FINAL TOWNSHIP TESTING NITRATE REPORT: WASHINGTON COUNTY 2014-2015

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Pesticide and Fertilizer Management Division

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EXECUTIVE SUMMARY

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 sources such as fertilizer, animal manure, and human waste. Nitrate is a concern because it can be a risk to human health at elevated levels. The Minnesota Department of Health (MDH) has established a Health Risk Limit (HRL) of 10 mg/L nitrate as nitrogen (nitrate-N) for private drinking water wells in Minnesota.

In response to health concerns over nitrate-N in drinking water the Minnesota Department of Agriculture (MDA) developed the Nitrogen Fertilizer Management Plan (NFMP). The NFMP outlines a statewide plan to assess vulnerable areas for nitrate in groundwater known as the Township Testing Program.

The goal of the Township Testing Program is to identify areas that have high nitrate concentrations in their groundwater. Areas were selected based on historically elevated nitrate conditions, aquifer vulnerability and row crop production. The MDA plans to offer nitrate tests to more than 70,000 private well owners in over 300 townships by 2019. This will be one of the largest nitrate testing efforts ever conducted and completed.

In 2014 private wells in the Washington County study area (one township and one city) were sampled for nitrate. Samples were collected from private wells using homeowner collection and mail-in methods. These initial samples were collected from 526 wells representing 37 percent response rate of homeowners. Well log information was obtained when available and correlated with nitrate results.

The MDA completed follow-up sampling and well site visits at 169 wells in 2015. A follow-up sampling was offered to all homeowners with wells that had a detectable nitrate result.

A well site visit was conducted to identify wells that were unsuitable for analysis. Wells with construction issues or nearby potential point sources of nitrogen were removed from the final well dataset. Point sources of nitrogen include: feedlots, subsurface sewage treatment systems, fertilizer spills, bulk storage of fertilizer, and wastewater treatment plants. A total of 85 (16%) wells were removed from the dataset. The final well dataset had a total of 441 wells.

The final well dataset was analyzed to determine the percentage of wells over the HRL of 10 mg/L nitrate-N. When analyzed at the township or city scale the percent of wells over the HRL ranged from 8.3 to 20.2 percent.

INTRODUCTION

The Minnesota Department of Agriculture (MDA) is the lead agency for nitrogen fertilizer use and management. The NFMP is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The MDA revised the Nitrogen Fertilizer Management Plan (NFMP) in 2015. Updating the NFMP provided an opportunity to restructure county and state strategies for reducing nitrate contamination of groundwater, with more specific, localized accountability for nitrate contamination from agriculture. The NFMP outlines how the MDA addresses elevated nitrate levels in groundwater. The NFMP has four components: prevention, monitoring, assessment and mitigation.

The primary goal of nitrate monitoring and assessment is to develop a comprehensive understanding of the severity, magnitude, and long term trends of nitrate in groundwater as measured in public and private wells. The MDA established the Township Testing Program to determine current nitrate concentrations in private wells on a township scale. This program is designed to quickly assess a township in a short time window. Monitoring focuses on areas of the state where groundwater nitrate contamination is more likely to occur. This is based initially on hydrogeologically vulnerable areas where appreciable acres of agricultural crops are grown. Statewide the MDA plans to offer nitrate tests to more than 70,000 private well owners in over 300 townships between 2014 and 2019.

In 2014, one township and one city in Washington County were selected to participate in the Township Testing Program (Figure 1). Areas were chosen based on several criteria. Criteria used includes: professional knowledge shared by the local soil and water conservation district (SWCD) or county environmental departments, past high nitrate as nitrogen (nitrate-N) results, vulnerable groundwater, and the amount of row crop production. Initial water samples were collected from private wells by homeowners and mailed to a laboratory. Sample results were mailed by the lab to the participating homeowners. The sampling, analysis, and results were provided at no cost to participating homeowners and paid for by the Clean Water Fund.

Well owners with detectable nitrate-N results were offered a no cost pesticide sample and a follow-up nitrate-N sample collected by MDA staff. The MDA began evaluating pesticide presence and concentrations in private water wells at the direction of the Minnesota Legislature. The follow-up pesticide and nitrate-N sampling in Washington County occurred in 2015. The follow-up included a well site visit (when possible) in order to rule out well construction issues and to identify potential point sources of nitrogen (Appendix B). Wells that had questionable construction integrity or are near a point source of nitrogen were removed from the final well dataset. After the unsuitable wells were removed, the nitrate-N concentrations of well water were assessed for each area.

For further information on the NFMP and Township Testing Program, please visit the following webpages:

www.mda.state.mn.us/nfmp
www.mda.state.mn.us/townshiptesting

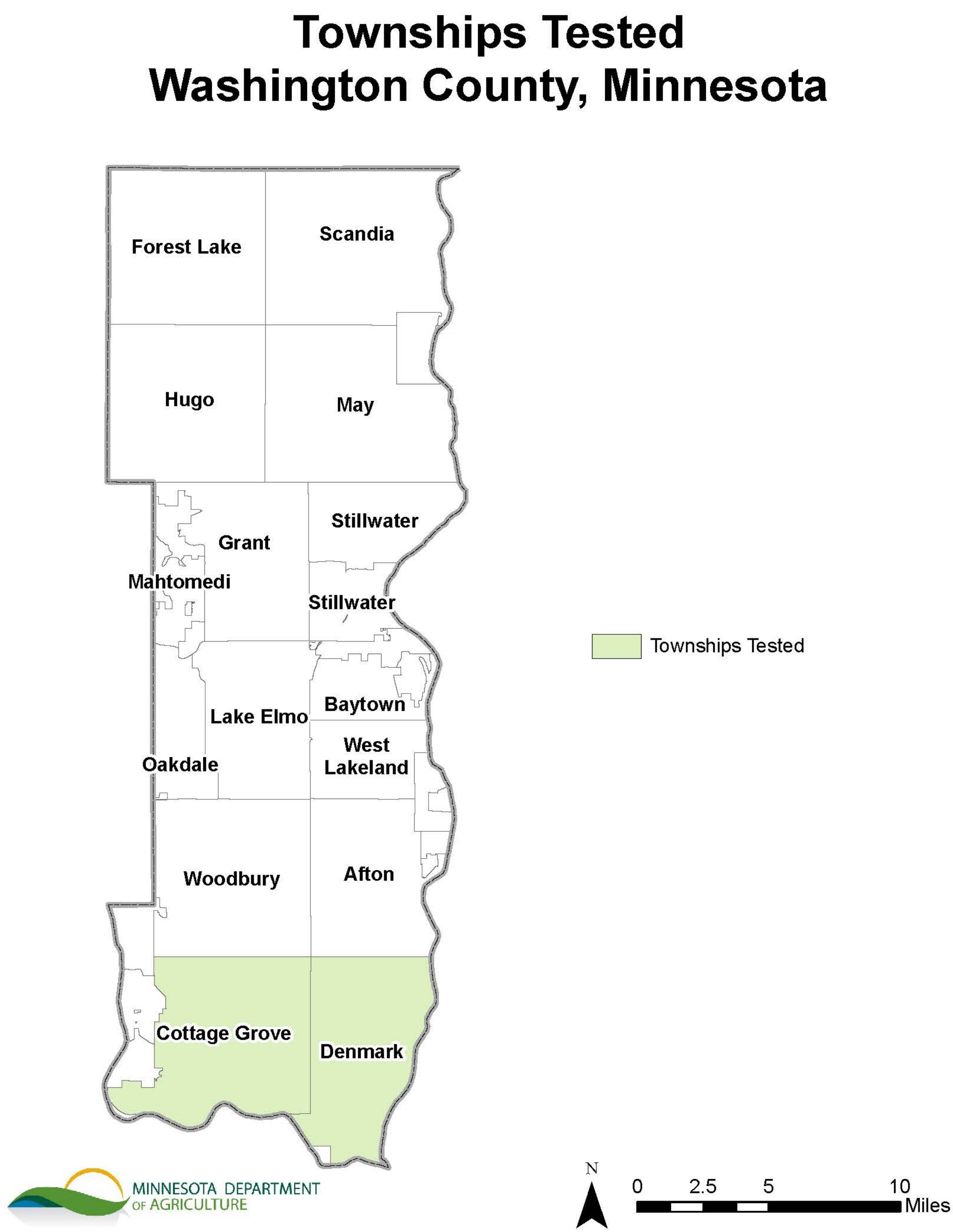

Figure 1. Townships Tested in Washington County

BACKGROUND

In many rural areas of Minnesota, nitrate is one of the most common contaminants in groundwater, and in some localized areas, 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 other 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 United States Environmental Protection Agency has established a drinking water Maximum Contaminant Level (MCL) of 10 mg/L for nitrate as nitrogen (nitrate-N) (US EPA, 2009) in municipal water systems. The Minnesota Department of Health (MDH) has also established a Health Risk Limit (HRL) of 10 mg/L nitrate-N for private drinking water wells in Minnesota.

Nitrogen present in groundwater can be found in the forms of nitrite and nitrate. In the environment, nitrite generally converts to nitrate, which means nitrite occurs very rarely in groundwater. The nitrite concentration is commonly less than the reporting level of 0.01 mg/L, resulting in a negligible contribution to the nitrate plus nitrite concentration (Nolan and Stoner, 2000). Therefore, analytical methods generally combine nitrate plus nitrite together. 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 stable and can move large distances from its source. However, in some settings 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 Washington County with glacial outwash aquifers and intensive row crop agriculture, are particularly vulnerable to elevated nitrate concentrations. However, geochemical conditions can be variable within an aquifer or region and can change over-time (MPCA, 1998).

NITROGEN POINT SOURCES

The focus of the Township Testing Program is to assess nitrogen contamination in groundwater as a result of commercial nitrogen fertilizer applied to cropland. Any wells potentially impacted by point sources were removed from the final well dataset. Potential point sources such as subsurface sewage treatment systems (more commonly known as septic systems), feedlots, fertilizer spills, bulk storage of fertilizer, and wastewater treatment plants are considered in this section. Below is a brief overview of these sources in Washington County. Further details are in Appendix B.

SUBSURFACE SEWAGE TREATMENT SYSTEM

Subsurface Sewage treatment systems (SSTS) can be a potential source for contaminates in groundwater such as nitrate and fecal material (MDH, 2014).

Washington County keeps electronic records of SSTS permits, inspections and maintenance. There are electronic records of inspections since 2009, pumping records from 2000-2013 and permits records since 2015. According to Washington County (2015), 71.6 percent of their inspections during this five year period were compliant, 24.4 percent were “failing to protect groundwater” (FTPGW) and 6.6 percent were an “imminent threat to public health and safety” (ITPHS) (Appendix B, Table 6). In 2014, Washington County reported a total of 18,528 SSTS. Of these only 393 (2.1%) were inspected for compliance (MPCA, 2015a).

FEEDLOT

Manure produced on a feedlot can be a potential source of nitrogen pollution if improperly stored or spread. In the Washington County study area there are a total of 14 feedlots. The majority of the feedlots are permitted to house less than 100 animal units (AU) (Appendix B; Figure 3). Denmark Township has the most permitted AU per square mile (Appendix B; Table 8).

FERTILIZER STORAGE LOCATION

Bulk fertilizer storage locations are potential point sources of nitrogen because they store large concentrations of nitrogen based chemicals. Licenses are required for individuals and companies that store large quantities of fertilizer. The Washington County study area has one bulk fertilizer storage license and one anhydrous ammonia storage license and 24 chemigation sites (Appendix B; Table 9).

FERTILIZER SPILLS AND INVESTIGATIONS

There have only been three historic fertilizer spills in the Washington County study area. Each of these were located in Cottage Grove (Appendix B; Table 10 and Table 11).

TOWNSHIP TESTING METHODS

VULNERABLE TOWNSHIPS

Well water sampling is focused on areas that are considered vulnerable to groundwater contamination by nitrogen fertilizer. Typically townships and cities are selected for sampling if more than 30 percent of the underlying geology is considered vulnerable and more than 20 percent of the land cover is row crop agriculture. These are not rigid criteria, but are instead used as a starting point for creating an initial plan. A map depicting the areas that meet this preliminary criteria can be found in the initial Washington County report (MDA, 2016a). Additional factors such as previous nitrate results and local knowledge of groundwater conditions were, and continue to be, used to prioritize townships for testing.

Aquifer sensitivity ratings from the Minnesota Department of Natural Resources were used to estimate the percentage of geology vulnerable to groundwater contamination. The ratings are based upon guidance from the Geologic Sensitivity Project Workshop's report "Criteria and Guidelines for Assessing Geologic Sensitivity in Ground Water Resources in Minnesota" (MDNR, 1991). A map depicting these sensitivities and a more detailed description can be found in the initial Washington County report (MDA, 2016a). The National Agriculture Statistics Service data (USDA NASS, 2013) on cropland was used to determine the percentage of row crop agriculture. A map and table depicting the extent of the cropland in Washington County can be found in Appendix C (Figure 5, Table 12).

PRIVATE WELL SAMPLING - NITRATE

The testing is done in two steps in each township: "initial" sampling and "follow-up" sampling. The initial sampling for nitrate-N was conducted in 2014. In the initial sampling, all private well owners in the selected townships or cities are sent a nitrate test kit. These kits include instructions on how to collect a water sample, a sample bottle, a voluntary survey, and a prepaid mailer. Each homeowner was mailed the nitrate result for their well along with an explanatory brochure (Appendix D). Well water samples were collected by 526 homeowners using the mail-in kit (

Table 1). These 526 samples are considered the "initial well dataset".

All of the homeowners with a nitrate-N detection from the initial sampling were asked to participate in a follow-up well site visit and sampling. The well site visit and follow-up sampling was conducted in 2015 by MDA staff and supplemented by Washington County conservation district staff. A total of 169 follow-up samples were analyzed (Table 1).

Each follow-up visit was conducted at the well site by a trained MDA hydrologist. Well water was purged from the well for 15 minutes before a sample was collected to ensure a fresh water sample. Additionally, precautions were taken to ensure no cross-contaminate occurred. A more thorough explanation of the sampling process is described in the sampling and analysis plan (MDA, 2016b). As part of the follow-up sampling, homeowners were offered a no cost pesticide test. As pesticide results are finalized they will be posted online in a separate report (www.mda.state.mn.us/pwps).

Table 1. Homeowner Participation in Initial and Follow-Up Well Water Sampling, Washington County

Township	Estimated Households on Private Wells*	Initial Well Dataset	Well Site Visits & Follow-Up Sampling Conducted
Cottage Grove (City)	800	300	109
Denmark	625	226	60
Total	1425	526	169

* Estimate provided by Washington County.

The well site visit was used to collect information on potential nitrogen point sources, well characteristics (construction type, depth, and age) and the integrity of the well construction. Well site visit information was recorded on the Well Information and Potential Nitrate Source Inventory Form (Appendix A).

WELL ASSESSMENT

All wells testing higher than 5 mg/L were carefully examined for well construction, potential point sources and other potential concerns.

Using the following criteria, a total of 85 wells were removed to create the final well dataset. See Appendix E (Table 15 and 16) for a summary of the removed wells.

HAND DUG

All hand dug wells were removed from the dataset, even if the nitrate-N result was less than 5 mg/L. Hand dug wells do not meet well code and are more susceptible to local surface runoff contamination. Hand dug wells are often very shallow, typically just intercepting the water table, and therefore are much more sensitive to local surface runoff contamination (feedlot runoff), point source pollution (septic system effluent), or chemical spills.

POINT SOURCE

Well code in Minnesota requires wells to be at least 50 feet away from most possible nitrogen point sources such as SSTS (septic tanks and drain fields), animal feedlots, etc. High nitrate-N wells that did not maintain the proper distance from these point sources were removed from the final well dataset. Information gathered from well site visits was used to assess these distances. If a well was not visited by MDA staff, the well survey information provided by the homeowner and aerial imagery was reviewed.

WELL CONSTRUCTION PROBLEM

The well site visits allowed the MDA staff to note the well construction of each well. Some wells had noticeable well construction problems. For instance, a few wells were missing bolts from the cap, making the groundwater susceptible to pollution. Other examples include wells buried underground or wells with cracked casing. Wells with significant problems such as these were excluded from the final well dataset.

IRRIGATION WELL

If the water sample from the initial homeowner sample was likely collected from an irrigation well, it was removed from the dataset. This study is focused on wells that supply drinking water.

UNSURE OF WATER SOURCE

Also, if the water source of the sample was uncertain, then data pertaining to this sample was removed.

SITE VISIT COMPLETED - WELL NOT FOUND & CONSTRUCTED BEFORE 1975 & NO WELL ID

Old wells with no validation on the condition of well construction were removed from the dataset. These wells were installed before the well code was developed in Minnesota (mid-1975), did not have a well log, and MDA staff could not locate the well during a site visit.

NO SITE VISIT & CONSTRUCTED BEFORE 1975 & NO WELL ID

Additionally if there was no site visit conducted, and the well is an older well (pre-1975) the well would not be used in the final analysis.

NO SITE VISIT & INSUFFICIENT DATA & NO WELL ID

Wells that were clearly lacking necessary background information were also removed from the dataset. These wells did not have an associated well log, were not visited by MDA staff, and the homeowner did not fill out the initial well survey or the address could not be found.

RESULTS

FINAL WELL DATASET

A total of 526 well water samples were collected by homeowners from the two communities. A total of 85 (16%) wells were removed to create the final well dataset. The final analysis was conducted on the remaining 441 wells (Table 2). The wells in the final well dataset represent ambient groundwater conditions.

WELL WATER NITROGEN ANALYSIS

The final analysis was based on the number of wells over the nitrate-N Health Risk Limit of 10 mg/L. percent.

Table 2 shows the results for both communities sampled. The percent of wells at or over the Health Risk Limit ranged from 8.3 to 20.2 percent.

Table 2. Initial and Final Well Dataset Results, Washington County

Township	Initial Well Dataset	Final well Dataset	Wells ≥10 mg/L Nitrate-N	
			Count	Percentage
Cottage Grove (city)	300	248	50	20.2%
Denmark	226	193	16	8.3%
Total	526	441	66	15.0%

The individual nitrate-N results from this final well dataset are displayed spatially in Figure 2. Due to the inconsistencies with geocoding the locations, the accuracy of the points is variable and ten wells are not depicted.

The final well dataset summary statistics are shown in Table 3. The minimum values were all below the detection limit. The maximum values ranged from 16.4 to 23.7 mg/L nitrate-N, with Cottage Grove having the highest result. The 90th percentile ranged from 9.1 to 13.9 mg/L nitrate-N, with Cottage Grove having the higher result.

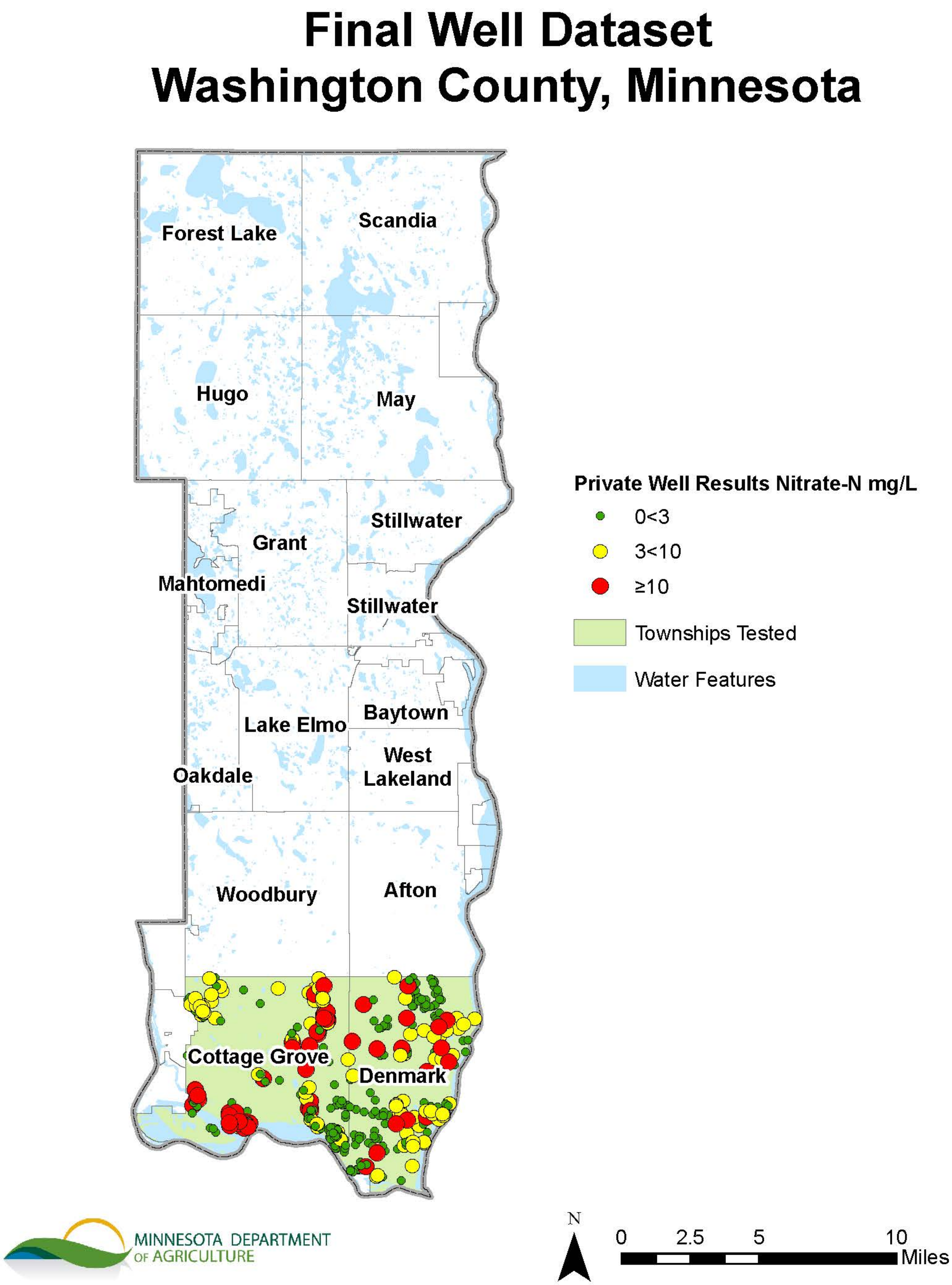

Figure 2. Well Locations and Nitrate Results from Final Well Dataset in Washington County

Table 3. Washington County Township Testing Summary Statistics for Final Well Dataset

Township	Total Wells	Values			Percentiles					Number of Wells					Percent				
		Min	Max	Mean	(50^{th}) Median	75th	90th	95th	99th	<3	3<10	≥5	≥7	≥10	<3	3<10	≥5	≥7	≥10
		Nitrate-N mg/L or parts per million (ppm)																	
Cottage Grove (city)	248	<0.03	23.7	4.6	1.4	8.3	13.9	16.6	20.3	137	61	82	67	50	55.2%	24.6%	33.1%	27.0%	20.2%
Denmark	193	<0.03	16.4	2.6	0.0	4.6	9.1	12.0	14.7	133	44	44	29	16	68.9%	22.8%	22.8%	15.0%	8.3%
Total	441	<0.03	23.7	3.7	0.3	6.0	12.1	14.8	19.0	270	105	126	96	66	61.2%	23.8%	28.6%	21.8%	15.0%

The 50^{th} percentile (75^{th}, 90^{th}, 95^{th}, and 99^{th} respectively) is the value below which 50 percent (75%, 90%, 95% and 99%) of the observed values fall.

As discussed previously, the areas selected were deemed most vulnerable to nitrate contamination of groundwater. Table 4 compares the final results to the percent of vulnerable geology (MDNR, 1997) and row crop production (USDA NASS Cropland Data Layer, 2013) in both communities. The percent land area considered vulnerable geology and in row crop production was estimated using a geographic information system known as ArcGIS.

Table 4. Township Nitrate Results Related to Vulnerable Geology and Row Crop Production, Washington County

Township	Total Wells	Percent Vulnerable Geology	Percent Row Crop Production	Percent ≥7 mg/L	Percent ≥10 mg/L
				Nitrate-N mg/L or parts per million (ppm)	
Cottage Grove (city)	248	95%	21%	27.0%	20.2%
Denmark	193	77%	35%	15.0%	8.3%
Totals	441	86%	28%	21.8%	15.0%

ESTIMATES OF POPULATION AT RISK

The human population at risk of consuming well water over the HRL of 10 mg/L nitrate-N was estimated based on the sampled wells. An estimated 619 people in Washington County's study area may have drinking water over the nitrate-N Health Risk Limit (Table 5). Nitrate contamination is a significant problem across much of Washington County. Additional public awareness and education programming will need to take place in some of the townships.

Table 5. Estimated Population with Water Wells Over 10 mg/L Nitrate-N, Washington County

Township	Estimated Households on Private Wells[1]	Estimated Population on Private Wells[2]	Estimated Population ≥10 mg/L Nitrate-N
Cottage Grove (city)	800	2,360	476
Denmark	625	1,775	147
Total	1,425	4,135	619

[1] Data obtained from Washington County

[2] Estimates based off of the estimated households on private wells and the 2013 persons per household data gathered from Minnesota State Demographic Center (http://mn.gov/admin/demography/)

WELL AND WATER CHARACTERISTICS

WELL CONSTRUCTION

Unique identification numbers from well logs were compiled for the wells within the Washington County final well dataset. The well logs provided information on the well age, depth, and construction type. These well characteristics were also provided by some homeowners. The well characteristics are described below and a more comprehensive view is provided in Appendix F (Tables 17-19).

- The majority of wells were drilled (95%), only 5 (1%) were sand point wells.
- The median depth of wells was 280 feet, and the shallowest was 100 feet
- The median year the wells were constructed in was 1992

WELL WATER PARAMETERS

MDA staff conducted the follow-up sampling. Field measurements of the well water parameters were recorded on a field log (Appendix G). The measurements included temperature, pH, specific conductivity, and dissolved oxygen. The well was purged for 15 minutes, so that the measurements stabilized, ensuring a fresh sample of water was collected. The stabilized readings are described below and a more comprehensive view is available in Appendix H (Tables 20-23).

- The temperatures ranged 8.04 °C to 13.56 °C
- The median specific conductivity was 562 µS/cm, and was as high as 1030 µS/cm
- The water from the wells had a median pH of 7.73
- The dissolved oxygen readings ranged from 0.02 mg/L to 15.74 mg/L

Water temperature can affect many aspects of water chemistry. Warmer water can facilitate quicker chemical reactions, and dissolve surrounding rocks faster; while cooler water can hold more dissolved gases such as oxygen (USGS, 2015).

Specific conductance is the measure of the ability of a material to conduct an electrical current at 25°C. Thus the more ions present in the water, the higher the specific conductance measurement (Hem, 1985). Rainwater and freshwater range between 2 to 100 µS/cm. Groundwater is between 50 to 50,000 µS/cm (Sanders, 1998).

The United States Environmental Protection Agency has set a secondary pH standard of 6.5-8.5 in drinking water. These are non-mandatory standards that are set for reasons not related to health, such as taste and color (40 C.F.R. §143).

Dissolved oxygen concentrations are important for understanding the fate of nitrate in groundwater. When dissolved oxygen concentrations are low (<0.5 mg/L) (Dubrovsky, 2010), bacteria uses electrons on the nitrate molecule to convert nitrate into nitrogen gas (N_2). Thus nitrate can be removed from groundwater through the process known as bacterial denitrification (Knowles, 1982).

SUMMARY

The focus of this study is to assess nitrate-N concentrations in groundwater impacted by row crop production. In order to prioritize testing, the MDA looked at townships with significant row crop production and vulnerable geology. Approximately 28 percent of the land cover is row crop agriculture and there are over 1,906 acres of groundwater irrigation in the study area.

One township and one city were sampled covering over 43,327 acres. The initial (homeowner collected) nitrate sampling resulted in 526 samples, which was 37 percent of the population on private wells. Well owners with measureable nitrate results were offered a follow-up nitrate sample and a pesticide sample. The MDA resampled and visited 169 wells.

The MDA conducted a nitrogen source assessment and identified wells near potential point sources and wells with poor construction. A total of 85 (16%) wells were found to be unsuitable and were removed from the final well dataset of 441 wells. The remaining wells were wells believed to be impacted by nitrogen fertilizer and were included in the final well dataset.

A majority of wells (95%) were drilled; less than 1 percent were sand points. The median depth of the wells was 240 feet and depths ranged from 100 to 420 feet.

In Cottage Grove more than 10 percent of the wells were over the Health Risk Limit of 10 mg/L. The percent of wells over the Health Risk Limit in each township ranged from 8.3 to 20.2 percent.

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APPENDIX A

Well information and Potential Nitrate Source Inventory Form

UNIQUE NUMBER:________________ or SITE ID:______________________

Well Information and Potential Nitrate Source Inventory Form

General Information

Date of Visit: ________________County: ____________________ Township_______________

Well Unique Number (6 digits): ______________ Parcel Number: ______________________

Site ID (from township sampling if no Unique ID):____________________________________

GPS location of well: Latitude:_________________ Longitude:________________________

Owner Name: ____

Owner Phone: ____

Owner Address: ____

e-mail:________________________________

Inspector Name:____________________________Inspector Phone: ____________________

Well Construction Information

1. Is this well used for drinking water? (Circle One) a) YES or b) NO
2. Is the outdoor water raw or filtered? (softened, distilled, reverse osmosis, activated carbon, etc.)

   ____

3. Well Information collected from (Circle One):
   - a) Well Log (**Attach**) or b) Verbal (Indicate Person): _________________
4. Well Construction Type: _______________________ (Drilled, Sand point, Hand-dug, other)
5. Well Construction Date: __________________________
6. Well Depth (Feet): __________________
7. Well Diameter (Inches): _________
8. Pump Installer (Sticker):___________________________
9. Who services the well (if available)? _______________________________
10. Is there more than one well on this property?______________________________________
    - If yes, list well type and Unique No. if available:____________________________

1

UNIQUE NUMBER:________________ or SITE ID:_______________________

11. Is Fertilizer stored on this property(Circle One) a) YES or b) NO
    - If yes, what is the distance to the well?_______________________
12. Historical fertilizer storage? a) YES or b) NO
    - If yes, what is the distance to the well? _______________________
13. Historic/Abandoned septic system? a) YES or b) NO
    - If yes, what is the distance to the well?_______________________
14. List sample types collected at this site:____
15. Have you made any changes to your well in the last year? _____________________________

    (added filtration system, raised well, replaced pump, upgraded well casing, replaced well, etc.)

16. Are there potential nitrate sources nearby that are >300 ft. away from the well, if so list type and approximate distance____

Go to last page for Source Codes and well drawing.

ADDITIONAL NOTES:

____

____

____

____

UNIQUE NUMBER:________________ or SITE ID:_______________________

DIRECTIONS: Stand at the well, find north and describe the type, position and distance to potential nitrate sources with 300 feet of the well. Put a dot where nitrate source is relative to the well. Label the dot with the appropriate code and label the distance. Codes are given below:

CODES

AFL: Animal Feedlot
APB: Animal/Poultry Building
MSA: Manure Storage Area
FSA: Fertilizer Storage Area
LAP: Land Application of Manure, Septage, Sewage Sludge, Waste
FWP: Feeding or Watering Area
DRA: Drain field - Above or Below Grade
PRV: Privy (Old Outhouse)
SET: Septic Tank
AGG: Dry Well, Leaching Pit, Seepage Pit, Injection Well, Agricultural Drainage Well
FIELD: Agricultural Field

17. Does water drain toward the well? a) YES or b) NO

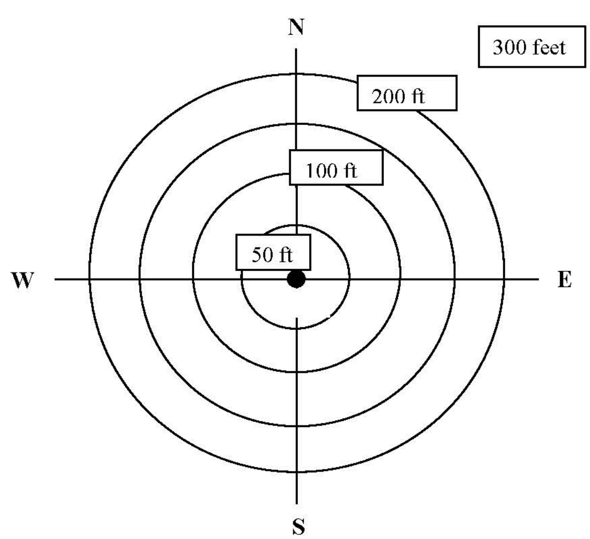
18. Which direction does the landscape slope? (Draw arrow across bull's eye, through well, and label)

19. Is the slope: a) Steep or b) Shallow

20. Are there any *obvious* problems with the well? a) YES or b) NO

21. If yes, describe the problem:____

20. Source Codes and Distances:____



3

APPENDIX B

SUBSURFACE SEWAGE TREATMENT SYSTEM

Most homes that have private wells also have private subsurface sewage treatment systems (SSTS). These treatment systems can be a potential point source for contaminates such as nitrate and fecal material. To protect drinking water supplies in Minnesota, SSTS holding tanks and the associated drain fields are required to be at least 50 feet away from private drinking water wells. The minimum required distance doubles for wells that have less than ten feet of a confining layer or if the well has less than 50 feet of watertight casing (MDH, 2014).

Technical and design standards for SSTS systems are described in Minnesota Rules Chapter 7080 and 7081. Some local government units (LGU) have their own statutes that may be more restrictive or differ from these standards.

Many LGUs collect information on the condition of SSTS in their jurisdiction. Often information is collected when a property is transferred, but inspections can occur at other times as well. A SSTS inspection determines if a system is compliant or non-compliant. A non-compliant treatment system can be further categorized as “failing to protect groundwater (FTPGW)” or “imminent threat to public health and safety (ITPHS)”. A system is considered FTPGW if it is a seepage pit, cesspool, the septic tanks are leaking below their operating depth, or if there is not enough vertical separation to the water table or bedrock. A system is considered ITPHS if the sewage is discharging to the surface water or groundwater, there is sewage backup, or any other condition where the SSTS would harm the health or safety of the public (Minnesota Statutes, section 335.01 and MPCA, 2013a).

Washington County delegates the authority to inspect SSTS to the township or city government. While most have maintenance programs and require inspections at the point of sale of a property, there are very few electronic records of SSTS condition. In 2014 Washington County reported a total of 7,300 SSTS. Of these 133 (1.8%) were inspected for compliance (MPCA, 2015a). A total of 169 inspections were completed in the study area. Approximately 73% of the systems were compliant while 27% were not compliant. Table 6 shows the breakdown of each township for the SSTS compliance inspections.

Table 6. SSTS compliance.

SSTS Compliance 2009-2015		Cottage Grove	Denmark Township	Vulnerable Townships	Washington County
Number of Inspections		104	65	169	1,877
Compliant		74.0%	72.3%	73.4%	71.6%
Non-Compliant	Not Failing or ITPH	1.0%	1.5%	1.2%	1.1%
	Failing only	12.5%	20.0%	15.4%	20.7%
	ITPH only	5.8%	1.5%	4.1%	2.9%
	Failing and ITPH	6.7%	4.6%	5.9%	3.7%
Non-Compliant (total)		26.0%	27.7%	26.6%	28.4%

FEEDLOT

The amount of nitrogen in manure depends on the species of animal. For example, there is approximately 31-32 pounds of nitrogen in 1,000 gallons of liquid dairy cow manure, and 53-63 pounds in 1,000 gallons of liquid poultry manure. Most of the nitrogen in manure is in organic nitrogen or in ammonium (NH_4^+) forms (Hernandez and Schmitt, 2012).

Under the right conditions organic nitrogen can be converted into ammonium and then eventually transformed into nitrate. Nitrate is a highly mobile form of nitrogen that can move into groundwater and become a contamination concern (MPCA, 2013b).

Government agencies regulate feedlots to reduce the risk of contamination to water resources. Rules pertaining to feedlots have been in place since the 1970's; they were revised in 2000 and 2014 (MPCA, 2014). The degree of regulation of a feedlot is dependent on the amount of manure that is produced; measured in animal units (AU) (MPCA, 2011). One AU is equal to the amount of manure produced by one beef cow (Table 7) (MPCA, 2014).

Table 7. Animal Unit Calculations (MPCA, 2014)

Animal Type	Number of Animal Units (AU)
Mature dairy cow (over 1,000 lbs.)	1.4
Cow/calf pair	1.2
Stock cow/steer	1.0
Horse	1.0
Dairy heifer	0.7
Swine (55-300 lbs.)	0.3
Sheep	0.1
Broiler (over 5 lbs., dry manure)	0.005
Turkey (over 5 lbs.)	0.018

Animal feedlots with 1-300 AU require a 50 foot setback from private water wells. Larger feedlots (≥300 AU) must be at least 100 feet away from private water wells. The minimum required distance doubles for wells that have less than ten feet of a confining layer or if the well has less than 50 feet of watertight casing (MDH, 2014).

Farmers must register a feedlot through the Minnesota Pollution Control Agency (MPCA) if they have at least 50 AU, or 10 AU if the feedlot is located near shoreline. Larger feedlots must follow additional regulations. Feedlots with more than 300 AU must submit a manure management plan if they do not use a licensed commercial applicator (MPCA, 2014). Feedlots with more than 1,000 AU are regulated through federal National Pollution Discharge Elimination System (NPDES) permits (MPCA, 2011) and must submit an annual manure management plan as part of their permit (MPCA, 2015d).

As part of new feedlot construction, an environmental assessment must be completed for feedlots with a proposed capacity of greater than 1,000 AU. If the feedlot is located in a sensitive area the requirement for an environmental assessment is 500 AU (MPCA, 2014).

Farmers must register their feedlot if it is in active status. Feedlots are considered active until no animals have been present on the feedlot for five years. To register, farmers fill out paperwork which includes a chart with the type and maximum number of animals on the feedlot. Registration is required to be completed at least once during a set four year period, the most recent period ran from January 2014 to December 2017 (MPCA, 2015b). From 2010 to 2014, approximately 18,000 feedlots were registered in Minnesota (MPCA, 2014). A map and table of the feedlots located in the Washington County study area can be found below (Figure 3; Table 8).

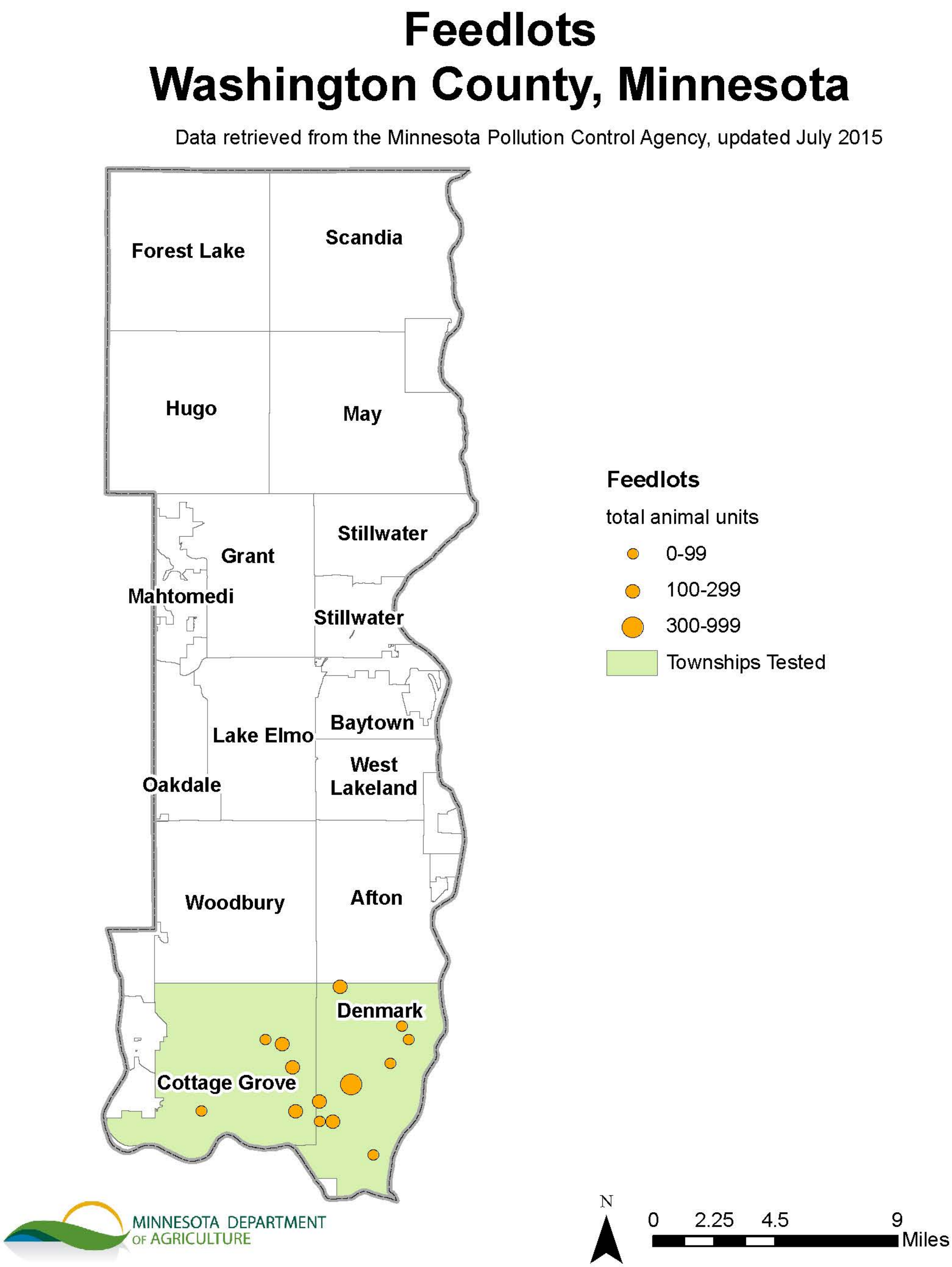


Figure 3. Feedlot Locations in Washington County (MPCA, 2015c)

FERTILIZER STORAGE LOCATION

MDA tracks licenses for bulk fertilizer storage facilities, anhydrous ammonia, and chemigation sites (Table 9). Abandoned sites are facilities that once housed fertilizer chemicals. These sites are also noted and tracked by MDA as they are potential contamination sources.

Table 8. Fertilizer Storage Facility Licenses and Abandoned Sites, Washington County

Township	*Bulk Fertilizer Storage	*Anhydrous Ammonia	*Chemigation Sites	*Abandoned Sites	Total
Cottage Grove (city)	1	1	24	0	24
Denmark	0	0	0	0	0
Total	0	0	24	0	24

* Data retrieved from MDA Pesticide and Fertilizer Management Division, 2015; updated December 2015

SPILLS AND INVESTIGATIONS

MDA is responsible for investigating any fertilizer spills within Minnesota. Figure 4 shows the locations of mapped historic spills within the Washington County study area. These sites are potential point sources of nitrogen to the groundwater (MDA, 2015b).

MDA tracks several types of incidents. Incident investigations are typically for larger spills. There are eight in the study area. Contingency areas are locations that have not been remediated because they were inaccessible or the contaminant could not be removed for some other reason. They are often a part of an incident investigation. There are no contingency areas in this study area. Old emergency incidents were closed prior to March 1st, 2004 (MDA, 2015a), but they can still be a point source. At most of these older sites, the contaminants are unknown and their location may not be precise. Small spills and investigations are typically smaller emergency spills such as a truck spilling chemicals. It is important to note that while the locations of the incidents described are as accurate as possible, it is an incomplete dataset (MDA, 2015a). Many types of spills are reported to the MDA, however only spills that potentially contain nitrogen are reported here. A breakdown of chemical type of these incidents can be found in Table 10. A breakdown of the fertilizer specific spills and investigations, by township, can be found in Table 11.

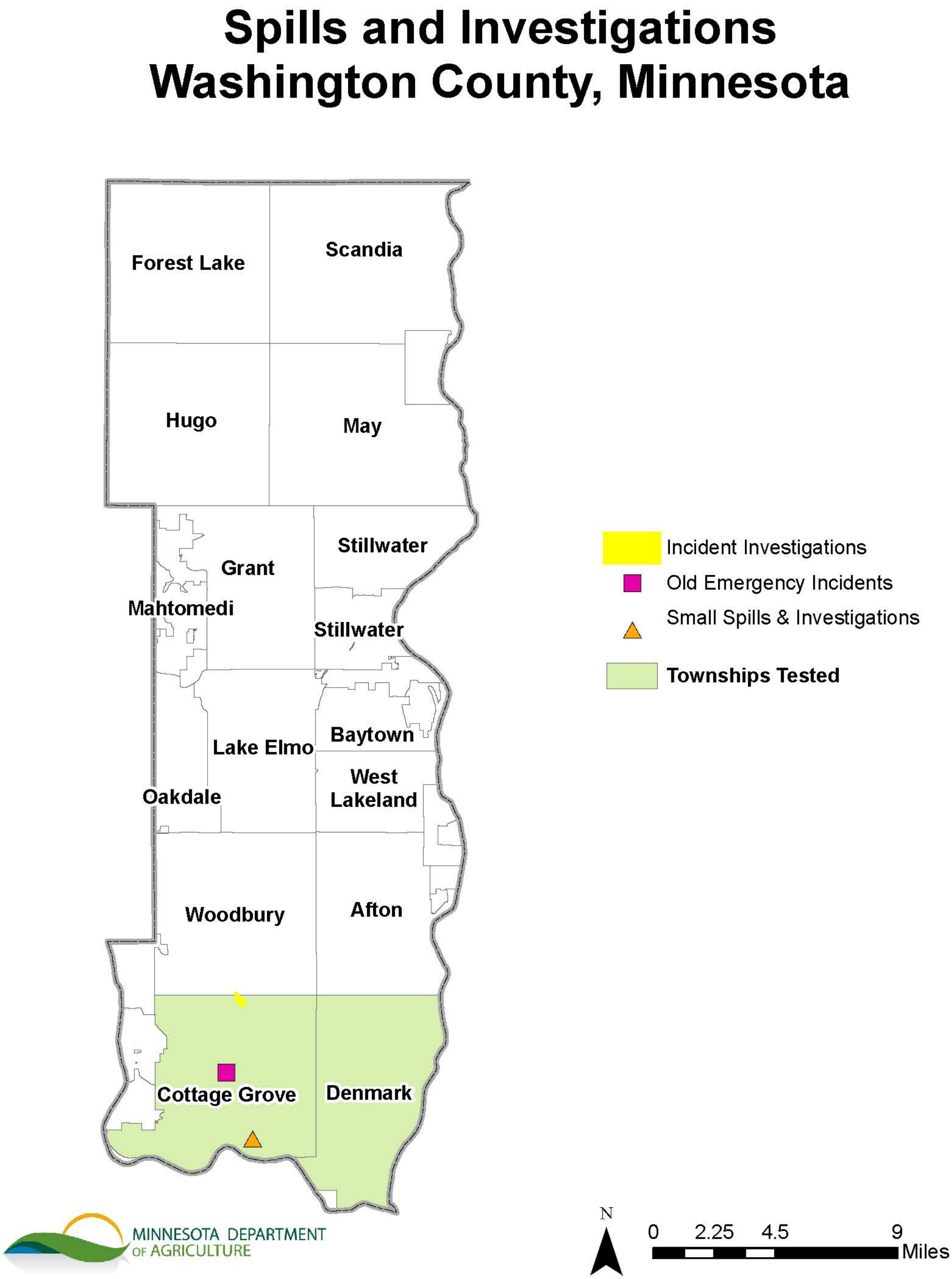


Figure 4. Fertilizer Spills and Investigations in Washington County (MDA, 2015a)

Table 9. Spills and Investigations by Chemical Type, Washington County

Contaminant	Incident Investigations	Contingency Areas	Small Spills and Investigations	Old Emergency Incidents
Fertilizer	1	0	1	0
Pesticides & Fertilizer	0	0	0	1
Anhydrous Ammonia	0	0	0	0
Total	1	0	1	1

Table 10. Fertilizer Related Spills and Investigations by Township, Washington County

Township	Incidents and Spills
Cottage Grove (city)	3
Denmark	0
Total	3

APPENDIX C

LAND AND WATER USE

LAND COVER

Typically locations were selected for the Township Testing Program if at least 20 percent of the land cover was in row crop production. Despite its close proximity to the Twin Cities, 28 percent of the study area is dominated by agricultural activities (Figure 5; Table 12). Row crops can include: corn, sweet corn, soybeans, alfalfa, sugar beets, potatoes, wheat, dry beans and double crops involving corn and soybeans.

Washington County is located just east of a large metropolitan area and abuts the Mississippi River on the south boundary. Eighteen percent of the land area in the two communities is developed. Cottage Grove and Denmark Township are influenced by the Mississippi River to their south; about eight percent of the terrain is water or wetlands.

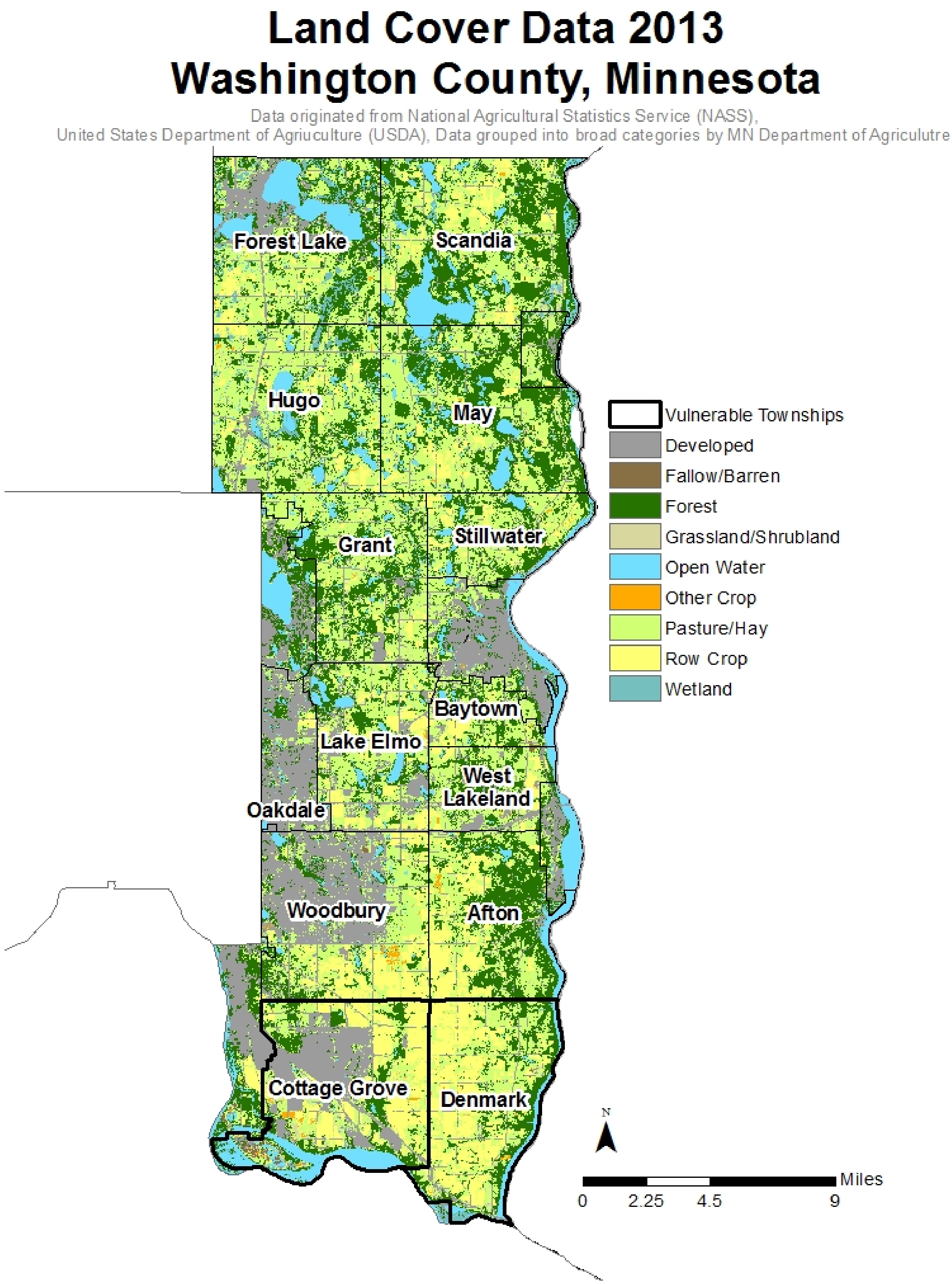


Figure 5. Land Cover in Washington County (USDA NASS Cropland Data Layer, 2013)

Table 11. Land Cover Data (2013) by Township, Washington County (USDA NASS Cropland Data Layer, 2013)

Township	Total Acres	Row Crop	Other Crops	Forest	Open Water	Pasture/ Hay	Wetland	Developed	Fallow/ Barren	Grassland/ Shrubland
Cottage Grove (city)	23,992	21%	1%	14%	11%	19%	1%	28%	1%	3%
Denmark	19,334	35%	0%	19%	6%	31%	1%	5%	0%	2%
Total	43,327	28%	1%	16%	8%	24%	1%	18%	1%	3%

WATER USE

Water use permits are required for wells withdrawing more than 10,000 gallons of water per day or 1,000,000 gallons of water per year (MDNR, 2016). There are a total of 67 groundwater permits in the study region and 14 are used for irrigating crops (Table 13; Figure 6). The major crop irrigation permits total 2,146 acres across the study area. Most permitted wells are withdrawing groundwater from Paleozoic aquifers (Table 14). More specifically the Jordon formation and the Prairie du Chien group are the most heavily utilized aquifers.

Table 12. Active Groundwater Use Permits by Township, Washington County

Township	Major Crop Irrigation Permits	Permitted Irrigated Acres	Average Depth (feet)
Cottage Grove (city)	10	1,046	325
Denmark	4	860	351
Total	14	1906	335

Table 13. Active Groundwater Use Permits by Aquifer, Washington County

Water Use Permits	Total	Average Depth (feet)	Aquifer System			
			Quaternary (Water Table)	Quaternary (Buried)	Paleozoic	Not Classified
Major Crop Irrigation	14	335	0	0	12	2
Non-Crop Irrigation	9	347	0	0	9	0
Waterworks	19	320	2	0	17	0
Industrial Processing	12	196	3	0	7	2
Water Level Maintenance	0	0	0	0	0	0
Special Categories	6	320	0	0	6	4
Air Conditioning	6	194	2	0	4	0
Power Generation	1	230	0	0	1	0
Total	67	290	7	0	56	4

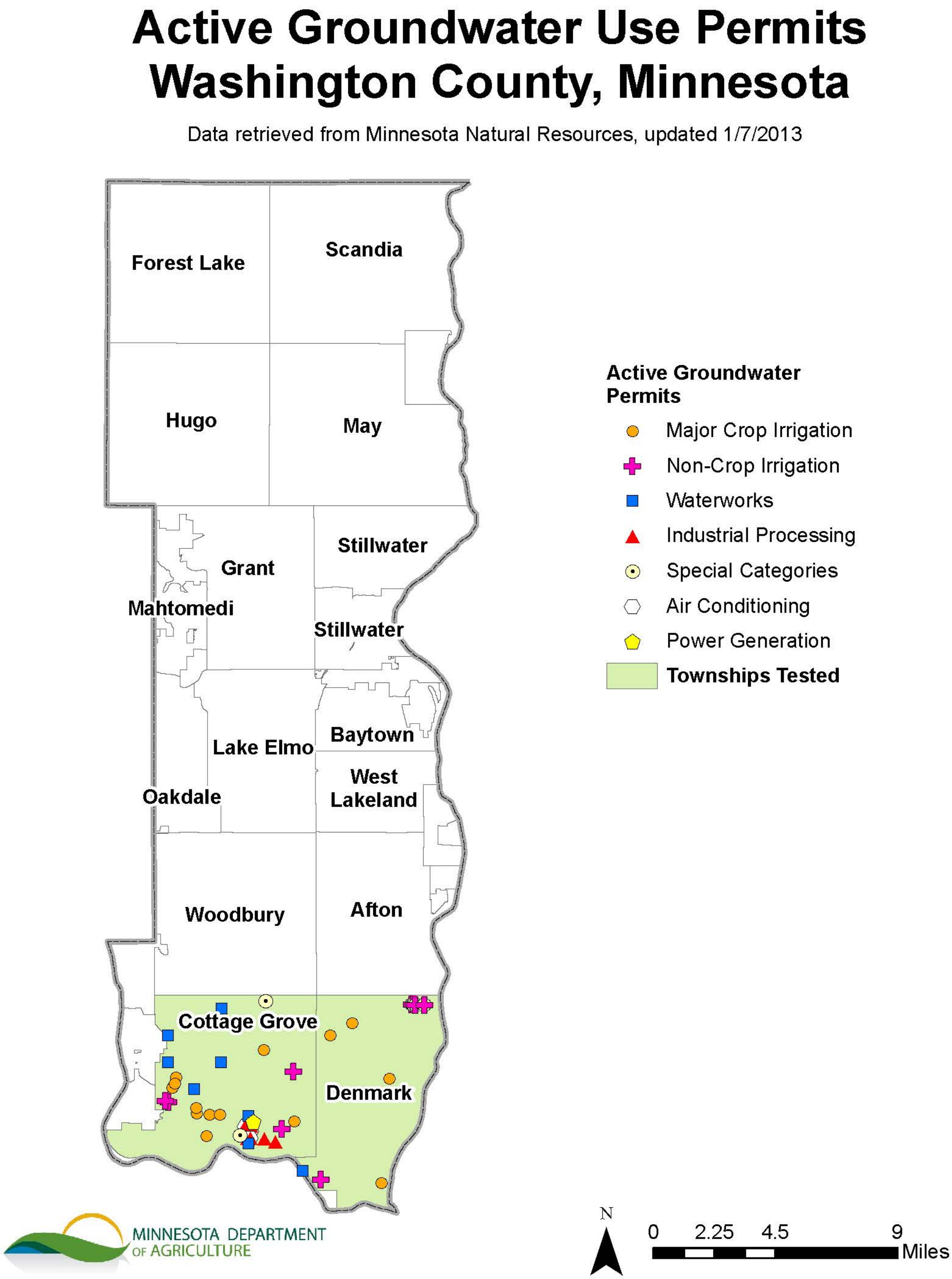


Figure 6. Active Groundwater Use Permits in Washington County (MDNR, 2013)

APPENDIX D

Nitrate Brochure

The Minnesota Department of Agriculture and the _ County SWCD would like to **thank you** for participating in the private well volunteer nitrate monitoring. The results of your water sample are enclosed. Results from this sampling event will be reviewed and summarized and a summary report will be issued to the counties. In addition, the data will be used to determine the need and the design of a long-term monitoring network. Below is general information regarding nitrate result ranges.

If the Nitrate result is between 0 to 4.9 mg/L:

- Continue to test your water for nitrate every year or every other year.
- Properly manage nitrogen sources when used near your well.
- Continue to monitor your septic tank. Sewage from improperly maintained septic tanks may contaminate your water.
- Private wells should be tested for bacteria at least once a year. A Minnesota Department of Health (MDH) certified water testing lab can provide nitrate and bacteria testing services. Search for the lab nearest you at www.health.state.mn.us/labsearch.

If the Nitrate result is between 5 to 9.9 mg/L:

- Presently the nitrate nitrogen level in your water is below the nitrate health standard for drinking water. However, you have a source of contamination which may include: contributions from fertilized lawns or fields, septic tanks, animal wastes, and decaying plants.
- Test annually for both nitrate and bacteria. As nitrate levels increase, especially in wells near cropped fields, the probability of detecting pesticides also increases. MDA monitoring data indicates that pesticide levels are usually below state and federal drinking water guidelines. For more information on testing and health risks from pesticides and other contaminants in groundwater go to: http://www.mda.state.mn.us/protecting/waterprotection/pesticides.aspx
- In addition to pesticides, high nitrate levels may suggest an increased risk for other contaminants. For more information go to: http://www.health.state.mn.us/divs/eh/wells/waterquality/test.html

If the Nitrate result is above 10 mg/L:

- **Do not allow this water to be consumed by infants**, Over 10 mg/L is not safe for infants younger than 6 months of age
- **Pregnant women** also may be at risk along with **other people with specific metabolic conditions.** Find a safe alternative water supply.
- Consider various options including upgrading the well if it was constructed before the mid 1970's.
- Be sure to retest your water prior to making any significant financial investment in your existing well system. See link to MDH certified labs listed above.
- ***Boiling your water increases the nitrate concentration in the remaining water.***

Infants consuming high amounts of nitrates may develop Blue Baby Syndrome (Methemoglobinemia). This disease is potentially fatal and first appears as blue coloration of the fingers, lips, ears, etc. Seek medical assistance immediately if detected.

If you have additional questions about wells or well water quality in Minnesota, contact your local Minnesota Department of Health office and ask to talk with a well specialist or contact the Well Management Section Central Office at health.wells@state.mn.us or at 651-201-4600 or 800-383-9808. If you have questions regarding the private well monitoring contact Nikol Ross at 651-201-6443 or Nikol.Ross@state.mn.us.

APPENDIX E

Table 14. Reasons Wells Were Removed from the Final Well Dataset by Township, Washington County

Township	Point Source	Well Construction Problem	Hand Dug Well	Irrigation Well	Unsure of Water Source	Site Visit Completed - Well Not Found & Constructed before 1975 & No Well ID	No Site Visit & Constructed before 1975 & No Well ID	No Site Visit & Insufficient Data & No Well ID	Total
Cottage Grove (city)	16	0	0	0	0	1	35	0	52
Denmark	8	0	0	0	1	1	23	0	33
Total	24	0	0	0	1	2	58	0	85

Table 15. Site Visits Completed for Wells Removed from the Final Well Dataset by Township, Washington County

Township	Site Visit	No Site Visit	Total Wells Removed
Cottage Grove (city)	6	46	52
Denmark	6	27	33
Total	12	73	85

APPENDIX F

Table 16. Well Construction Type for Final Well Dataset

Township	Samples	Drilled	Sand Point	Not Available
Cottage Grove (city)	248	235	3	9
Denmark	193	184	2	7
Total	441	419	5	16

Data compiled from well logs and homeowner responses.

Table 17. Well Depth for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	158	125	420	280	271
Denmark	134	100	400	300	287
Total	292	100	420	280	279

Data compiled from well logs only; homeowner responses are not included.

Table 18. Year of Well Construction for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	158	1975	2007	1990	1989
Denmark	133	1976	2011	1995	1993
Total	291	1975	2011	1992	1991

Data compiled from well logs only; homeowner responses are not included. Most wells do not have a well log if they were constructed before 1974.

APPENDIX G

Private Well Field Log

Minnesota Department of Agriculture -Private Well Field Log

Well Unique#	Site ID	Sample #'s	Date	Time	Well Depth (units)
		Nitrate:			
Sampler:		**Pesticide:**			**Well Type:**

Well Owner Name:
Well Owner Address:
GPS: Latitude: Longitude:

Duplicates collected? Yes or No

Duplicate #'s: nitrate: ______________________ pesticide:____________________________

Sample point location (for example: outside tap on south side of home)__________________________

Pump start time: ______________ Discharge rate: __________ Time sample collected:______________

Stabilization Measurements

Time	Temp (units) (1.0°)	pH (0.1)	Specific Cond. (units) (10%)	DO (units) (10%)	Appearance/Notes

Wind (units)	Air temp (units)	Weather	Nearest possible pesticide source (type and distance)

COMMENTS/Notes:

Updated 5/18/2015

APPENDIX H

Table 19. Temperature (°C) of Well Water for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	102	9.58	13.56	10.59	10.63
Denmark	54	8.04	12.28	10.08	10.17
Total	156	8.04	13.56	10.35	10.47

Table 20. Specific Conductivity (µS/cm) of Well Water for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	102	312	1030	597	612
Denmark	54	283	992	486	515
Total	156	283	1030	562	579

Table 21. pH of Well Water for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	102	7.41	8.02	7.73	7.70
Denmark	54	7.35	8.17	7.74	7.75
Total	156	7.35	8.17	7.73	7.72

Table 22. Dissolved Oxygen (mg/L) of Well Water for Final Well Dataset

Township	Samples	Min	Max	Median	Mean
Cottage Grove (city)	102	0.08	13.49	7.72	6.77
Denmark	54	0.02	15.74	9.27	7.45
Total	156	0.02	15.74	8.03	7.01