INITIAL TOWNSHIP TESTING OF NITRATE IN PRIVATE WELLS

WADENA COUNTY 2013 SUMMARY

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Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

In 2013, four townships in Wadena County were selected for private well nitrate sampling as a pilot project. Results showed that 19 percent of private wells sampled in Wadena Township were above the health standard of 10 mg/L. Eighteen percent of the private wells in Aldrich Township and 13 percent of the wells in Wing River Township were above the health standard of 10 mg/L. In Thomastown Township, only four percent of wells were above 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 Wadena 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.

http://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/townshiptesting.aspx

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 Wadena 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 Wadena County is heavily influenced by outwash plains and to a lesser extent, glacial till (Figure 1). Glacial outwash is relatively coarse-textured compared to other glacial deposits such as till and drift deposits. Outwash is material consisting primarily of sand and gravel that was deposited by running water that flowed from melting ice during the last glacial period. The outwash sand and gravel is typically deposited in a stratified (layered) fashion as the glacial melt conditions changed. The coarse-textured deposits associated with glacial outwash often allow contaminants from the surface to travel rapidly to the water table aquifers.

Wadena County overlies two large surficial aquifer systems. The Pineland Sands surficial aquifer is located in the northeast portion of the county and the Wadena surficial aquifer system is located in the southwest. The Pineland surficial aquifer consists of very fine-grained sand to fine gravel and is generally underlain by till (Helgeson, 1977). The Wadena aquifer in the southern portion of the county consists of medium to coarse grained sand with minor amounts of gravel and clay.

The Wadena surficial aquifer overlies a sandy till that contains lenses of buried sand and gravel that serve as artesian aquifers (Lindholm, 1970). Regional groundwater flow direction for the surficial aquifers and uppermost confined aquifers is toward the Leaf River in the southwest and toward Crow Wing River in the northeast. In both surficial aquifers, local ground-water flow generally follows the topographic relief towards small streams and lakes (Lindholm, 1970).

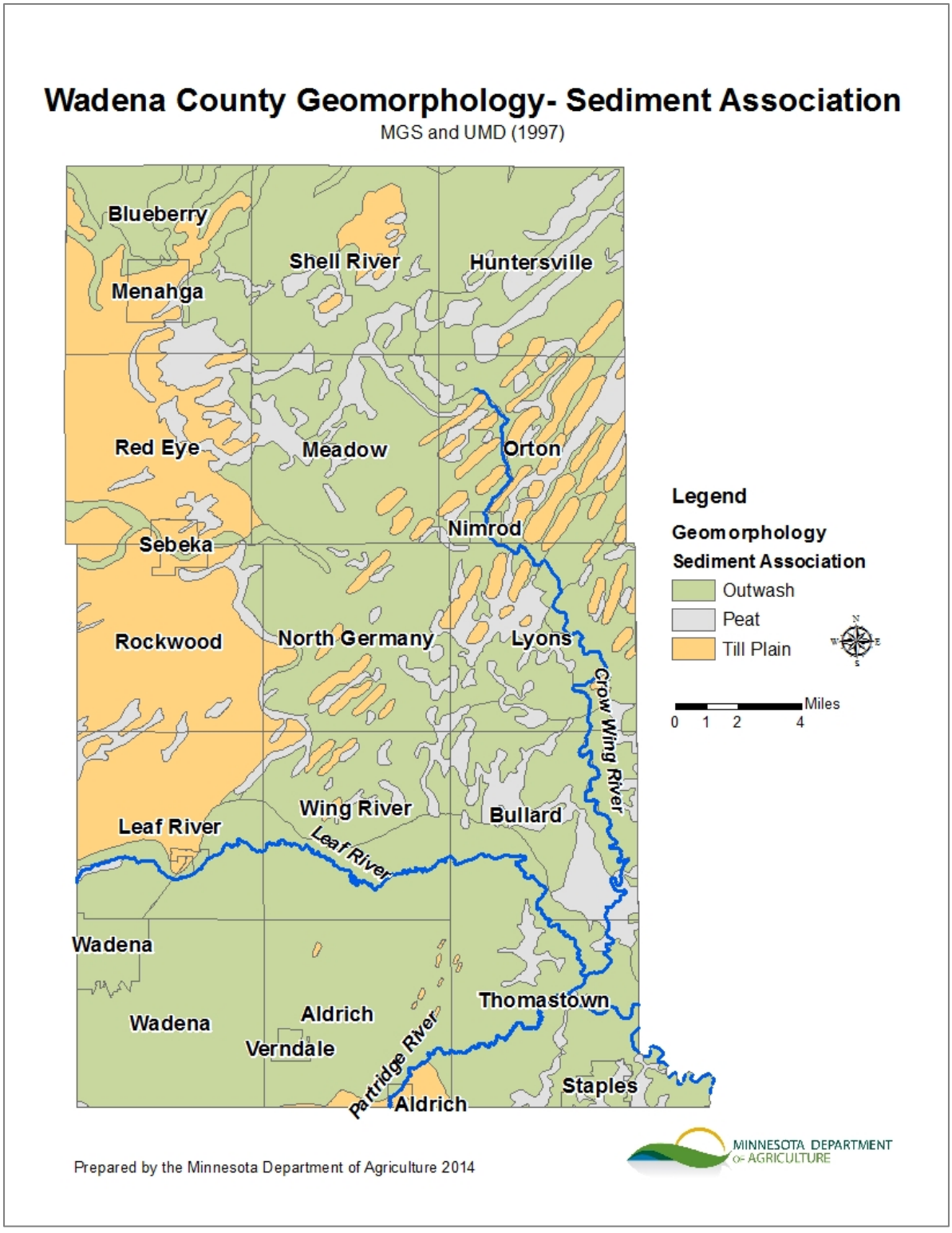

Figure 1. Statewide Geomorphology Layer, Sediment Association, Wadena County

The same geologic mapping project presented in Figure 1 was used to classify the state into aquifer sensitivity ratings. There are three ratings for aquifer sensitivity: low, medium and high. Sensitivity ratings are described in 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).

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

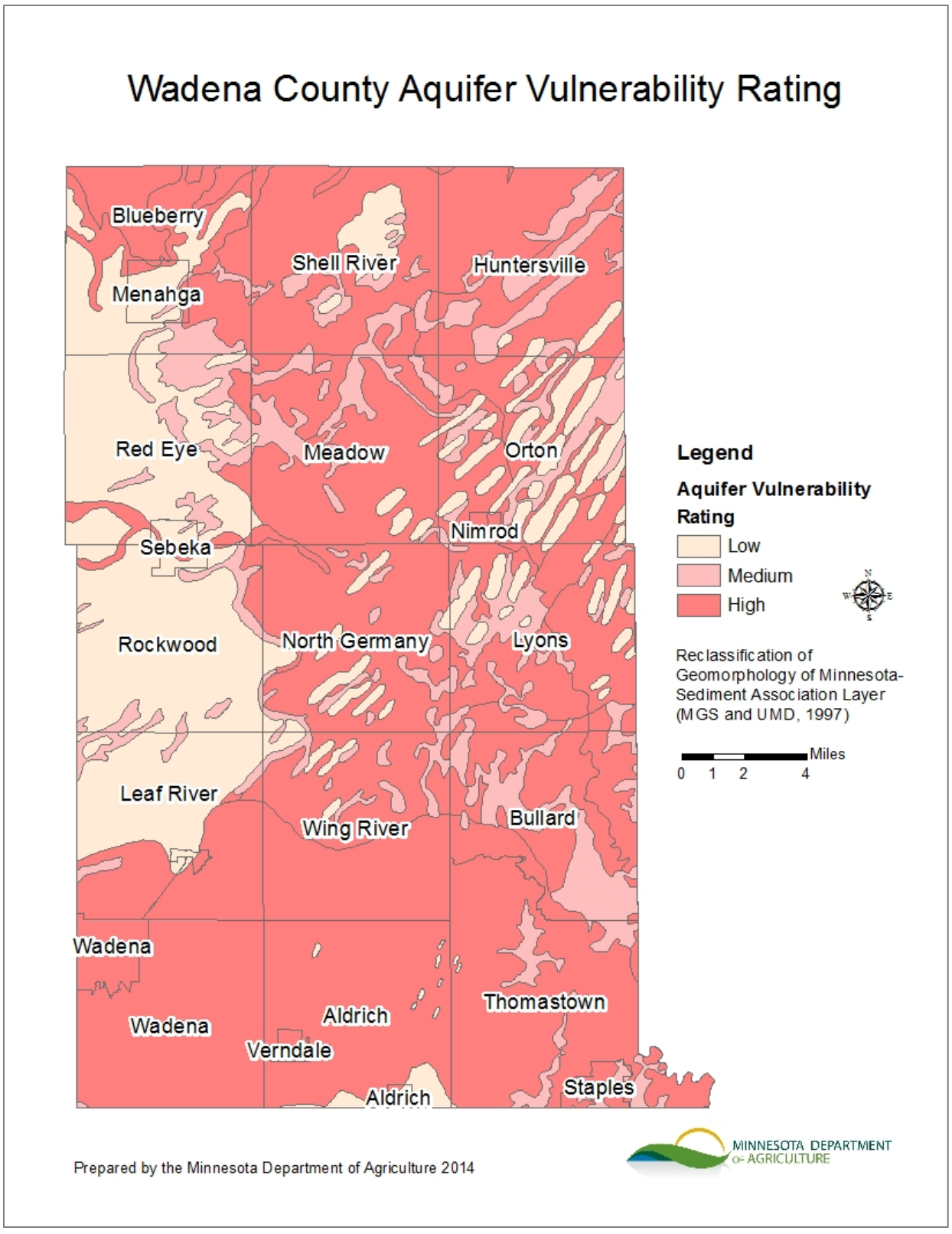

Figure 2. Water Table Aquifer Vulnerability for Wadena County

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 Wadena County Geologic Atlas Part A is currently being prepared by the MGS (as of May 2014).

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).

The CWI was used to gather information about the four townships included in this pilot study. Table 2 summarizes the general aquifer types, while the following section is a brief summary of the major aquifer types with the average well depth.

According to the information from the CWI (MDH, 2014):

In Aldrich Township, there are 170 “located” wells (those with location field-verified by MDH, MGS or other local partner):

- Fifty-four percent are completed in the shallow Quaternary Water Table Aquifer (QWTA) and are 33 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 (MPCA, 1998). When there is less than 10 feet of clay, it can allow 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-nitrogen contamination.
- Thirty-five percent are completed in a Quaternary buried aquifer and are 99 feet deep on average.
    - Buried aquifer wells have more than 10 feet of confining material between the land surface and the well screen.

In Thomastown Township, there are 289 located wells:

- Twenty-seven percent are completed in the shallow QWTA and are 37 feet deep on average.
- Fifty-seven percent are completed in a Quaternary buried aquifer and are 100 feet deep on average.

In Wadena Township, there are 224 located wells:

- Sixty-three percent are completed in the shallow QWTA and are 52 feet deep on average.
- Twenty-seven percent are completed in a Quaternary buried aquifer and are 105 feet deep on average.

In Wing River Township, there are 132 located wells:

- Fourteen percent are completed in the shallow QWTA and are 47 feet deep on average.
- Thirty-five percent are completed in a Quaternary buried aquifer and are 93 feet deep on average.

Table 2. Aquifer Type Distribution of Wells in the County Well Index

Township	Total Wells	Aquifer Type				
		Water Table	Quaternary Buried	Quaternary Undifferentiated	Undesignated	Others
Aldrich	170	54%	35%	<1%	11%	<1%
Thomastown	289	27%	57%	1%	15%	0%
Wadena	224	63%	27%	3%	6%	1%
Wing River	132	14%	35%	0%	51%	0%

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 groundwater. 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 nitrate probability map is similar in appearance compared to the updated aquifer vulnerability map; however it shows less area categorized in the high rating. Wadena County's report was published in 2002 and can be accessed here:

http://www.health.state.mn.us/divs/eh/water/swp/nitrate/reports/2002method/wadena.pdf

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 3 and Table 3). Homeowners from 14 counties were systematically chosen to participate in this project and had their private well water tested for free. Overall, results from the 14 counties combined showed that 89 percent of the 1555 wells had nitrate concentrations less than 3 mg/L, seven percent ranged from 3-9.9 mg/L and less than five percent of wells had concentrations greater than 10 mg/L (Kaiser, 2012). However, Wadena County results had the third highest percentage of wells greater than 10 mg/L compared to most other counties in the Central Sands Private Well Network. Because of this, Wadena County was given a high priority in the Township Testing Program.

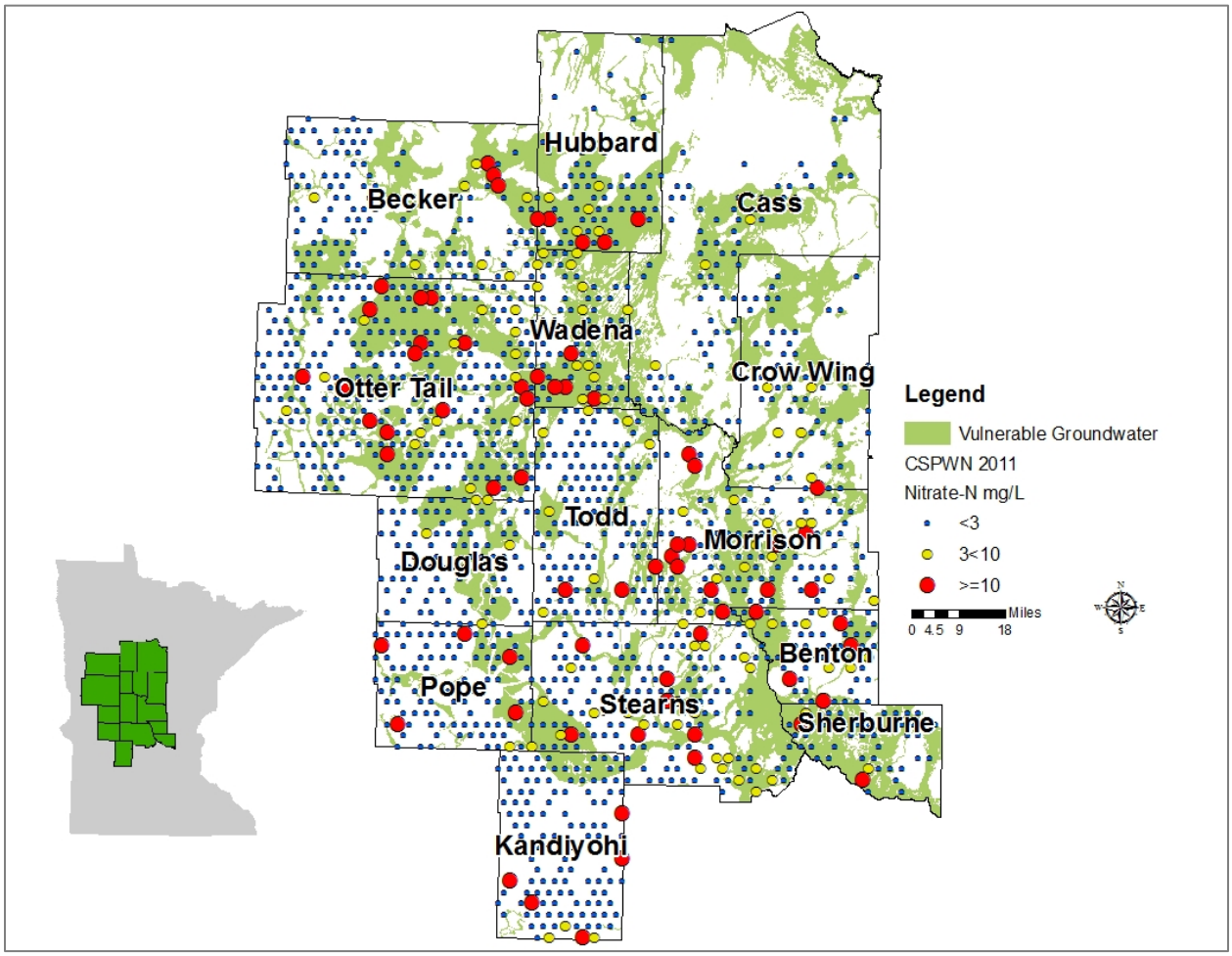

Figure 3. Central Sands Private Well Network 2011 Sampling Event

Table 3. Central Sands Private Well Network 2011 Results Summary

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 *total samples*	<.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 4 . 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.

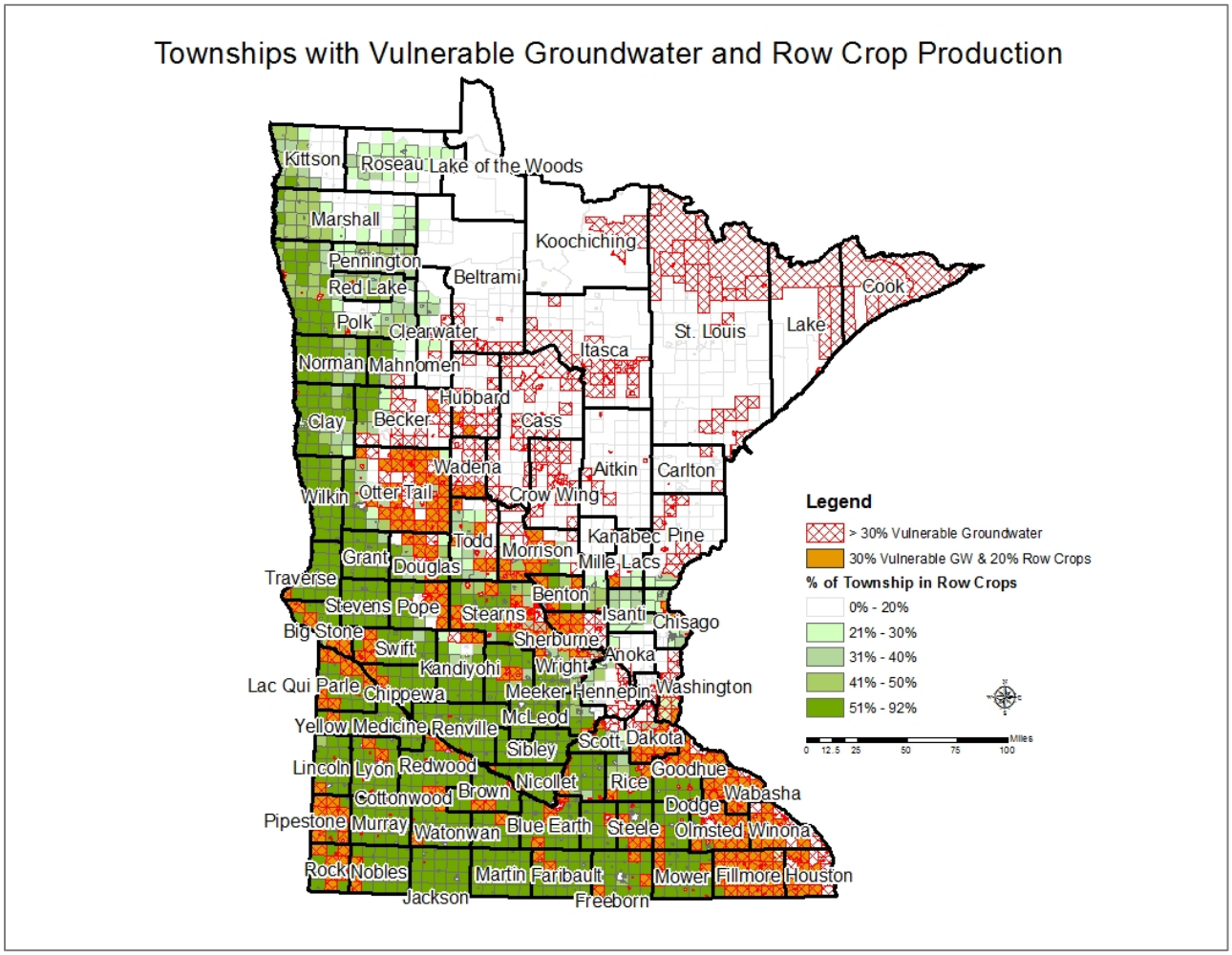

Figure 4. Townships with Vulnerable Groundwater and Row Crop Production

METHODS

Aldrich and Wing River Townships were chosen for sampling based on high results from the 2011 Central Sands Private Well Network sampling event. Thomastown and Wadena 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 a majority of 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 complete 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: Aldrich, Thomastown, Wadena, and Wing River.

RESULTS

Approximately 270 well owners returned water samples for analysis across the four townships (Figure 5). On average, 29 percent of households in these townships responded to the free nitrate test offered by MDA (Table 4). The results of the township nitrate sampling are displayed in Figure 5. The summary statistics are presented in Table 5, which shows all of the well types except those of hand dug construction. Only one sample came from a well that was of hand dug construction.

The minimum values for each township were less than the detection limit which is 0.03 mg/L. The maximum values range from 21.2 to 32.4 mg/L, with Aldrich Township having the highest result. Median values ranged from < 0.03 to 0.8 mg/L, with Wadena Township having the highest median value. The 90th percentiles ranged from 7.7 to 21.6 mg/L, with Aldrich Township having the highest value.

Results from the sampling showed that in Wadena Township, 19 percent of wells were greater than the 10 mg/L. In Aldrich Township, 18 percent of the wells were over 10 mg/L, Wing River Township at 13 percent and in Thomastown Township, only four percent were over 10 mg/L. Previous sampling of 72 wells in Wadena County showed that 8 percent of wells were at or over 10 mg/L (Kaiser, 2012). This data suggests Aldrich and Wadena Townships are more impacted than the other two townships sampled. Wadena Township had both the highest percent of vulnerable groundwater and highest percent of row crop production compared to the other two townships (Table 6).

With the exception of Thomastown Township, 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 five 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 4. Township Population, Households, Sample Kit Distribution and Return Rate

Township	2012 Population	2012 Households	Kits Sent	Kits Returned	Return Rate
Aldrich	430	174	135	33	24%
Thomastown	818	300	276	110	40%
Wadena	857	342	353	95	27%
Wing River	466	183	126	32	25%
Total	2571	999	890	270	*29%

* Represents the average return rate

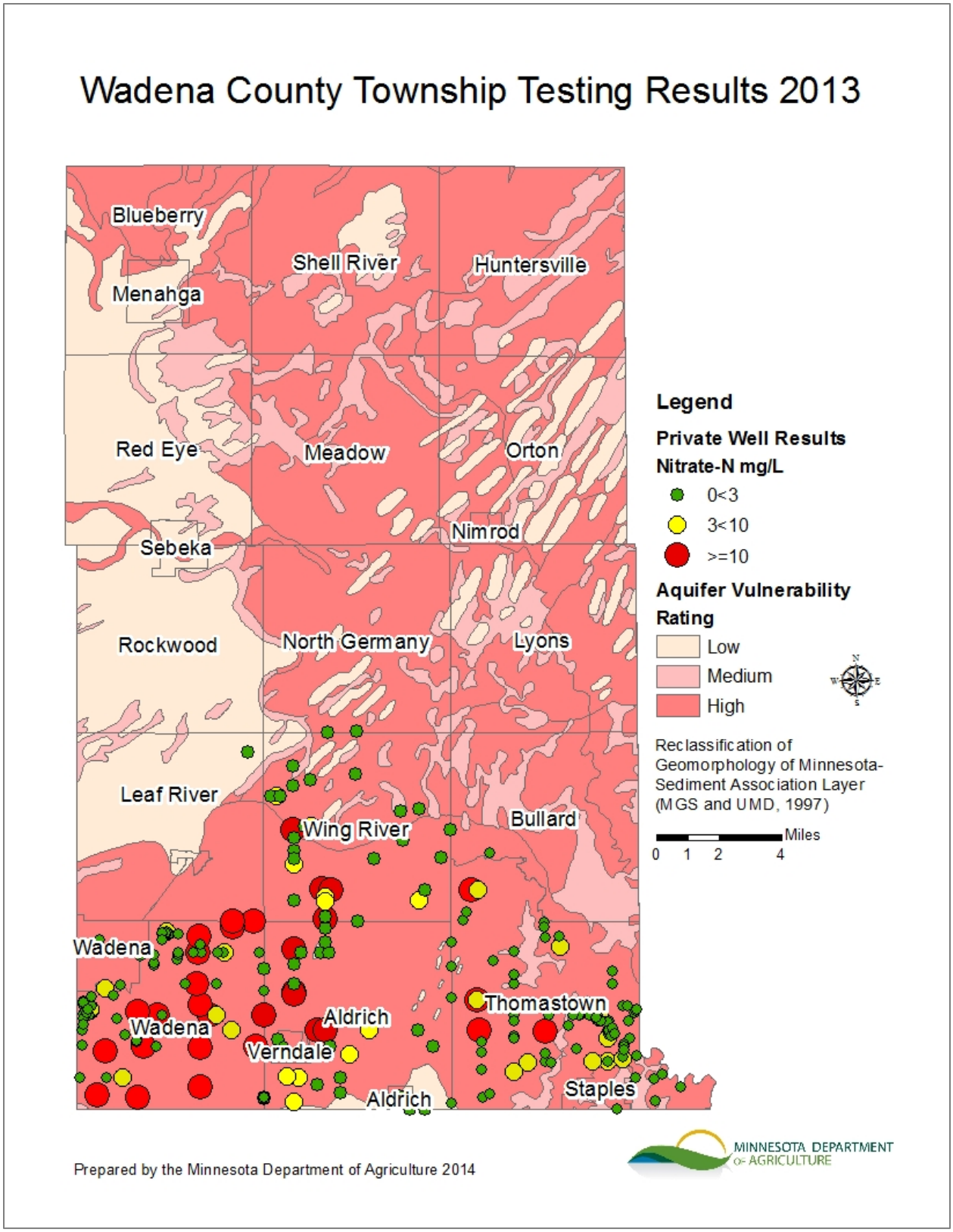

Figure 5. Wadena County Private Well Township Sampling Results 2013

Table 5. Wadena 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-N mg/L or parts per million (ppm)																	
Aldrich	33	<DL	32.4	4.9	<DL	5.8	21.6	23.8	32.4	22	5	9	7	6	67%	15%	27%	21%	18%
Thomastown	109	<DL	21.2	1.4	<DL	0.1	7.7	9.8	16.8	94	11	15	13	4	86%	10%	14%	12%	4%
Wadena	95	<DL	31.3	4.4	0.8	6.5	14.5	20.8	29.6	67	10	26	22	18	71%	11%	27%	23%	19%
Wing River	32	<DL	23.4	3.5	<DL	4.1	12.7	21.8	23.4	22	6	6	5	4	69%	19%	19%	16%	13%

< 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 Aquifer	Percent Row Crop Production	Percent of Wells* Nitrate-N >= 10 mg/L	90th Percentile Nitrate-N mg/L
Aldrich	33	93%	39%	18%	21.6
Thomastown	109	88%	29%	4%	7.7
Wadena	95	99%	49%	19%	14.5
Wing River	32	98%	18%	13%	12.7

*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 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 erroneous. The following section is a summary of information gathered from the well owner survey (complete well survey results are located in Appendix B at the end of this document, Tables 8-22).

The majority of wells in each township are located on "rural" property. Approximately 60 percent of wells in these townships are of drilled construction and 33 percent are sand-point wells. Throughout the four townships, there was only one hand dug well, found in Thomastown Township. Sand point (drive-point) wells are typically completed at shallower depths than drilled wells. Whether a steel or plastic casing is installed, the well code requires that it be watertight and extend at least 15 feet below the ground surface. Sand point wells are also usually installed in areas where sand is the dominant geologic material and where there are no thick confining units such as clay. A confining layer can create a physical barrier to vertical nitrate movement from the water table to deeper portions of the aquifer. These factors make sand point wells more vulnerable to contamination from the surface. Most wells in these townships are less than 100 feet deep. The majority of wells are completed between 11 and 40 feet below ground surface. Well age does not seem to be as much of a factor in affecting nitrate concentrations as the well depth.

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 sometimes be linked to the nitrate result. In this case, 25 wells (nine percent) were identified in the CWI and well logs were obtained (Table 7).

Only Thomastown Township had more than 10 wells with Unique IDs and well logs. Two of the wells were identified as water table wells and none of those were greater than or equal to 10 mg/L. Thirteen were completed in buried sand and gravel aquifers and none of these were greater than or equal to 10 mg/L.

Table 7. Aquifer Designation and Nitrate Results

Township	Aquifer Designation	Total Wells	Ave Depth	Number			Percent		
				<3	3<10	≥10	<3	3<10	≥10
			(Feet)	Nitrate-N mg/L					
Aldrich	Water Table	1	32.0	1	0	0	100%	0%	0%
	Quaternary Buried	1	138.0	1	0	0	100%	0%	0%
Thomastown	Water Table	2	42.0	1	1	0	50%	0%	0%
	Quaternary Buried	13	98.6	12	1	0	92%	8%	0%
Wadena	Water Table	2	68.0	2	0	0	100%	0%	0%
	Quaternary Buried	4	131.0	4	0	0	100%	0%	0%
Wing River	Quaternary Buried	2	73.5	1	0	1	50%	0%	50%
Total	All	25	83.3	22	2	1	88%	8%	4%

* 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 homeowners (complete well survey results are located in Appendix B at the end of this document, Tables 8-22).

- On average only 15 percent of the well owners responded that they have livestock (greater than 10 head of cattle or other equivalent) on their property.
- Few well owners (one percent) across all townships store more than 500 pounds of fertilizer on their property.
- Sixty-four percent of wells are greater than 300 feet from an active or inactive feedlot.
- The majority of wells are more than 50 feet away from septic systems.
- Farming takes place on 38 percent of the properties within these four townships.

- Agricultural fields are greater than 300 feet from wells at 50 percent of the properties.

SUMMARY

Using aquifer (groundwater) vulnerability and row crop production as indicators for nitrate contamination in private wells seems to be a useful tool in targeting nitrate sampling. Results from this study indicated Aldrich Township (18 percent) and Wadena Township (19 percent) had a greater nitrate detection frequency for concentrations above 10 mg/L (which is the state Health Risk Limit (HRL)) as compared to more regional sampling studies. Evaluation of this data suggests Aldrich and Wadena Townships are more impacted than Thomastown or Wing River Townships. Aldrich and Wadena Townships also have the highest percent of vulnerable groundwater and highest percent of row crop production compared to the other two townships.

The lower concentrations in Thomastown and Wing River Townships may be due to the fact that they partially overly the Pineland Sands surficial aquifer. The Pineland Sands aquifer consists of finer-grained material than the Wadena surficial aquifer. The finer grained material appears to slow the transport of nitrate to the water table or provides conditions for denitrification as compared to coarser grained material.

Future work that will 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 nitrate results and the aquifer designation can be compared in a more comprehensive fashion.

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APPENDIX A

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	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Setting	Percent				
Country	97%	80%	82%	97%	89%
Lake	0%	2%	0%	0%	0%
Sub-division	0%	4%	8%	0%	3%
Not available	3%	14%	10%	3%	7%

Table 9. Well Construction Type

Well Construction Type					
Well Type	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Well Type	Percent				
Drilled	58%	71%	42%	69%	60%
Sand point	36%	18%	51%	28%	33%
Hand dug well	0%	1%	0%	0%	0%
Not available	6%	10%	7%	3%	7%

Table 10. Age of Well

Well Age					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Age	Percent				
0-10 years	6%	21%	13%	22%	15%
11-20 years	30%	25%	23%	31%	27%
21-40 years	48%	36%	39%	31%	39%
over 40 years	9%	10%	15%	13%	12%
Not available	6%	8%	11%	3%	7%

Table 11. Depth of Well

Well Depth					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Depth	Percent				
0-50 feet	48%	29%	54%	34%	41%
51-100 feet	27%	34%	26%	34%	30%
101-300 feet	12%	25%	12%	25%	19%
over 300 feet	0%	0%	0%	0%	0%
Not available	12%	12%	8%	6%	10%

Table 12. Unique Well ID Known

Does the Well have a Unique ID					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Unique ID	Percent				
No	52%	27%	39%	28%	36%
Yes	6%	17%	8%	6%	10%
Not available	42%	55%	53%	66%	54%

Table 13. Livestock Located on Property

Livestock on Property					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Livestock	Percent				
No	70%	79%	84%	69%	75%
Yes	27%	8%	7%	19%	15%
Not available	3%	13%	8%	13%	9%

Table 14. Fertilizer Stored on Property

Fertilizer Stored on Property					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Fertilizer	Percent				
No	97%	88%	93%	94%	93%
Yes	0%	0%	1%	3%	1%
Not available	3%	12%	6%	3%	6%

Table 15. Farming on Property

Does Farming take place on Property					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Farming	Percent				
No	48%	60%	66%	50%	56%
Yes	48%	28%	27%	47%	38%
Not available	3%	12%	6%	3%	6%

Table 16. Distance to an Active Feedlot

Feedlot located on Property					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Distance to Feedlot	Percent				
0-50 feet	6%	8%	5%	0%	5%
51-100 feet	6%	4%	0%	3%	3%
101-300 feet	24%	4%	7%	19%	13%
over 300 feet	48%	65%	66%	75%	64%
Not available	15%	20%	21%	3%	15%

Table 17. Distance to Septic System

Distance to Septic System					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Distance to Septic	Percent				
0-50 feet	6%	2%	5%	0%	3%
51-100 feet	24%	34%	36%	41%	34%
101-300 feet	55%	44%	41%	47%	47%
over 300 feet	9%	12%	7%	9%	9%
Not available	6%	9%	11%	3%	7%

Table 18. Distance to an Agricultural Field

Distance to an Agricultural Field					
Agricultural Field	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Distance to Field	Percent				
0-50 feet	15%	5%	3%	9%	8%
51-100 feet	9%	8%	11%	3%	8%
101-300 feet	27%	19%	29%	28%	26%
over 300 feet	39%	58%	46%	56%	50%
Not available	9%	10%	11%	3%	8%

Table 19. Drinking Water Well

Is the Well used for Drinking Water					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Drinking Water	Percent				
No	0%	0%	2%	3%	1%
Yes	94%	92%	93%	94%	93%
Not available	6%	8%	5%	3%	6%

Table 20. Treatment System Present

Treatment System used for Drinking Water					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Treatment System	Percent				
None	58%	61%	55%	50%	56%
Filtering System	3%	10%	10%	28%	13%
Reverse Osmosis	18%	9%	13%	9%	12%
Distillation	0%	0%	0%	0%	0%
Other	3%	0%	5%	0%	2%
Not available	18%	20%	17%	13%	17%

Table 21. Last Tested for Nitrate

When was the Well Last Tested for Nitrate					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Last Tested	Percent				
Within the last year	6%	3%	8%	3%	5%
Within the last 3 years	9%	15%	11%	34%	17%
Within the last 10 years	18%	17%	24%	13%	18%
Never Tested	15%	20%	12%	16%	16%
Greater than 10 years	33%	15%	20%	25%	23%
Not sure	12%	23%	20%	6%	15%
Not available	6%	7%	5%	3%	5%

Table 22. Last Nitrate Test Result

What was the Last Nitrate Result					
Township	Aldrich	Thomastown	Wadena	Wing River	Average
Total Wells	33	110	95	32	68
Last Nitrate-N Result	Percent				
<3 mg/L	15%	23%	14%	31%	21%
3-10 mg/L	12%	5%	10%	13%	10%
> 10 mg/L	9%	<1%	12%	9%	8%
Not available	64%	72%	64%	47%	62%