers choices: Sub-division, Lake Home, River Home, Country, Municipal/city, or Other.
2. Are there livestock on this property? Yes or No
3. Do you mix or store fertilizer (500lbs or more) on this property? Yes or No
4. Does farming take place on this property? Yes or No

Well Information Section

5. Does your well have a Unique Well ID number? Yes or No
6. If yes, what is the Unique ID?
(6 digit number found on a metal tag attached to your well casing)
7. Type of well construction?
Answer choices: Drilled, Sandpoint, Hand dug, Other, Other, and don't know.
8. Approximate age (years) of your well?
Answer choices: 0-9.9 years, 10-19.9 years, 20-39.9 years, and 40 or more years old.
9. Approximate depth of your well
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
10. Distance to an active or inactive feedlot
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
11. Distance to a septic system
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
12. Distance to an agricultural field
Answer choices: 0-50 feet, 51-100 feet, 101-300 feet, and 300 or more feet.
13. Is this well currently used for human consumption? Yes or no
14. Please check any water treatment you have other than a water softener.
Answer choices: None, Reverse osmosis, distillation, filtering system and other.
15. When did you last have your well tested for nitrates?
Answer choices: Never, with the last year, within the last 3 years, the last 10, or 10 or more.
16. What was the result of your last nitrate test?
Answer choices: 0<3, 3<10, 10 and greater, or don't know.

APPENDIX B

Table 8. Property Setting for Well Location

Property Setting							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Percent of Wells							
Country	50%	85%	84%	96%	97%	90%	84%
Lake	40%	1%	9%	0%	0%	0%	8%
Sub-division	4%	9%	1%	0%	0%	4%	3%
Not Available	6%	5%	6%	4%	3%	6%	5%

Table 9. Well Construction Type

Well Construction Type							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	
Percent of Wells							
Drilled	70%	71%	76%	82%	91%	83%	79%
Sand point	19%	20%	19%	8%	3%	7%	13%
Hand dug well	0%	3%	1%	6%	2%	7%	3%
Not Available	11%	6%	4%	4%	3%	3%	5%

Table 10. Age of Well

Well Age							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Age	Percent of Wells						
0-10 years	21%	14%	18%	19%	19%	16%	18%
11-20 years	30%	19%	28%	21%	21%	21%	23%
21-40 years	32%	47%	38%	35%	29%	40%	37%
over 40 years	11%	16%	12%	17%	29%	20%	18%
Not Available	6%	5%	4%	8%	2%	3%	5%

Table 11. Depth of Well

Well Depth							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Depth	Percent of Wells						
0-50 feet	29%	33%	30%	17%	19%	37%	28%
51-100 feet	52%	42%	53%	77%	60%	46%	55%
101-300 feet	5%	19%	10%	0%	21%	11%	11%
over 300 feet	1%	0%	0%	0%	0%	1%	0%
Not Available	13%	7%	7%	6%	0%	4%	6%

Table 12. Unique Well ID Known

Does the Well have a Unique ID							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Unique ID for Well	Percent of Wells						
No	17%	30%	28%	40%	26%	40%	30%
Yes	25%	17%	21%	8%	9%	20%	16%
Not Available	59%	53%	51%	52%	66%	40%	53%

Table 13. Livestock Located on Property

Livestock on Property							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Livestock	Percent of Wells						
No	83%	88%	87%	56%	66%	76%	76%
Yes	6%	6%	7%	27%	31%	21%	17%
Not Available	10%	6%	6%	17%	3%	3%	8%

Table 14. Fertilizer Stored on Property

Fertilizer Stored on Property							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Fertilizer	Percent of Wells						
No	87%	95%	93%	94%	91%	96%	93%
Yes	0%	0%	0%	2%	7%	3%	2%
Not Available	13%	5%	7%	4%	2%	1%	5%

Table 15. Farming on Property

Farming on Property							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Farming	Percent of Wells						
No	72%	65%	73%	42%	36%	49%	56%
Yes	17%	31%	20%	52%	62%	50%	39%
Not Available	11%	4%	7%	6%	2%	1%	5%

Table 16. Distance to an Active Feedlot

Distance to an Active Feedlot							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Distance to Feedlot	Percent of Wells						
0-50 feet	1%	6%	5%	0%	3%	3%	3%
51-100 feet	2%	2%	4%	2%	17%	1%	5%
101-300 feet	3%	4%	4%	19%	21%	14%	11%
over 300 feet	77%	70%	70%	69%	55%	76%	70%
Not Available	17%	18%	16%	10%	3%	6%	12%

Table 17. Distance to Septic System

Distance to a Septic System							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Distance to Septic	Percent of Wells						
0-50 feet	8%	7%	3%	4%	0%	3%	4%
51-100 feet	38%	35%	36%	29%	31%	33%	34%
101-300 feet	43%	50%	50%	42%	45%	49%	46%
over 300 feet	5%	4%	6%	21%	22%	10%	11%
Not Available	6%	5%	5%	4%	2%	6%	5%

Table 18. Distance to an Agricultural Field

Distance to an Agricultural Field							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Distance to Field	Percent of Wells						
0-50 feet	2%	9%	4%	10%	21%	4%	8%
51-100 feet	10%	13%	9%	13%	22%	19%	14%
101-300 feet	21%	22%	19%	27%	21%	29%	23%
over 300 feet	59%	50%	61%	46%	36%	44%	49%
Not Available	8%	7%	6%	4%	0%	4%	5%

Table 19. Drinking Water Well

Is the Well used for Drinking Water							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Drinking Water	Percent of Wells						
No	6%	2%	3%	0%	2%	0%	2%
Yes	87%	92%	94%	94%	98%	96%	94%
Not Available	6%	6%	3%	6%	0%	4%	4%

Table 20. Treatment System Present

Treatment System used for Drinking Water							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Treatment	Percent of Wells						
None	67%	73%	68%	71%	69%	69%	70%
Filtering System	6%	8%	11%	17%	9%	9%	10%
Reverse Osmosis	14%	8%	8%	4%	10%	9%	9%
Distillation	0%	0%	1%	0%	0%	1%	0%
Other	1%	0%	1%	0%	3%	1%	1%
Not Available	12%	10%	11%	8%	9%	11%	10%

Table 21. Last Tested for Nitrate

When was the Well Last Tested for Nitrate							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Last Tested	Percent of Wells						
Within the last 3 years	8%	9%	6%	4%	13%	8%	8%
Within the last 10 years	20%	23%	18%	23%	16%	26%	21%
Never Tested	22%	16%	31%	29%	27%	23%	25%
Greater than 10 years	29%	25%	21%	17%	22%	20%	22%
Not sure	11%	22%	21%	21%	22%	22%	20%
Not Available	10%	5%	3%	6%	0%	2%	4%

Table 22. Last Nitrate Test Result

The Last Nitrate Result							
Township	Agram	Belle Prairie	Bellevue	Buh	Culdrum	Swan River	Average
Total Wells	109	101	135	52	58	70	88
Last Nitrate-N Result	Percent of Wells						
<3 mg/L	18%	21%	17%	51%	53%	15%	29%
3-10 mg/L	15%	10%	4%	0%	0%	5%	6%
> 10 mg/L	15%	10%	4%	4%	2%	5%	7%
Not Available	51%	60%	74%	45%	45%	74%	58%