Minnesota Department of Agriculture

Pesticide and Fertilizer Management Division

STATEMENT OF NEED AND REASONABLENESS

In the Matter of Proposed Permanent Rules relating to Groundwater Protection

April 30, 2018

The *State Register* notice, this Statement of Need and Reasonableness (SONAR) and the proposed Rule will be available during the public comment period on the MDA's website: **www.mda.state.mn.us/nfr**

Alternative Format:

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Acronyms or Abbreviations

Acronym or Abbreviation	Full Text
AMT	Alternative Management Tool
BMP	Best Management Practice
CFR	Code of Federal Regulations
Commissioner	Commissioner of the MDA (unless otherwise noted)
DAP	Diammonium Phosphate
DWSMA	Drinking Water Supply Management Area
USEPA	United States Environmental Protection Agency
HRL	Health Risk Limit
LAT	Local Advisory Team
MAP	Monoammonium Phosphate
MAWQCP	Minnesota Agricultural Water Quality Certification Program
mg/L	Milligrams per liter
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MDNR	Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
N	Nitrogen
N2	Gaseous molecular nitrogen
N2O	Nitrous oxide
NFMP	Nitrogen Fertilizer Management Plan
NH3	Ammonia
NH4	Ammonium
NO	Nitric oxide
NO2	Nitrite
NO3	Nitrate
NRCS	Natural Resources Conservation Service
NRS	Nutrient Reduction Strategy
P	Phosphorus
SSURGO	Soil Survey Geographic Database
SONAR	Statement of Need and Reasonableness
SWCD	Soil and Water Conservation District
TTP	Township testing program
U of M	University of Minnesota
USDA	United States Department of Agriculture
USGS	United States Geologic Service
UAN	Urea and Ammonium Nitrate (solution)
WHPA	Wellhead Protection Area

I. Introduction

The Groundwater Protection Act states, *"it is the goal of the state that groundwater be maintained in its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities this degradation prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged."* Minn. Stat. § Section 103H.001.

Nitrate is a compound that naturally occurs in our environment at very low levels, generally less than 3 mg/L, and has many human-made sources. Nitrate is in some lakes, rivers, and groundwater in Minnesota. The Minnesota Department of Health (MDH) Health Risk Limit (HRL) for nitrate (expressed as nitrate-nitrogen) is 10 mg/L; consuming too much nitrate can be harmful — specifically for infants under the age of six months. The majority of Minnesota households have access to safe drinking water supplies. However, in areas vulnerable to groundwater contamination, some public wells have nitrate-nitrogen concentrations that exceed the MDH HRL. While elevated concentrations of nitrate-nitrogen in groundwater can result from several factors, a major contributor in rural Minnesota is nitrogen fertilizer that leaches past the crop root zone (MDA. n.d. (d)). When groundwater resources become contaminated with nitrate, efforts to remove or mitigate the contamination are challenging and expensive. These results show that action is needed in order to ensure that Minnesotans have safe drinking water for years to come.

State agencies, under Minn. Stat. §103H.101, subd. 7, must identify and develop best management practices (BMPs) for programs under their authority that have activities that may cause or contribute to groundwater pollution. For those activities which may cause or contribute to pollution of groundwater, but are not directly regulated by the state, BMPs shall be promoted through education, support programs, incentives, and other mechanisms.

Specifically, Minn. Stat. § 103H.151, subd. 2, requires the Minnesota Department of Agriculture (MDA), in consultation with local water planning authorities, to develop BMPs for agricultural chemicals and practices. The MDA must give public notice and solicit comments from affected persons interested in developing BMPs. Once developed, Minn. Stat. § 103H.151, subd. 3 requires the MDA to promote the BMPs and provide education on how the use of BMPs will prevent, minimize, reduce, and eliminate the source of groundwater contamination. The MDA is also required to monitor the use and effectiveness of BMPs. BMPs are defined in Minn. Stat. § 103H.005, subd. 4 as, *"practicable voluntary practices that are capable of preventing and minimizing degradation of groundwater, considering economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects. BMPs apply to schedules of management plans; practices to prevent site releases, spillage, or leaks; application and use* *of chemicals; drainage from raw material storage; operating procedures; treatment requirements; and other activities causing groundwater degradation."*

Additionally, the MDA is also required under Minn. Stat. § 103H.251 to evaluate the detection of pollutants in groundwater of the state as it pertains to agricultural chemicals and practices. If conditions indicate a likelihood of the detection of the pollutant or pollutant breakdown to be a common detection, the MDA must begin developing BMPs and continue to monitor for the pollutant or pollutant breakdown products. Once detected, the MDA must develop and implement groundwater monitoring and hydrogeologic evaluations to evaluate pollution frequency and concentration trend.

Minn. Stat. § 103H.275 states that if groundwater pollution is detected, the MDA must also promote the implementation of BMPs to prevent or minimize the source of pollution to the extent practicable. Further, the MDA may also develop adopt water resource protection requirements by rule that are consistent with the goal of Minn. Stat. § 103H.001 and are commensurate with the groundwater pollution if the implementation of BMPs has proved to be ineffective. The water resource protection requirements are defined in Minn. State. § 103H.005, subd. 15 as, *"requirements adopted by rule for one or more pollutants intended to prevent and minimize pollution of groundwater. Water resource protection requirements include design criteria, standards, operation and maintenance procedures, practices to prevent releases, spills, leaks, and incidents, restrictions on use and practices, and treatment requirements."* They must be based on the use and effectiveness of BMPs, the product use and practices contributing to the pollution detected, economic factors, availability, technical feasibility, implementability, and effectiveness. The water resource protection requirements may be adopted for one or more pollutants or a similar class of pollutants. (Minn. Stat. § 103H.275, subd. 2).

The MDA has complied with all requirements under Minn. Stat. chap.103H to develop, educate and promote BMPs. The MDA has also conducted monitoring and testing as required under Minn. Stat. chap.103H, and, based on the extensive information gathered by the MDA, believes that the implementation of the nitrogen fertilizer BMPs have proven to be ineffective. Based on this determination, the MDA has proposed the Groundwater Protection Rule (the proposed Rule) under the authority of Minn. Stat. § 103H.275, subds.1 and 2.

This Statement of Need and Reasonableness (SONAR) is laid out in the following format:

- Background of the Nitrogen Pollution Issue
- Outline of the MDA's requirements under Minn. Stat. chap. 103H and how the MDA has complied with those requirements
- Justification of the MDA's authority to issue the proposed Rule (implementation of BMPs ineffective)
- Why the proposed Rule is needed and reasonable

II. Background regarding Nitrogen Fertilizer and its effects on Groundwater

A. What is Nitrogen Fertilizer?

Nitrogen fertilizers as addressed by the proposed rule are substances containing nitrogen that are designed for use or claimed to have value in promoting plant growth.

The behavior of nitrogen (N) in the environment is governed by a complex set of interrelated chemical and biological transformations. These reactions are summarized in the "nitrogen cycle" (Figure II-1). The nitrogen cycle describes the inputs, pools, pathways, transformations, and losses of nitrogen in the environment.

Current agricultural crop production systems require the input of nitrogen fertilizer to increase food and feed production for consumption by humans and livestock as well as fiber and fuel. However, nitrate that is not utilized by the crop may leach into the groundwater. Many of Minnesota's groundwater aquifers are susceptible to contamination due to diverse geology and soils, climate, and land use. Concentration of nitrates in the groundwater can be harmful, especially to infants under 6 months.

The complex interrelationships between nitrogen use, benefits, and long term environmental consequences are termed by Nobel Peace Prize recipient Dr. Otto Doering as a "*wicked problem*" (Frear, 2014; Charles, 2013). Some experts believe that 50% of the world's current population would not exist without the additional food supplies produced through the use of commercial nitrogen fertilizers. The problem of nitrogen fertilizer use is termed "wicked" because, despite the benefits of the additional food production, there is no clear consensus on how to solve the environmental issues due to the complexities and interrelationships between crop production and the environment. This has led to an enormous research effort to develop the nitrogen fertilizer Best Management Practices (nitrogen fertilizer BMPs). These nitrogen fertilizer BMPs are designed to improve use efficiencies, quantify movement into the atmosphere and water resources, as well as ensure economic benefits for increased food production.

One of the most in-depth examinations of nitrogen usage and subsequent losses to water and air was released by the USEPA Science Advisory Board (2011). This Board concluded that agriculture uses more nitrogen and accounts for more nitrogen losses to the environment than any other economic sector. The Board concluded that synthetic nitrogen fertilizers are the largest sources of nitrogen inputs to agricultural systems. The Board further characterized the nitrogen in the environment issue through the following statement:

> *"In the past 60 years N fertilizers have had a beneficial effect on agriculture both nationally and globally by increasing crop yields. However, the high loading of N from*

agricultural nutrient sources has led to deleterious effects on the environment, such as decreased visibility from increased aerosol production and elevated N concentrations in the atmosphere, ground, and surface waters." (USEPA Science Advisory Board, 2011)

The Nitrogen Cycle

The nitrogen cycle is the biogeochemical cycle by which nitrogen is converted to multiple chemical forms as it circles through the air, ground, and water. The nitrogen cycle reactions are influenced by the interaction of numerous chemical, biological, environmental, and management factors (Figure II-1; Lamb et al. 2008). The interaction of these factors complicates predictions of the behavior of nitrogen introduced into the environment. Understanding the nitrogen cycle is important to help understand how multiple factors will interact to influence nitrogen behavior at a given site. Sound nitrogen management decisions can then be made based upon knowledge of the nitrogen cycle.

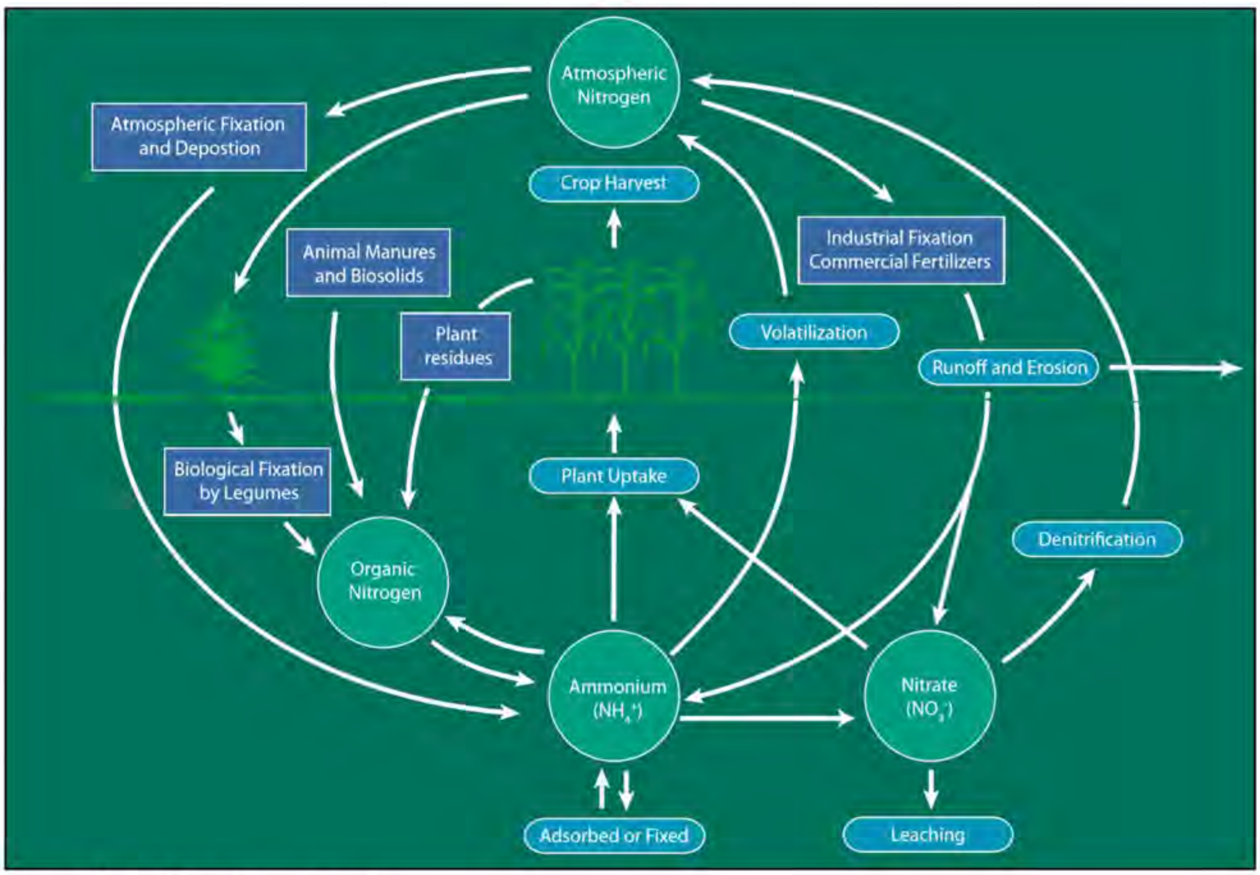


Figure II-1. The nitrogen cycle.

<u>There are multiple terms used in this rule when referring to nitrogen.</u> Nitrogen is used when referring to the nutrient for plant growth, fertilizer containing nitrogen or nitrogen fertilizer Best Management Practices (BMPs). Nitrate is a general term used in reference to leaching or

groundwater. Nitrate-nitrogen describes the concentration in groundwater and the health risk limit in milligrams per liter (mg/L).

Components of the nitrogen cycle

Although several nitrogen compounds are involved in the cycle, the primary compounds in the soil are nitrate-nitrogen (NO_3^-), ammonium nitrogen (NH_4^+), and organic nitrogen. Nitrogen in the nitrate form is highly water soluble and extremely mobile, which poses economic and environmental concerns. The characteristics of these compounds and related processes are summarized below:

- **Organic nitrogen:** Organic nitrogen is the predominant nitrogen compound in the soil profile. Organic nitrogen first must be transformed into inorganic forms by microbial action (mineralization) in order to dissolved into water. Organic nitrogen may be the primary source of nitrogen in surface runoff but rarely contributes to groundwater contamination.

- **Nitrate (NO_3^-):** Nitrate is extremely soluble in water. Due to its chemistry, nitrate does not tend to stay attached to the soil, but instead moves through soil. These characteristics mean it is highly susceptible to leaching and therefore groundwater contamination.

- **Nitrite (NO_2^-):** Nitrite is an intermediate product in the conversion of ammonium to nitrate in the soil and is the compound of toxicological concern in the human system. Although nitrite is highly soluble, it is also very unstable and is rarely detected in groundwater except at very low levels.

- **Ammonia (NH_3)/ammonium (NH_4^+):** Ammonia (gas) is the primary form of nitrogen feedstock applied in fertilizers. It reacts to form ammonium immediately upon contact with water. Ammonium will be temporally immobile until soil bacteria convert it to the much more soluble nitrate form.

The primary chemical and biological processes of the nitrogen cycle include:

- **Leaching:** Leaching is the process where nitrates move through soil via water. Nitrate is the principal nitrogen compound transported in subsurface water due to its solubility and exclusion from adsorption onto soil colloid surfaces. Nitrate leaching is one of the primary avenues of nitrogen loss, particularly during years with above-normal precipitation.

- **Mineralization:** The microbial degradation of organic nitrogen to produce the inorganic forms of nitrogen (nitrate, nitrite, and ammonia).

- **Immobilization:** The assimilation of inorganic forms of nitrogen by plants and microbes, producing various organic nitrogen compound.

- **Net Mineralization:** The cumulative balance at the end of the growing season between mineralization and immobilization.

- **Nitrification:** The transformation through microbes of ammonium to nitrite and then to nitrate. This is the primary nitrate-producing reaction in the cycle.

- **Denitrification:** The biochemical reduction of nitrate and nitrite to gaseous molecular nitrogen (N_2) or a nitrogen oxide form nitrous oxide (N_2O), nitric oxide (NO), or nitrogen dioxide (NO_2). This is a primary volatile loss pathway to the atmosphere. Over 78% of the atmosphere is comprised of N_2.

There are multiple potential sources of nitrogen in the soil system. In an agronomic context, all nitrogen sources applied to a field should be taken into account in determining the appropriate nitrogen fertilizer rate. All nitrogen sources perform the same function in the context of the nitrogen cycle, although they may enter the cycle at different points. This means that all nitrogen sources are potential nitrate sources and could contribute to groundwater contamination. It is important to recognize that nitrate occurs naturally in the soil system. Nitrate losses can occur under natural vegetative conditions, (such as grassland and forestland), although these losses are typically minor. Losses can be much higher after major events such as prairie fires, land clearing and/or disturbances, and the initiation of major tillage operations. Significant losses can also occur after extended drought conditions followed by prolonged wet cycles.

Nitrogen sources include agronomic inputs and external sources:

Agronomic Inputs:
- Soil organic matter and crop residue
- Commercial fertilizers
- Atmospheric deposition
- Atmospheric fixation (legumes fixing nitrogen in the soil)
- Land-applied manure and other organic residues

External Sources:
- Municipal Wastes and Landfills
- Septic systems
- Feedlots (concentrated animal wastes)
- Turf grass (golf course, parks, private and public lawns)
- Wildlife excretions.

B. Understanding Nitrogen Fertilizer Usage and Impacts to Water Resources

Nitrogen fertilizer is a major input to agricultural land, and fertilizer sales have increased along with nitrogen demanding crops. Unfortunately, nitrate can also leach into groundwater (MDA. n.d. (d)). Given the importance of this topic, there have been many studies on different soils and rates, and research to develop the nitrogen fertilizer BMPs. Studies in Minnesota and other Midwestern states have identified nitrogen fertilizer as a major source of nitrate in some aquifer systems.

1. Although there are multiple sources of nitrogen, the majority of nitrogen inputs are applied to agricultural land.

One significant challenge in dealing with nitrogen related environmental issues is the fact that there are multiple sources from either natural or human-induced sources (Figure II-2). Nitrogen inputs statewide have been evaluated by the Minnesota Department of Agriculture (MDA). The majority (over 82%) of the nitrogen inputs occur on agricultural lands. The sources include cropland mineralization (net); commercial nitrogen fertilizers; contributions from nitrogen fixing legume crops such as alfalfa, clover and soybeans; manure applications, and atmospheric deposition. There are also other minor sources such as septic tanks and feedlot contributions.

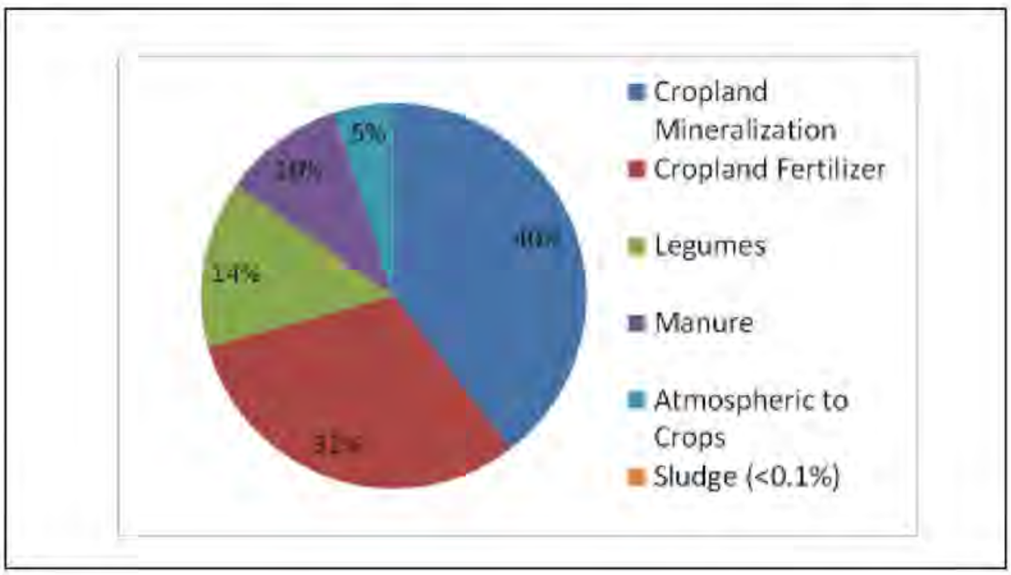


Figure II-2. Comparison of Minnesota's major agricultural nitrogen sources. (MDA, 2015)

Other inputs that are applied to non-agricultural landscapes include fertilizers applied to turf grass (lawns, parks and golf courses), non-cropland mineralization, septic system waste, and atmospheric deposition.

To put these inputs in perspective in terms of a representative acre of Minnesota farmland growing corn (in a corn-soybeans rotation which encompasses about 75% of the state's cropland), the nitrogen inputs would be in the following general ranges: 1) Commercial nitrogen fertilizer 120-150 lb/acre; 2) Legume credits of 30-40 lb/acre based on U of M soybean crediting; 3) Mineralization 50-100 lb/acre; and 4) Manure. Manure inputs are highly variable---about 15-20% of the intended corn acres in livestock regions get manure applied. Typically, manure inputs are under-represented, resulting in over-applications of commercial fertilizer.

It is generally accepted that anhydrous ammonia is one of the best commercial nitrogen sources available. Anhydrous ammonia is a gas and is applied by injecting it into the soil. For a number of reasons, this product generally produces the best yields and less likely to leach or be lost to various gaseous pathways. Despite being an excellent nitrogen source, anhydrous ammonia sales have dropped significantly over the past 25 years (Figure II-3; MDA, 2015). The primary reasons for the downward trends are likely safety and complex requirements regarding its storage, transportation, and use. Anhydrous ammonia must be stored and handled under high pressure and is highly dangerous. Misuse of this fertilizer can cause serious burns and death in severe cases (Shutske, 2013). Additionally, it is a difficult product to work with within precision type applications.

Urea has overtaken anhydrous ammonia as the most sold nitrogen fertilizer product. Urea is a solid. Urea sales have steadily increased and have taken up much of the marketplace sales reductions in anhydrous ammonia. This product (containing 46% nitrogen) is a solid and when properly used, can produce yields similar to anhydrous ammonia if leaching and gaseous losses can be managed. Because Urea is soluble, it should not be used in a fall application in areas with leaching concerns.

Nitrogen solutions (28%, 30%, and 32%) account for 10% of the statewide sales. These products are frequently applied as an application in the spring with a herbicide after the crop has already begun to grow. Many of the products listed as "Misc. Sources" in Figure II-3 are frequently custom dry blends for specialty crops.

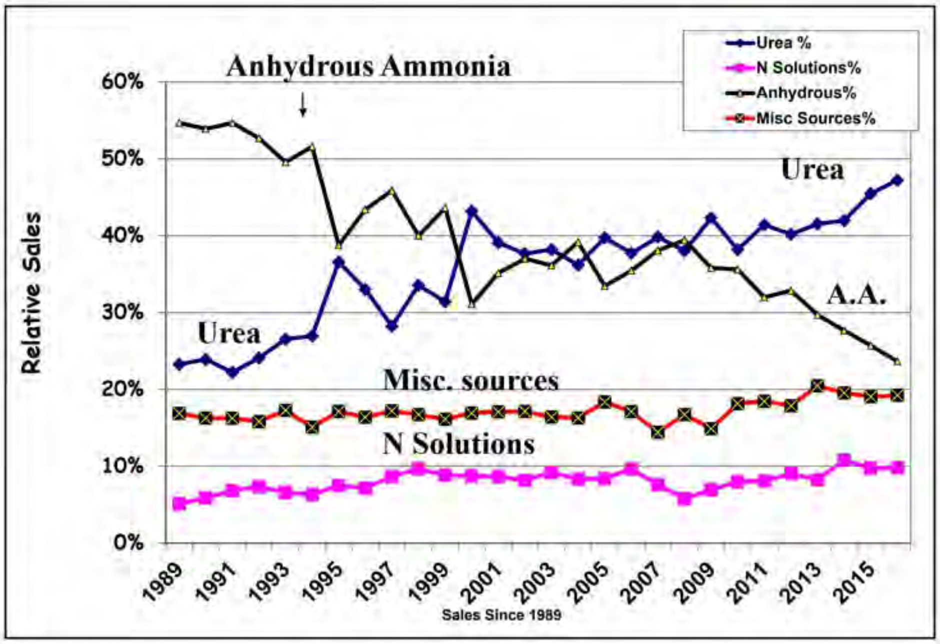


Figure II-3. Trends in three major nitrogen fertilizer sources used in Minnesota: 1989-2016. (MDA, 2015)

Nitrogen fertilizer is a valuable tool for producers. Unfortunately, it can also leach into groundwater and cause significant health concerns. The most prevalent use of nitrogen is application to agricultural land.

2. Studies show an increase in sales of nitrogen fertilizer and an increase in planting of nitrogen-demanding crops, resulting in an increase potential of leeching of nitrogen into groundwater.

Reliance on nitrogen fertilizers and subsequent consequences to water and air quality align with the post-war era. From a historical perceptive, the industrial process for creating ammonia was first developed in the early part of the 20th century. However, it was not until World War II ended that synthetic ammonia was readily available for agricultural use. Adoption of commercial fertilizer proceeded slowly but then catapulted in the United States during the 1960s and 1970s as a result of educational efforts, lower costs, and introduction of improved plant genetics that needed increased inputs.

Minnesota sales are very similar to the national trends (Figure II-4, data sourced from MDA, Tennessee Valley Authority, and the American Association of Plant Food Control Officials). Sales rapidly increased in the 1960-1970 era, stabilized during the 1980s, and then remained fairly consistent during the 1990s (averaging 653,000 tons/year) and the early 2000s (averaging 648,000 tons).

Figure II-4. Commercial nitrogen fertilizer sales trends, Minnesota and U.S.

More recently, nitrogen fertilizer sales have been trending upward with a notable jump when grain prices were high in 2010-2014. Nitrogen consumption over the past five years is averaging 760,000 tons/year, which is a 14-15% increase compared to the twenty-five-year average. Overall, Minnesota's nitrogen fertilizer sales have increased over six-fold since 1965 while at the same time corn production has increased four-fold and corn acres have substantially increased (MDA, 2015). This increase in corn production has had a significant impact on the use of nitrogen.

Crop selection, as reported by the National Agriculture Statistics Service (USDA NASS, n.d. (a)) over the past ninety years, has changed dramatically. Before the mid-1950s, Minnesota annually planted over 8 million acres of small grains, including wheat, oats, rye, barley and other minor crops (Figure II-5). Small grain acres dropped significantly in the late1950s and again during the 1980s and 1990s. Over the past decade, approximately 2 million acres of small grains have been grown. Small grains are generally considered to have a low-to-moderate impact on groundwater quality for the following reasons: solid seeding resulting in a uniform root distribution; they are typically grown in areas of low groundwater vulnerability; and they require moderate nitrogen inputs due to lodging concerns.

The following are some of the major crops currently grown in Minnesota:

- **Corn:** Corn acres have been steadily increasing for the last ninety years. Corn has high nitrogen requirements and has a narrow uptake period. Those implementing Minnesota's nitrogen fertilizer BMPs can select from options to ensure that corn crops have the nutrients needed during this critical uptake period.

- **Legumes:** Looking back at the trends in several legume crops since the 1920s, there has been a very steady decline of alfalfa and clover acres. These declines are linked to the significant changes in the dairy industry and due to lower production costs in neighboring states. These crops have strong, positive implications on groundwater quality and have been demonstrated to be extremely effective at removing nitrate from the soil profile resulting in high quality recharge into groundwater.

- **Soybeans:** Despite being one of the oldest crops known to human civilization, soybeans did not become an important crop in the U.S. until the turn of the 20th century. Soybean production started in Minnesota in the early 1940s and has steadily increased to about 7-8 million acres. Provided with the proper nitrogen-fixing bacteria (via inoculum), soybeans are highly capable of supplying their own nitrogen needs as well as utilizing residual soil nitrate from previous crops.

- **Other crops:** There are other nitrogen-demanding crops grown on a small scale in the state of Minnesota, but they can have significant impacts (both economic and environmental) on a local level.

Table II-1. Typical nitrogen requirements and potential impacts on nitrate leaching losses for crops/cover in Minnesota (MDA, 2015; p 117)

Commonly grown Agricultural Crops or Alternative Cover	Typical Nitrogen Requirements (Pounds per Acre)	Characteristics	Relative Nitrogen Leaching Loss Rating System*
Corn (Grain or Silage)	70-180	Deep rooted; Inputs highly dependent on anticipated yields	M-H Spring Applied; H-VH Fall Applied; M-H Irrigated; M-VH Manured
Wheat, Barley, Oats	60-100	Solid seeded	L-M
Soybeans	Legume; No additional nitrogen needed	Poor scavenger of residual soil nitrate	M
Potatoes – Irrigated	200-250	High management, shallow root system	H-VH
Sugar Beets	100-120	Sugar quality decreases if too much nitrogen available	M
Alfalfa	Legume; No additional nitrogen needed	Very deep rooted, excellent scavenger; Crediting to subsequent crops critical upon termination	L; Potential losses after crop is terminated
Grass-Legume Mixtures	60; Lower nitrogen rates allow for legume growth	NA	VL-L
Pasture/Grazing	Plant nutrition provided by manure or supplemental fertilizer	NA	L (typically); Dependent upon grazing pressure
Conservation Reserve Program Mixtures	Application at establishment	Mixtures vary but diverse systems tend need less nitrogen	VL
Lawns and Golf Fairways	40-160	Fall nitrogen applications; Split applications	L; L
Golf Greens, High Input Areas	120-220	Split applications needed	M-H

* VH= Very High, H=High, M=Medium, L=Low, VL=Very Low, NA=Not Applicable

Between the 1920s and 1960s, amounts of nitrate-nitrogen leaching below the root zone were relatively minor compared to recent years. The major changes over the past ninety years are: 1) the additional influx of commercial fertilizers (Figure II-4); 2) substantially more acres of nitrogen demanding crops (Figure II-5); and 3) replacement of nitrogen conserving crops, such as alfalfa, clovers, pasture, and hay grasses with soybeans. These changes combined contribute to an increased risk of nitrate entering groundwater. The continuance of these trends will lead to an ongoing increased risk of nitrate loading to groundwater.

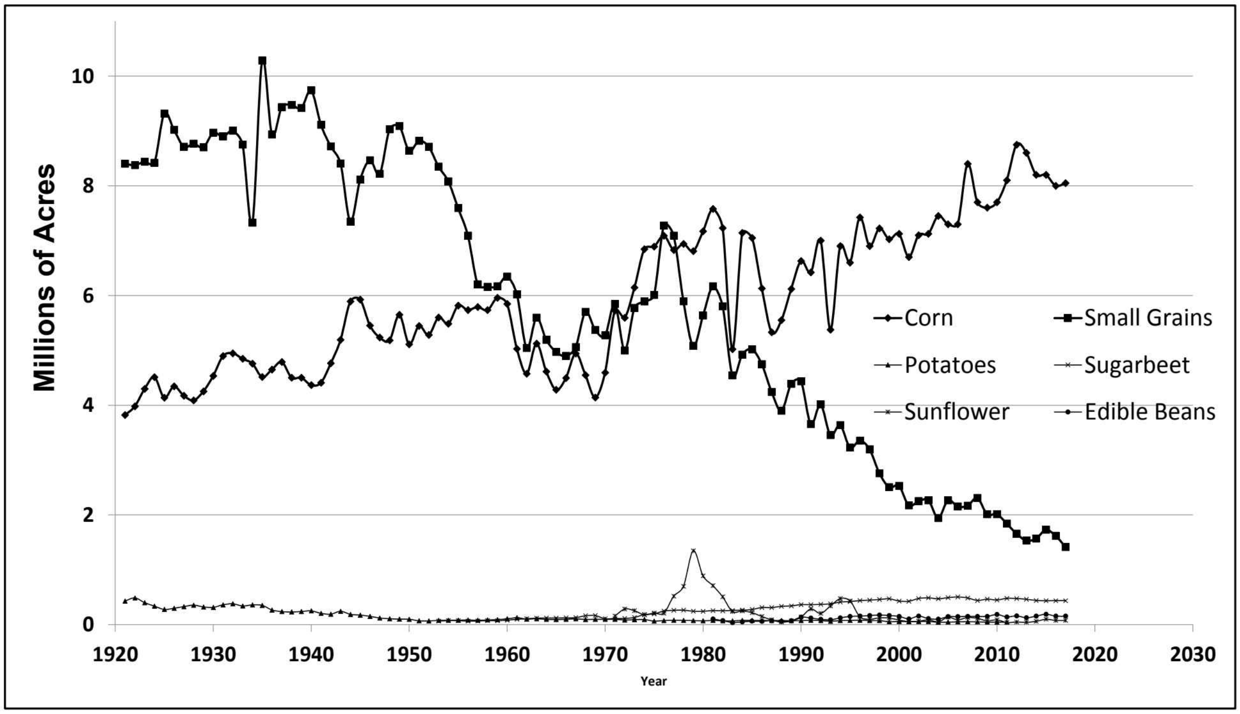


Figure II-5. Acreage trends for Minnesota's nitrogen demanding crops. (USDA NASS n.d. (a); MDA, 2015)

Therefore, studies showing an increase in nitrogen fertilizer sales, along with the change from planting nitrogen-friendly crops to more nitrogen-demanding crops, have created a greater probability of nitrogen leeching into groundwater.

3. Understanding Groundwater's susceptibility to nitrate pollution.

Groundwater is the most abundant source of freshwater in the world.

Groundwater is water found beneath the soil surface that resides in the soil pore spaces or within cracks of fractured rock. Most of groundwater is stored in underground layers known as aquifers. These saturated layers allow water to flow into and through them relatively easily. Even though water can move through these layers, the water typically moves slowly. In certain environments, where there are larger fractures or conduits in the rocks, groundwater can move more rapidly through these spaces. The susceptibility of groundwater to contamination is referred to as "vulnerability". Several environmental factors determine the vulnerability of an area, including 1) physical and chemical properties of the soil and geologic materials, 2) climatic effects, and 3) land use. These factors vary widely throughout Minnesota, making vulnerability very site-specific.

Nitrate can occur naturally in groundwater at levels typically in the range of 0 to 3 parts per million (ppm) (MDH, n.d.). Human activities such as sewage disposal, livestock production, and crop fertilization can elevate the level of nitrate in groundwater. The Minnesota Department of Health (MDH) has set a Health Risk Limit (HRL) of 10 milligrams per liter (10 mg/L, or 10 ppm) for nitrate-nitrogen (MDH, n.d.). Nitrate-nitrogen contamination above the MDH HRL is most commonly found in aquifers that are vulnerable to contamination from the land surface, such as sand and gravel aquifers and fractured bedrock aquifers. Areas with heavy row crop agriculture and vulnerable groundwater are especially at risk.

A simple search via Google Scholar using the key words "nitrogen fertilizer water quality Minnesota" will yield hundreds of studies conducted over the last three to four decades. There have been many small plot research efforts conducted that studied nitrogen movement below the crop root zone or via a tile drainage system. Much of the Minnesota research evolved from the finer textured, tile-drained soils found at the U of M Research and Outreach Centers (Waseca and Lamberton). Frequently variables include different rates, timings, sources, and other potential techniques to improve fertilizer use efficiency and reduce environmental impacts (Carlson et al., 2017; Davis et al., 2000; Feyereisen et al, 2006; Huggins et al, 2001; Jokela and Randall, 1989; Miao et al., 2007; Mulla and Strock, 2008; Nangia et al., 2008; Oquist et al., 2007; Randall, 1984; Randall and Mulla, 2001; Randall and Vetsch, 2005(a); Randall and Vetsch, 2005(b); Randall et al. 2003 (a); Randall et al., 2003(b); Randall and Goss, 2001; Schmidt et al. 2000; Schmitt et al., 1996; Vetsch and Randall, 2004; Yost et al., 2014). Studying nitrate leaching losses in the irrigated outwash soils is extremely difficult and consequently the knowledge base is smaller (Bierman et al., 2015; Hopkins et al, 2008; Venterea et al., 2011; Wilson et al., 2009; Zvomuya et at., 2003; Walters and Malzer, 1990, MDA. n.d. (d)).

These types of studies are extremely valuable for the development of nitrogen fertilizer BMPs and are frequently used to model nitrogen movement on a larger scale. These studies provide information on nitrogen fertilizer rate and management practices, and how these impact in crop yields and nitrate movement in the soil profile.

A small percentage of these Minnesota studies included the use of ^{15}N isotope technology. This approach allows researchers to effectively track the fate of nitrogen fertilizer as it is taken up by the crop, the atmosphere, the organic fraction or lost in the leachate (Zvomuya et at., 2003; Walters and Malzer, 1990). This is one of the most reliable methods for isolating fertilizer contributions from other inputs such as through mineralization of organic matter. Due to the high costs and complexities of analysis, these types of studies are very limited.

4. Studies demonstrate significant nitrogen contamination of groundwater in certain areas of the state where there is a demonstrated increase of nitrogen use.

Due to the post-World War II increase of nitrogen fertilizer use and the subsequent rise in nitrate-related water quality issues, there are few nitrate monitoring studies conducted prior to the 1960s and 1970s. It was uncommon to have the research opportunity to observe water quality conditions prior to the nitrogen fertilizer use era. Most monitoring reports for either groundwater or surface waters began in the 1980s or later.

For purposes of the statement of need and reasonableness (SONAR), groundwater conditions in Hastings, Minnesota and surface water conditions of the Minnesota River will serve as examples of monitoring studies illustrating the relationship between the increase in nitrogen fertilizer use and increased nitrate-related water quality concerns.

The Hastings public water supply, along with Perham and St. Peter, were some of the first to start showing rapidly increasing nitrate-nitrogen concentrations (Figure II-6).

In the case of Hastings, numerous studies were conducted with producers within the wellhead protection area (WHPA). Most of the soils there are vulnerable to leaching due to being coarse-textured, as well as areas of karst, and frequently under center pivot irrigation. Nitrogen from fertilizer, manure, and legumes were the dominant sources that could be managed or controlled by producers.

Over a number of years, nitrate-nitrogen concentrations continued to climb nearing the MDH HRL, forcing the city of Hastings to install a nitrate removal system in 2007 at a cost of $3.5 million. The city of Perham was experiencing similar trends and how they reversed these trends is discussed below. (Section II.b).

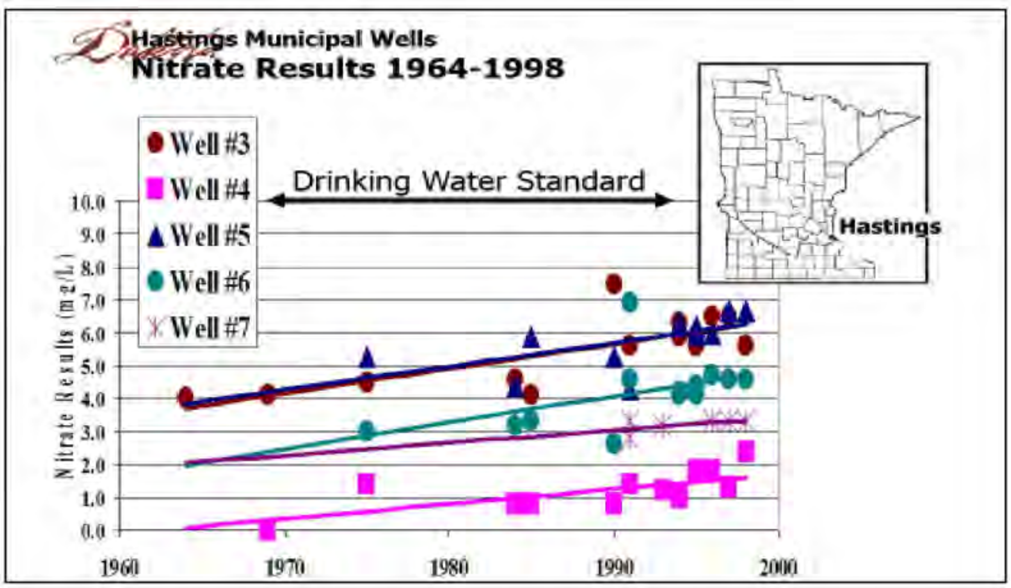


Figure II-6. Forty years of nitrate-nitrogen concentration trends in municipal wells, Hastings, Minnesota.

Another example is Mankato, which withdraws water from both the Minnesota and the Blue Earth Rivers for its public water supply. Nitrate-nitrogen concentrations and annual loads are slowly trending upward in the Minnesota River near Mankato (Figure II-7, S. Matteson, MDA. Personal Communication. 2017) and are highly influenced by rainfall and runoff amounts. Nitrate-nitrogen concentrations have doubled since the early 1970s. More importantly, the extremes are getting much larger.

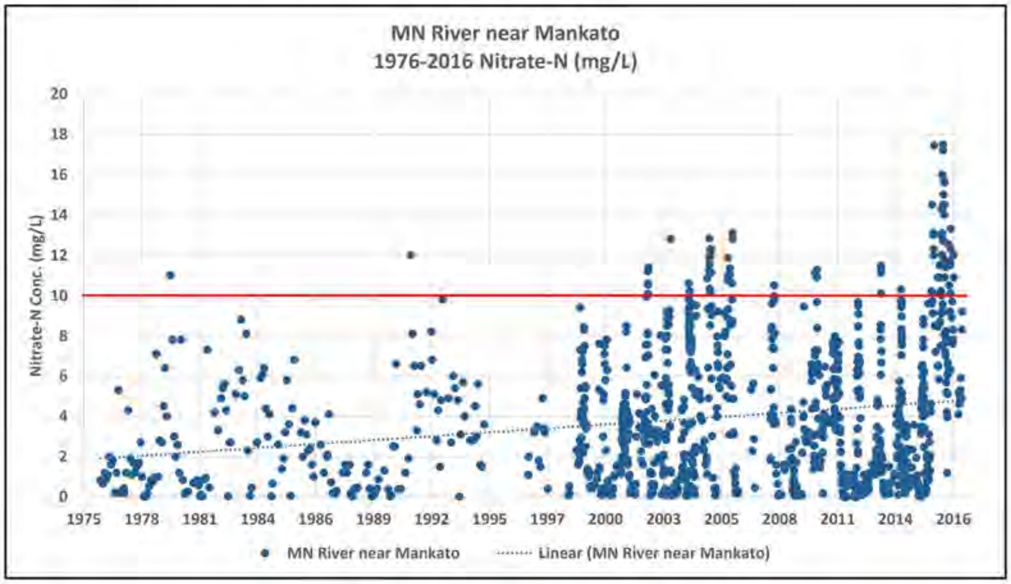


Figure II-7. Forty years of nitrate-nitrogen concentration trends in the Minnesota River.

a) Nitrogen fertilizer use and impacts to groundwater

In answering the question "what role does nitrogen fertilizer play in understanding elevated nitrates in groundwater systems," researchers from United States Geological Survey (USGS) conducted some significant studies in the Midwest, including Minnesota, which started in the 1970s (Figure II-7, S. Matteson, MDA. Personal Communication. 2017; Figure II-8, Puckett et. al, 2011; Puckett and Cowdery, 2002; Böhlke et al., 2002 and Puckett et al., 1999). These USGS reports are pertinent to the SONAR because they are highly focused on vulnerable groundwater systems typically found in Minnesota and the researchers have investigated potential sources. When nitrate-nitrogen concentrations were readjusted for denitrification losses, USGS concluded that nitrate-nitrogen concentrations in groundwater increased from about 2 mg/L in the early 1940s to about 15 mg/L in 2003 (Figure II-8 & Figure II-9, Puckett et al., 2011). Two of the eight sites were in Minnesota (Princeton and Perham) and represented vulnerable conditions found in the Midwest. This analysis also estimated that 14-18% of the nitrogen reaching the land surface as fertilizer, manure, and atmospheric deposition eventually would leach into groundwater.

Figure II-8. U.S. nitrogen sales and nitrate-nitrogen concentration in groundwater from 20 long-term sites (including Perham and Princeton, Minnesota).

USGS scientists also reported that within these 20 vulnerable areas, the probability of finding nitrate-nitrogen concentrations above the MDH HRL of 10 mg/L increased from <1% in the 1940s to over 50% by 2000 (Figure II-9, Puckett et al., 2011). Nitrogen fertilizer was clearly identified as the major source of nitrate in selected Minnesota aquifer systems (Puckett and Cowdery, 2002; Puckett et. al, 1999).

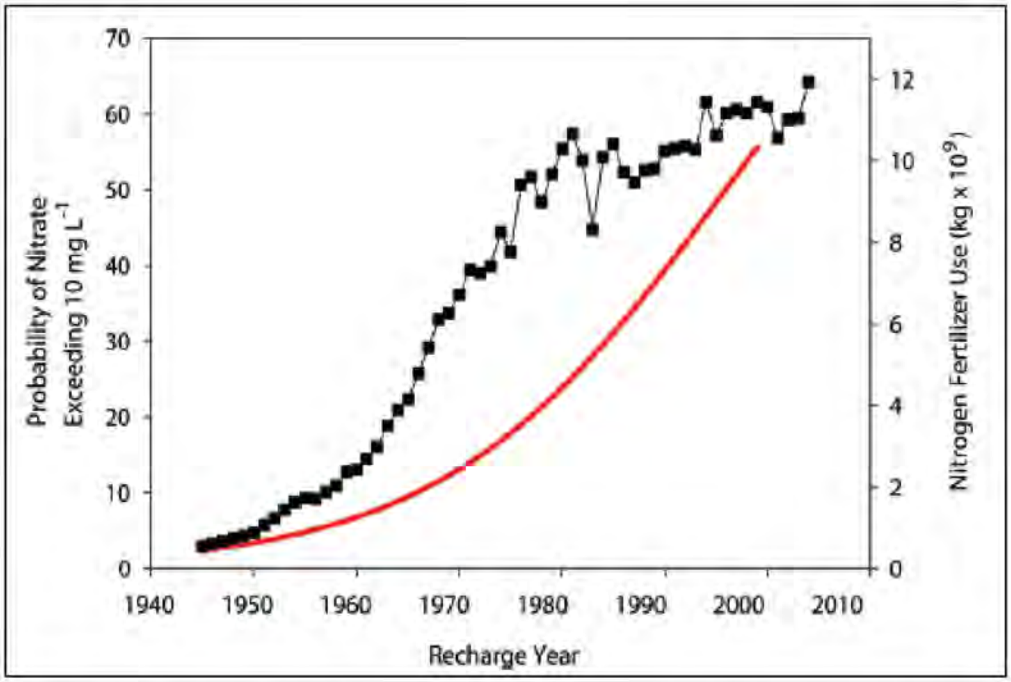


Figure II-9. Probability of nitrate-nitrogen concentrations in recharging groundwater exceeding 10 mg/L in areas of nitrogen fertilizer use (including Perham and Princeton, Minnesota).

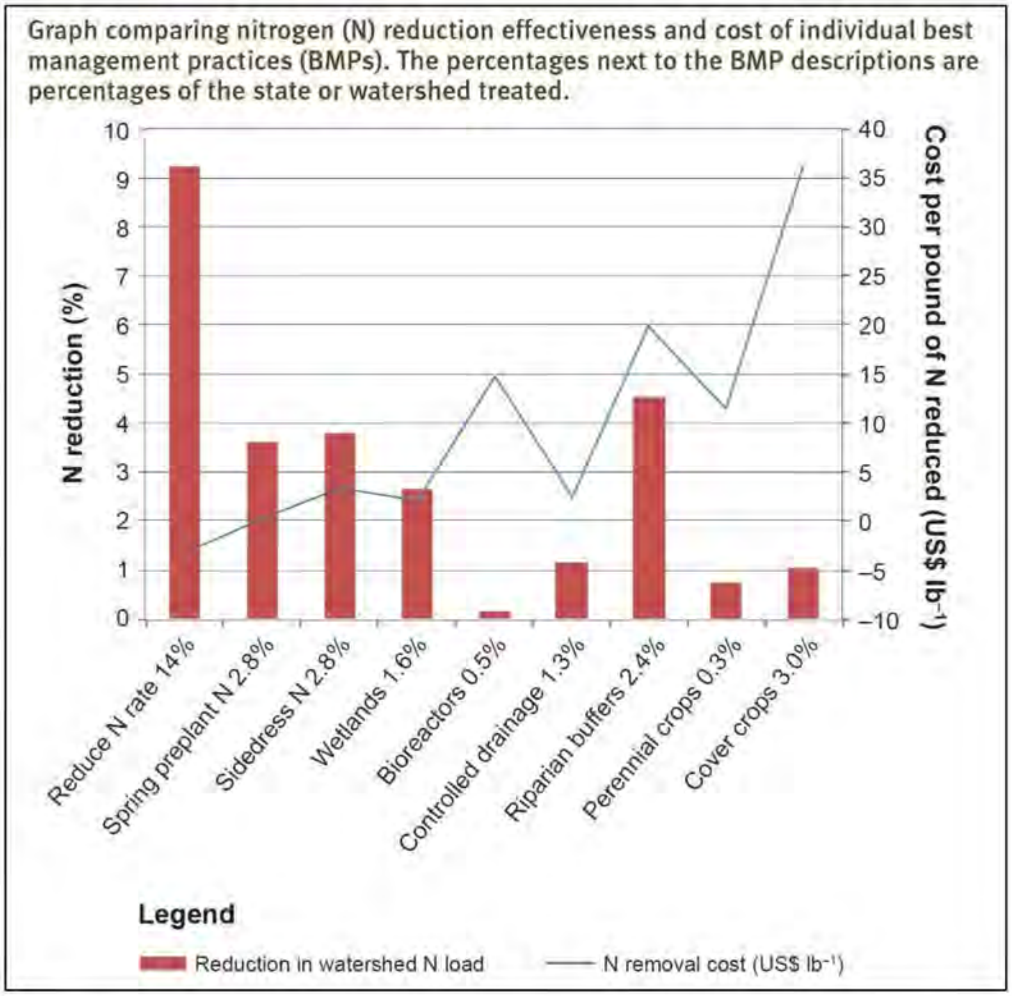


Figure II-10. BMP treatment opportunity (percent) in Minnesota's watersheds and corresponding nitrogen reduction effectiveness and cost estimated in the Nutrient Reduction Strategy. (Lazarus et al., 2014)

b) Perham drinking water protection

In the early 1990s, the city of Perham began to recognize that nitrate-nitrogen concentrations in their drinking water were rapidly increasing. By the late 90s, some of the city's wells sporadically exceeded the MDH HRL of 10 mg/L nitrate-nitrogen, requiring city staff to blend water from multiple wells to provide safe drinking water. Coarse textured soils, shallow groundwater, and an agricultural crop rotation demanding a high amount of nitrogen fertilizer created a challenging situation for groundwater protection in this area.

During this time, Perham leaders partnered with the MDA through state wellhead protection programs to engage local agricultural partners in reducing nitrate-nitrogen groundwater concentrations. Through combined efforts of the city and the agricultural community over 20 years, average annual nitrate-nitrogen concentrations in community wells have declined (Figure

II-11). Educational events, on-farm nitrogen trials, crop variety trials, fertilizer management changes, the use of new fertilizer technology, and perennial crops in select fields have led to higher nitrogen use efficiency across agricultural fields in the area. In addition, the city worked with area farmers in the early 2000s to purchase and trade land immediately up-gradient of public supply wells to further protect the city's drinking water. These elements are incorporated into the proposed Rule.

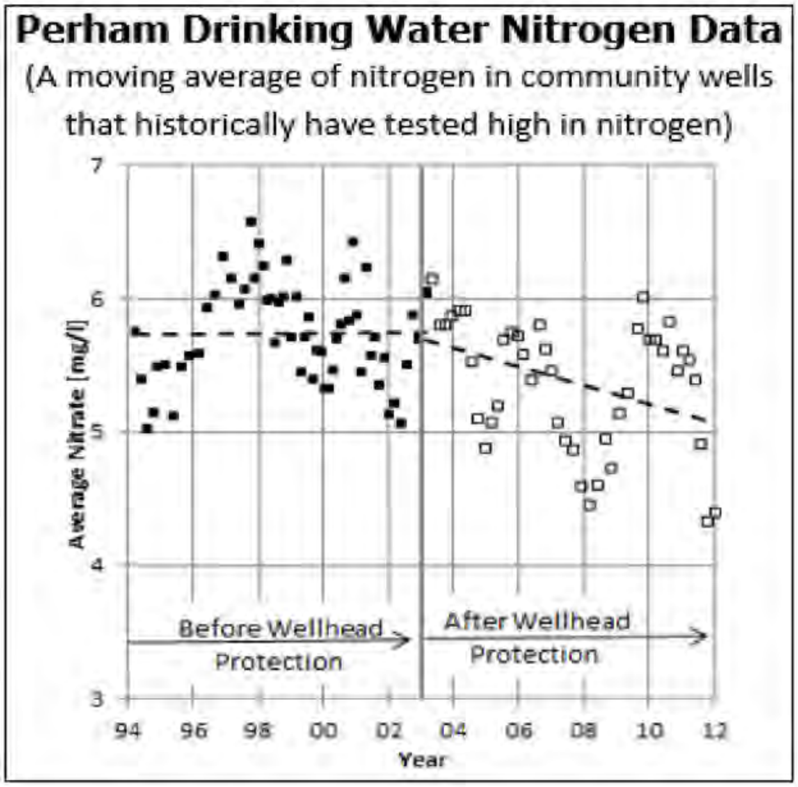


Figure II-11. Perham community well nitrate-nitrogen concentrations before and after wellhead protection efforts (Luke Stuewe, MDA Personal Communication)

c) Other Midwestern States have also linked nitrogen fertilizer use to water quality issues.

Commercial nitrogen fertilizer has been identified as the major source of groundwater nitrogen-contamination nationwide (Rupert, 2008; Burow et al., 2010, MDA. n.d. (d)) and has long been recognized as the major source of contamination in Nebraska's aquifers (Exner and Spalding, 1979; Gormly and Spalding, 1979).

Nebraska has extensive experience dealing with elevated nitrates in groundwater. Numerous Natural Resource Districts, in partnership with the University of Nebraska, have been pioneers in developing innovative methodologies for identifying nitrate sources, developing monitoring approaches, and implementation strategies, including the nation's first nitrogen fertilizer regulations. Scientists successfully developed a technique enabling them to distinguish nitrogen sources based on the inherent ratios of natural abundance ^{15}N (a naturally occurring nitrogen isotope) to ^{14}N (the normal atomic number). Scientists were also able to “age” groundwater to better understand the timeframe when most of the contamination occurred. A significant amount of loading occurred in the 1970s-1980s when the management of N and water inputs (via flood irrigation) was much less efficient compared to current practices. An excellent historical summary on various Nebraska nitrate research can be found in Exner et al., 2014.

Wisconsin is reporting a large increase in the number of municipal water supply systems exceeding the state’s 10 mg/L level of concern (WI GCC, 2017). A 2012 survey found that 47 systems had raw water samples in excess of 10 mg/L compared to 14 systems in 1999. Collectively over $32.5 Million was spent in 2012 for mitigating nitrate contamination. Similar to Minnesota’s private well results, about 10% of the private wells tested in Wisconsin exceed the MCL and 20-30% in highly cultivated regions.

Wisconsin researchers report that 20% of nitrogen fertilizer ends up in groundwater and estimated in 2007 that over 100,000 tons of nitrogen fertilizer was applied to agricultural lands in excess of UW recommendations (WIDATCP, 2015).

d) Drinking Water Supply Management Areas in Minnesota

Some Minnesota communities using groundwater supplies have exceeded the nitrate-nitrogen HRL 0f 10 mg/L in recent years, and others are approaching unsafe levels. Installing nitrate removal systems is one approach taken by public water suppliers within impacted communities. The number of community water systems with removal systems has increased from six systems serving 15,000 people in 2008 to eight systems serving 50,000 people in 2014.

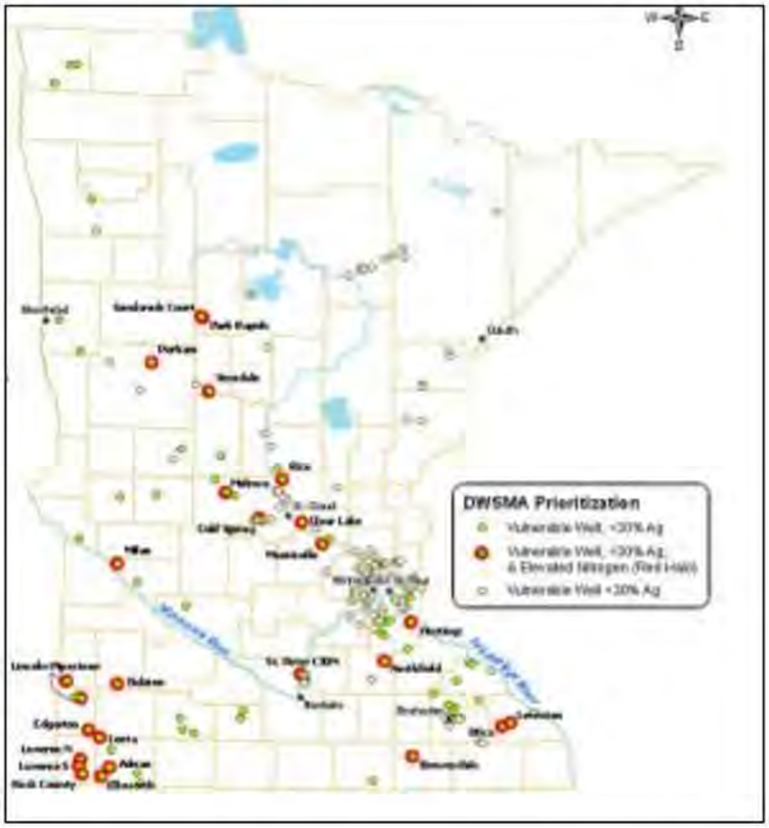


Figure II-12. Nitrate levels in public water supplies in agricultural areas.

There are roughly 30 to 40 public water suppliers in predominantly agricultural areas that are currently dealing with elevated nitrate-nitrogen concentrations. Associated costs for new wells, blending facilities, or installing nitrate removal systems can be significant, particularly to the smaller communities. Large systems serving many customers often can provide treatment at a lower cost per gallon than small communities. The cost of safe drinking water is not the same across the state and often the sources of contamination are outside water suppliers' control.

MDA has estimated that water costs to the consumer are several times higher in communities that are dealing with elevated nitrate levels compared to communities were nitrates are not an issue (UM, 2007).

III. Outline of the MDA's Requirements under Minn. Stat. chap. 103H

A. MDA must develop, educate and promote the use of BMPs for agricultural chemicals and practices.

Minn. Stat. § 103H.101, subd. 7 instructs state agencies to identify and develop best management practices (BMPs) for programs under their authority that have activities that may cause or contribute to groundwater pollution. For those activities which may cause or contribute to pollution of groundwater, but are not directly regulated by the state, BMPs shall be promoted through education, support programs, incentives, and other mechanisms.

Minn. Stat. § 103H.151, subd. 2-4 instructs the MDA specifically to develop and promote nitrogen fertilizer BMPs and provide education about how the use of BMPs will prevent, minimize, reduce and eliminate the source of groundwater degradation. The commissioner shall give public notice and contact and solicit comments from affected persons and businesses interested in developing the best management practices. The MDA also must monitor the use and effectiveness of the nitrogen fertilizer BMPs that the MDA has developed and promoted.

1. Nitrogen fertilizer BMP development

The nitrogen fertilizer BMPs are tools to manage nitrogen efficiently, profitably, and with minimized environmental loss. Nitrogen fertilizer BMPs were first developed for Minnesota in the late 1980s and early 1990s by the U of M and are based upon many decades of crop response research. The nitrogen fertilizer BMPs are tools to manage nitrogen efficiently, profitably, and with minimized environmental loss. Nitrogen fertilizer BMPs are a reflection of our understanding of the nitrogen cycle and are predicated on hundreds of site years of agronomics and environmental research. While acknowledging that no generalized recommendations are relevant all of the time, the nitrogen fertilizer BMPs represent a combination of practices that will reduce risk of excessive nitrogen loss in a normal year.

The nitrogen fertilizer BMPs are built on a four-part foundation that takes into account the nitrogen rate, application timing, source, and placement of the application, known as the "4Rs." If one of the "Rs" is not followed, the effectiveness of the system will be compromised, and there will be agronomic and or environmental consequences.

Minnesota has officially recognized statewide and regional nitrogen fertilizer BMPs. The MDA adopted the nitrogen fertilizer BMPs developed by the U of M according to the process laid out in Minn. Stat. § 103H.151, subd. 2. The MDA published public notice in the State Register, as well as contacted and solicited comment from affected persons and businesses that were interested in developing or who would be affected by the nitrogen fertilizer BMPs. The nitrogen fertilizer BMPs were published in the state register and adopted by the MDA in 1991, and irrigated potatoes were developed and adopted in 1996. The nitrogen fertilizer BMPs were updated in 2008 and the MDA again published in the State Register and solicited comment from affected persons and businesses as required by statute.

Due to major differences in geology, soils, and climate across the state, nitrogen fertilizer BMPs are not only needed statewide, but also on regional scale (Figure III-1; Table III-1). These regional recommendations give specific instructions on how to utilize the most appropriate nitrogen rate, source, timing, and placement. For example, practices that may work well in southwestern Minnesota may not be appropriate for southeastern Minnesota. Regional and specialized nitrogen fertilizer BMPs can be found on the MDA's website at http://www.mda.state.mn.us/protecting/bmps/nitrogenbmps.aspx.

- Best Management Practices for Nitrogen Use in Minnesota
- Best Management Practices for Nitrogen Use in Northwestern Minnesota
- Best Management Practices for Nitrogen Use in South-Central Minnesota
- Best Management Practices for Nitrogen Use in Southeastern Minnesota
- Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota
- Best Management Practices for Nitrogen Use on Coarse-textured Soils
- Best Management Practices for Nitrogen Use: Irrigated Potatoes

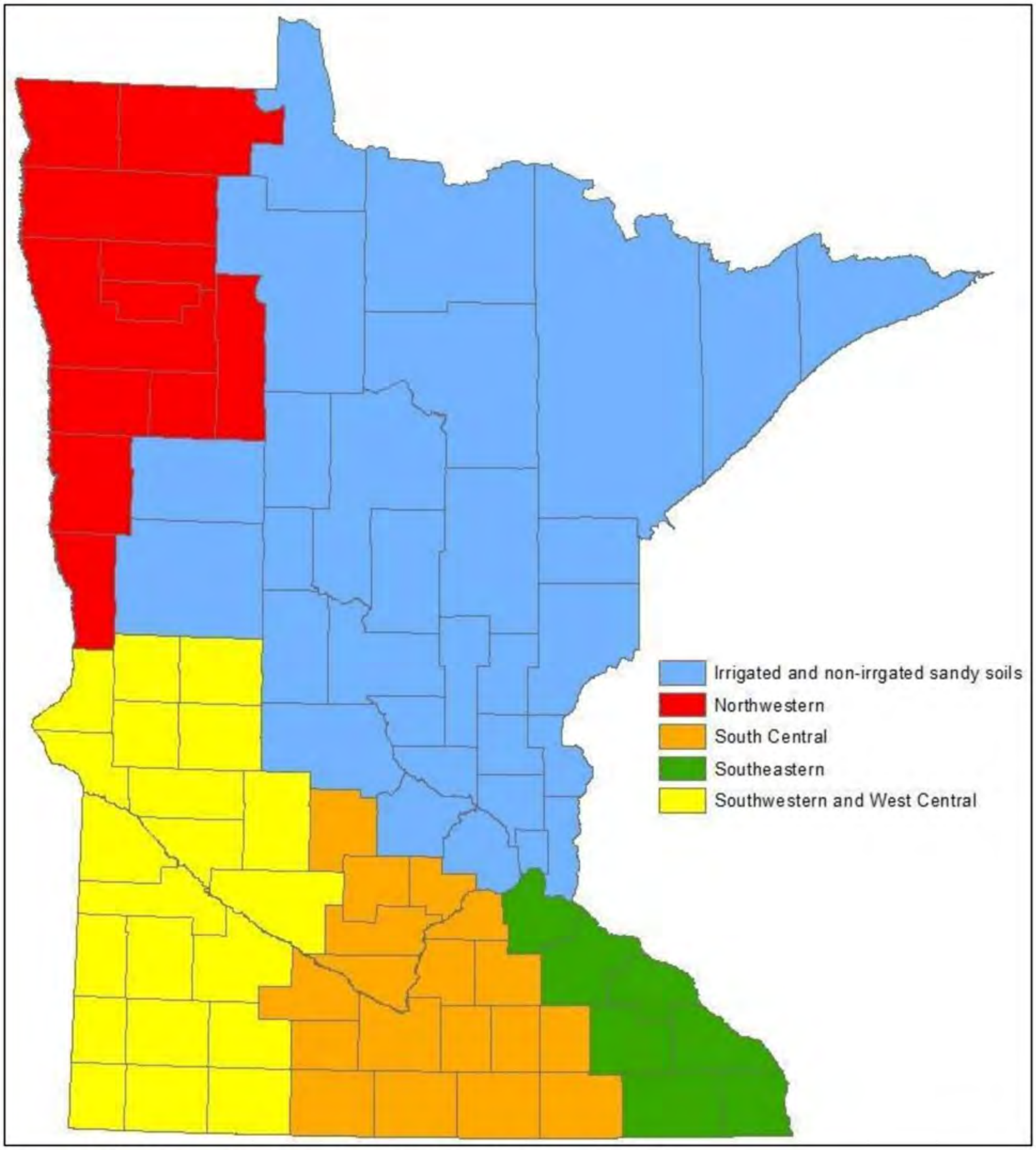


Figure III-1. Nitrogen fertilizer BMP regions. (Lamb et al., 2008).

Table III-1. Summary of the major nitrogen application timing and source BMP recommendations for corn by region (MDA, 2015).

	Minnesota Recommended Application Timing for Corn		
Nitrogen BMP Region	Fall*	Spring Preplant	Split or Sidedress
Southeast	Not Recommended	Highly Recommended: AA or Urea	Highly Recommended: AA, Urea, or UAN
		Acceptable with Risks: Preplant with UAN or ESN	
South-Central	Acceptable with Risks: AA or Urea with N-Serve	Highly Recommended: AA or Urea	Highly Recommended: Split Applications of AA, Urea, or UAN
	Not Recommended: Fall Application of Urea or UAN	Acceptable with Risks: Preplant with UAN or ESN	
Coarse-Textured Soils	Not Recommended	Acceptable with Risk: AA or Urea with N-Serve, Single Sidedress w/o N-Serve, or Single Preplant with ESN	Highly Recommended: Use Split Applications, N-Serve with Early Sidedress
Southwest/West-Central	Recommended: Fall Application of AA or Urea	Recommended: Urea, AA, or UAN	Recommended: Sidedress Prior to V7 Growth Stage
	Acceptable with Risk: Late Fall ESN or use of N-Serve or Agrotain		
	Not Recommended: Fall UAN or Any Fertilizer Containing Nitrate		
Northwest	Recommended: Fall Application of AA or Urea	Recommended: Urea, AA, or UAN	Recommended: Sidedress Prior to V7 Growth Stage
	Acceptable with Risk: Late Fall ESN or Use of N-Serve or Agrotain		
	Not Recommended: Fall UAN or Any Fertilizer Containing Nitrate		

*Only after six inch soil temperatures fall below 50 °F

Note: AA=Anhydrous Ammonia, ESN=Environmentally Smart Nitrogen, UAN=Urea Ammonium Nitrate Solution

Recognizing that nitrogen fertilizer use efficiency is profoundly impacted by management (rate, timing, source, and placement) and significant nitrogen losses can occur under agricultural production, the U of M developed (and subsequently updated) a very complete set of nitrogen fertilizer BMPs in conjunction with the passage of the 1989 Groundwater Protection Act (Lamb et al., 2008; Randall et al., 2008 (a)(b); Rehm et al., 2008(a)(b); Rosen and Bierman, 2008; Sims et al., 2008). Minnesota has a great deal of variability in terms of soils, climate, geology, and crop selection. All these factors influence nitrogen management, so the state was divided into five BMP regions. Each region has specific recommendations in terms of nitrogen timing, placement and sources as well as the use of nitrification inhibitors and other helpful guidance for increasing fertilizer efficiencies. Nitrogen rate recommendations are imbedded within the BMP publications for corn, sugar beets, coarse textured soils, and selected other crops (Kaiser et al., 2016; Kaiser et al., 2011; Lamb et al., 2015). The U of M is continually studying the nitrogen requirements to account for changes in varieties, climate variability and similar, and are updating their rate recommendations annually. The updated rates are available at http://cnrc.agron.iastate.edu/

Figure III-2. Minnesota's nitrogen fertilizer BMPs. (Lamb et al., 2008; Randall et al., 2008 (a)(b); Rehm et al., 2008(a)(b); Rosen and Bierman, 2008; Sims et al., 2008).

The U of M also provides critical fertilizer rate guidance for the minor crops and special situations such as under irrigated conditions (Kaiser et al., 2011; Lamb et al., 2015).

The selection of the correct nitrogen rate is one of the most important decisions that farmers make in terms of potential impacts to water resources. A relationship exists between nitrogen rates, yields, and environmental outcomes. The cornerstone of the nitrogen fertilizer BMPs is identifying the optimum rate and then a series of other related practices (timing, split applications, inhibitors, etc.) to ensure that the nitrogen will be there when the crop needs it.

There are a number of key points worth noting:

1. First, nitrogen losses are never zero under row crop production. Even with corn/soybean production where no commercial nitrogen is applied, many Minnesota fields on fine-textured soils are losing approximately 10 lb/acre/year (Carlson et al., 2017). Background losses on coarse textured outwash (irrigated) ranged from 20-50 lb/acre (Struffert et al, 2016);

2. Losses under U of M recommendations tend to be linear up to the optimum rates. Nitrogen losses at optimum rates are frequently found to be between 15-40 lb/acre (weather dependent) on fine-textured soils. Losses on the soils using U of M recommended rates will range from 50% to 300% higher than non-fertilized conditions and are highly dependent on rainfall patterns (Carlson et al., 2017). Losses can be also significant on the irrigated outwash (Struffert et al, 2016);

3. Once rates exceed U of M recommendations, losses tend to increase in a quadratic response. When nitrogen rates were increased from 120 to 150 lb/acre in southern Minnesota, yields were increased by four bushels but the amount of residual nitrate left over in the soil profile increased by 40% (Carlson et al., 2017); and

4. Year to year climatic variability can strongly impact losses and general relationships.

A significant percentage of Minnesota’s corn acres are receiving nitrogen rates above the MRTN (Maximum Return to Nitrogen) as recommended by the U of M.

2. Education and promotion of the nitrogen fertilizer BMPs

Field demonstration projects

As part of its statutory mandate to demonstrate and promote the effectiveness of the nitrogen fertilizer BMPs, the MDA has several on-going education and field demonstration programs. Educational outreach from these demonstrations are primarily with the participating farmers and their crop advisor(s), which in turn reaches other farmers and crop advisors they associate with. Educational outreach also occurs through presentations at field days and winter meetings, in media articles, and annual summary reports. Below are some examples of MDA’s education and promotion work:

- *Rosholt Farm*
  In the coarse-textured irrigated sands of Minnesota, suction cup lysimeters have been utilized at the Rosholt Farm (MDA, n.d. (m)) in Pope County to quantify the loss of

nitrate from the root zone under nitrogen rate plots that are currently being managed by U of M Extension. These nitrogen rate plots are part of the ongoing effort to revise and refine nitrogen fertilizer BMP application rates for irrigated coarse-textured soils (Struffert et al., 2016). MDA staff have developed additional demonstration sites in the coarse-textured soils of Dakota, Lyon, Otter Tail, Stearns, and Wadena Counties.

- *Nutrient Management Initiative*
  The Minnesota Nutrient Management Initiative (NMI) assists farmers and crop advisers in evaluating nitrogen fertilizer BMPs (MDA, n.d. (h)). Farmers can compare nitrogen rates, timing, placement, or the use of a stabilizer product on their own fields. Many famers choose a rate trial, comparing their normal nitrogen rate to a 30 lb reduction. At the end of the season, farmers are provided with a yield comparison and a simple economic analysis based on their actual nitrogen costs and corn yields. The Nutrient Management Initiative is designed to help farmers and crop consultants evaluate management decisions using the farmer's actual field conditions. On-farm trials allow farmers to compare different practices and evaluate their outcome. Some of the data from this program is used to inform the U of M Corn Nitrogen Rate Calculator and help evaluate nitrogen fertilizer BMP effectiveness. From 2015 through 2017 there have been more than 380 NMI field trial sites. On average, 100 farmers and 30 crop advisers participate annually in approximately 100-125 field trials per year.

- *Minnesota Discovery Farms*
  Minnesota Discovery Farms (MDF, n.d.), a farmer-led program that is directed by the Minnesota Agricultural Water Resource Center (MAWRC) and supported by the MDA, is also contributing to the promotion of the nitrogen fertilizer BMPs and our understanding their field scale impact along with other conservation practices. Minnesota Discovery Farms encompass numerous farm enterprises across Minnesota and will inform our understanding the water quality impacts of common agricultural practices. Staff from MAWRC meets annually with the participating farmers to review the monitoring data. The monitoring data is available on the Discovery Farm program's website. Monitoring data is additionally shared at field days and farmer meetings.

- *Root River Partnership*
  The Root River Partnership is designed to help southeastern Minnesota farmers and policy-makers better understand the relationship between agricultural practices and water quality (MDA, n.d. (j)). The purpose of this study is to conduct intensive surface and groundwater monitoring at multiple scales in order to provide an assessment of the amount and sources of nutrients and sediment delivered to the watershed outlet and also to determine the effectiveness of the nitrogen fertilizer BMPs and other conservation practices. This project includes an edge-of-field evaluation of the nitrogen fertilizer BMPs at one on-farm location. The study also includes a side-by-side field trial

comparing the U of M recommended rates and the farmer's normal nitrogen rates. Data is collected to compare crop yield as well as nitrate loss through tile drainage. This project has used monitoring data to provide information on the nitrogen fertilizer BMPs and other conservation practices needed to address water quality. This project is now transitioning from water monitoring to implementing conservation practices in the field. Project staff meet with the participating farmers annually to review the monitoring data, and the information is shared at field days, farmer meetings, professional meetings, as well as one-on-one meeting with area agronomists.

- *On-farm nitrogen fertilizer BMP studies with the U of M*
  MDA staff partner with U of M staff and staff of other partner organizations to conduct detailed nitrogen fertilizer BMP studies for the purposes of confirming or revising U of M guidelines on which the nitrogen fertilizer BMPs are based. Monitoring depends on the study being done and can include soil water nitrate-nitrogen concentration, as well as nitrogen concentrations in soil and tissue samples. Including in these studies is historic work done in Dakota County and current work at the Rosholt Farm in Pope County (MDA, n.d. (m)) and studies done as part of the Southeast Minnesota Nitrogen BMP Outreach Program. Education and outreach occurs through presentations at field days and winter meetings, media articles, and annual summary reports.

- *Soil temperature network*
  The MDA maintains a network of soil thermometers to assist farmers and applicators to follow the nitrogen fertilizer BMP of avoiding application in the fall until soil temperatures cool to 50^0 F (MDA, n.d. (l)). Every fall the MDA communicates through the media to remind farmers and applicators of this BMP and to remind them there are areas of the state where fall application of nitrogen fertilizer is not recommended, namely on coarse-textured soils and southeast Minnesota's region of karst geology.

a) Nitrogen fertilizer BMP education and outreach

There are many other outreach activities throughout the state that provide education about and promote the use of the nitrogen fertilizer BMPs. Some of these education and outreach programs are put on by other private or public groups outside of the MDA, with MDA either supporting or participating in the programs. All of these education and outreach opportunities "provide education about how the use of the best management practices will prevent, minimize, reduce, and eliminate the source of groundwater degradation."

- *Nitrogen Smart*
  Nitrogen Smart (UME, n.d.) is a training program for producers that presents fundamentals for maximizing economic return on nitrogen investments while minimizing nitrogen losses. The workshops deliver high-quality, research-based education so producers can learn:

- Sources of nitrogen for crops
- How nitrogen is lost from soil and how you can reduce losses
- How to manage nitrogen in drainage systems
- What the new NRS and NFMP mean for Minnesota producers
- Practices to refine nitrogen management, including split applications, alternative nitrogen fertilizers, soil and tissue testing, and nitrogen models

The Nitrogen Smart trainings are presented by U of M Extension, funded by Minnesota Corn Growers, and hosted by the Minnesota Agriculture Water Resource Center (MAWRC) at 8-10 locations throughout Minnesota during the winter months. There were 11 Nitrogen Smart trainings between February and March 2018.

- *Annual Nitrogen Conference*
  The U of M Minnesota Extension organizes an annual state-wide Nitrogen Conference that brings experts together to focus entirely on this valuable crop input (MAWRC, n.d.). The MDA is a lead sponsor of the conference. MDA staff regularly presents at the conference. Current topics in crop production and environmental stewardship are explored that are relevant and informative for farmers and their advisors. The conference attracts 125-175 attendees each year.

- *Annual Nutrient Management Conference*
  The MAWRC hosts an annual state-wide Nutrient Management Conference. The MDA is a lead sponsor of the conference. MDA staff members regularly presents at the conference. Although the conference covers all crop nutrient management issues, a substantial portion of its content is on nitrogen management. The conference is attended by farmers, their advisors, and water resource specialists and attracts up to 400 attendees each year.

- *U of M Extension winter meetings and summer field days*
  U of M Extension holds two winter meetings: the Research Updates held at the university's Research and Outreach Centers across the state and the Crop and Soil Days held at eight to ten state-wide locations. In addition to winter meetings, summer field days are held at the Waseca and Lamberton research and outreach centers, and the Institute for Agricultural Professionals Field School is held on the Saint Paul campus. Nitrogen fertilizer management is almost always on the agenda for meetings and field days because of its importance to agriculture agronomically and environmentally.

- *Minnesota Crop Production Retailers Association Short Course & Trade Show*
  Held jointly by the Minnesota Crop Production Retailers Association and the U of M Extension, this annual state-wide event for pesticide and fertilizer suppliers and

applicators is a reliable forum for sharing nitrogen management issues and technologies with licensed pesticide applicators, farmers, and crop advisors.

- *Source water protection plans*
  Public water suppliers are required to develop source water protection plans and update them on a ten-year schedule. When elevated nitrates in drinking water is an issue, these plans include educational activities to promote nitrogen fertilizer BMPs and AMTs in their WHPAs. Local soil and water conservation districts (SWCDs) are usually utilized to carry out the nitrogen fertilizer BMP and AMT education.

- *Ag supplier education and support*
  The primary source of nitrogen fertilizer management information for most farmers is their fertilizer dealer agronomist. It is with this advisor that most farmers decide on an annual NFMP. Fertilizer dealer agronomists provide education to their client farmers on crop nitrogen need, management, and water quality protection concerns. They also provide support services such as monitoring fall soil temperature to let farmers know soil temperatures have reached 50° F so they can apply fall nitrogen.

- *Ag supplier winter meetings*
  A regular feature of Minnesota's agricultural industry is the agricultural suppler winter meeting. Suppliers of seed, fertilizer, and pesticides invite their farmer clients to meetings where they will provide a free meal and information on upcoming product and program developments. Nitrogen fertilizer management is almost always on the agenda for these meetings because of its importance to agriculture agronomically and environmentally.

b) MDA's external partnerships providing education and promotion of the nitrogen fertilizer BMPs

In addition to the Fertilizer Field Unit within the Pesticide and Fertilizer Management Division of the MDA, there are several staff throughout the state whose positions are dedicated to providing education about and promote the use of nitrogen fertilizer BMPs.

- *Agricultural Water Quality Protection Educators, U of M Extension*
  The U of M supports two extension educator positions in the area of crop nitrogen fertilizer management, one in Saint Cloud and one in Rochester. The focus of their positions is assisting crop producers in implementing nitrogen fertilizer BMPs and AMTs as outlined in the state's NFMP. The positions are funded by state Clean Water Fund dollars administered by the MDA.

- *Irrigation Management Specialist, U of M Extension*
  The U of M supports an irrigation management specialist extension educator position that focuses on crop irrigation management as it relates to nitrogen management and water

quality protection. The position's objective is to increase the capacity of farmers and their advisors to more effectively manage cropland irrigation state-wide, especially in areas vulnerable to groundwater contamination (MDA, n.d. (e)). The position is funded by state Clean Water Fund dollars administered by the MDA.

- *Nitrogen management specialist, U of M Extension*
  The U of M supports a nitrogen management specialist position within its Department of Soil, Water, and Climate. Funded by the Minnesota Corn Growers Association, the position concentrates through research and outreach education on environmental issues related to nitrogen management of corn cropping systems, seeking to identify and implement nitrogen management practices that are sustainable both in terms of water quality protection and improving crop yields. This position is critical to developing and updating the nitrogen fertilizer BMPs, conducts MDA-sponsored research projects, consults regularly with MDA staff, and serves on several MDA advisory boards including the nitrogen fertilizer BMP Education and Promotion.

- *Source Water Protection Specialists, Minnesota Rural Water Association*
  The Minnesota Rural Water Association has two staff positions, one in Park Rapids and one in Rochester, which focus on addressing elevated nitrate-nitrogen concentration of rural public water suppliers. Since the source of this nitrate is often agriculture, they are actively involved in promoting nitrogen fertilizer BMPs and AMTs in WHPAs. These staff are frequently partners on a variety of demonstration sites, including the promotion of Kernza and other perennials with the wellhead protection areas (WHPAs) and will be directly or indirectly active with future Local Advisory Team activities.

- *Southwest Minnesota Regional Water Resources Specialist*
  MDH and local funds supports a Regional Water Resources Specialist who works with six counties in southwest Minnesota with a focus on nitrogen management. The position promotes nitrogen fertilizer BMP and AMT use in WHPAs that are vulnerable to nitrate groundwater contamination. MDA staff partner with the person in this position on various demonstration and outreach activities. The person in this position also will be directly or indirectly active with future LAT activities.

c) Minnesota Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water (MDA, n.d. (f)). Those who implement and maintain approved farm management practices will be certified and in turn obtain regulatory certainty for a period of ten years. Part of the farm operation review process associated with certification is a discussion and evaluation of nitrogen management, including the nitrogen fertilizer BMPs and AMTs. As of March 2018, 544 farmers are certified, comprising 341,800 acres of agricultural land.

d) Historic nitrogen fertilizer BMP Promotion: 1990-2011

- *Source Water Protection Areas*
  Focused education and demonstration projects related to nitrogen management within key agricultural SWPAs (Perham, St. Peter, Verndale, Lincoln-Pipestone, and Cold Spring);

- *Nitrate Testing Clinics*
  Successfully created awareness of nitrates in private drinking wells through the testing of over 50,000 wells from 1996 to 2006. The clinic format provided many excellent opportunities to discuss nitrogen fertilizer BMPs with farmers and home owners;

- *Field Scale Demonstrations*
  Created water quality demonstration sites at Red Top Farm (Nicollet Co), Highway 90 (Blue Earth Co), Perham SWPA (Otter Tail Co), Verndale SWPA (Wadena Co), and others. Sites were instrumented to measure nitrate losses as a function of various nitrogen fertilizer BMPs and crop selection. Numerous field day events and winter educational events provided outlets for the results;

- *Soil and Manure Testing Certification Programs*
  In support of nitrogen fertilizer BMPs related to soil and manure testing, the MDA developed certification programs for laboratories providing these services to farmers. The programs require approved testing procedures and the presentation of results that are in an understandable and standardized format. The vast majority of soil and manure analysis now come from certified labs;

- *MDA Leadership in nitrogen fertilizer BMP Research Projects*
  The MDA partnered and managed numerous grants from the Legislative Commission on Minnesota Resources/Legislative-Citizen Commission on Minnesota Resources (LCMR/LCCMR) and USEPA 319 grants to assist the U of M in the development and validation of nitrogen fertilizer BMPs;

- *Nitrogen Fertilizer BMP Insurance Concept*
  This was a pilot project funded by USDA-Federal Crop Insurance Corporation, led by the MDA in partnership with Iowa Department of Natural Resource and Wisconsin Department of Natural Resources. The project provided insurance protection for growers experimenting with nitrogen rates recommended by the land grant universities. Although the program eventually was discontinued, several key features led to the development of the MDA's Nutrient Management Initiative.

B. Nitrogen Fertilizer Management Plan (NFMP)

Laws of Minnesota 1989, Chapter 326, Article 6, Section 33, subd 2 required MDA to establish the following:

(1) establish best management practices and water resources protection requirements involving fertilizer use, distribution, storage, handling, and disposal;

(2) cooperate with other state agencies and local governments to protect public health and the environment from harmful exposure to fertilizer; and

(3) appoint a task force to study the effects and impact on water resources from nitrogen fertilizer use so that best management practices, a fertilizer management plan, and nitrogen fertilizer use regulations can be developed.

The law further required that this Task Force be made up of a diverse group of representatives from agriculture, environmental groups, and local and state governments. The Task Force was responsible for reviewing current information regarding the impact of nitrogen fertilizer on water resources and for making recommendations on ways to minimize these effects. The nitrogen fertilizer management plan must include components promoting prevention and developing appropriate responses to the detection of inorganic nitrogen from fertilizer sources in ground or surface water.The MDA uses the state's NFMP as the blueprint for prevention and minimization of the impacts of nitrogen fertilizer on groundwater. The NFMP, revised in 2015, was developed using a multi-stakeholder advisory committee and a public review process. It emphasizes involving local farmers and agronomists in problem-solving for local groundwater concerns when nitrate from fertilizer is a key contributor. Nitrogen fertilizer BMPs are the cornerstone of the NFMP and the proposed Rule. Authority for the proposed Rule comes from the Groundwater Protection Act, Minn. Stat. § 103H.275. The plan lays out education and promotion activities, how the MDA monitors groundwater and provides the framework for the proposed Rule.

In 2010, the MDA began the process of revising the 1990 NFMP to reflect current agricultural practices and activities, apply lessons learned from implementation activities and other work, and to better align it with current water resource conditions and program resources. The MDA assembled an Advisory Committee with 18 members, including three members from the original Task Force. The MDA hosted eighteen Advisory Committee meetings between 2011 and 2012 to review information related to the nitrogen cycle, nitrate contamination of ground and surface water, hydrogeologic conditions, crop production, nitrogen management, research, and implementation. Before the final version of the plan was released the MDA had a final public comment period. During this comment period, the MDA received 32comments from various stakeholders. These comments were addressed before releasing the final version of the NFMP (MDA, 2015). The NFMP is attached as appendix 9 and is available online at http://www.mda.state.mn.us/nfmp. The general approach used by the NFMP to address nitrate in groundwater consists of the following activities: prevention, monitoring and assessment, and mitigation.

The proposed Rule follows the process outlined in the NFMP and works with local farmers to make sure they are following the nitrogen fertilizer BMPs before moving to regulation.

Thus, MDA has satisfied its statutory obligation of education, promotion, and development of BMPs through their development in cooperation with the University of Minnesota, the numerous field demonstration projects, training programs and conferences, funding of positions dedicated to education of BMPs, and the Agricultural Water Quality Program. Through the NFMP, MDA has continued its development and education of BMPs, and is using the NFMP as a blueprint for the development of the rule.

C. MDA monitoring of nitrates in groundwater

MDA has been part of monitoring of groundwater for nitrates since 1987. Monitoring is done on both private and public wells.

A well is a hole drilled into the ground used to access water. A pipe and a pump move the water from an aquifer to a sink, shower, or other location for drinking, washing, etc. Wells can be either private or public. A private well is usually owned by a person and is intended to supply water to a home or for another nonpublic use. Public wells supply water to city residents, hotels, lodging facilities, schools, and other entities. If a public well is contaminated with nitrate, the water supplier bears the cost of treating the water or providing a safe source of water. Those costs are usually passed on to the ratepayers. Additional information on alternatives and costs is available in, the Regulatory Analysis section under, Alternative methods of achieving the proposed Rule that were considered and rejected, of the SONAR.

1. Private Wells – Township Testing

Water samples from large areas show that relatively small percentages of private wells exceed the health risk limit. The MDH estimates that around 1% of new Minnesota wells exceed 10 mg/L nitrate-nitrogen. A USGS report on nitrate concentrations in private wells in glacial aquifer systems of the United States estimates that less than 5% of wells had nitrate-nitrogen concentrations exceeding the health risk limit (Warner and Arnold, 2010).

However, wells in areas with vulnerable soils and geology are at much greater risk and exceed the health risk limit in larger numbers. The MDA is in the midst of offering nitrate testing to private well owners in areas vulnerable to groundwater contamination and with significant row crop production. The wells are sampled in townships and it is called the Township Testing Program (TTP).

From 2013 to 2017, 242 vulnerable townships from 24 counties participated in the TTP. Overall, 10.1% (2,583) of the 25,652 wells exceeded the health risk limit for nitrate in the townships that have been sampled. Some townships with initial results have yet to be analyzed for possible nitrogen sources, so the final percentage of wells over the health risk limit from a non-point source may change based on follow-up sampling (MDA, 2018 (b)). More than 70,000 private well owners will be offered nitrate testing in over 300 townships by 2019.

Table III-2. Township Testing Program nitrate-nitrogen summary: 2103-2017

Total Wells	Nitrate-Nitrogen mg/L (ppm)			
	<3	**3<10**	**≥10**	**≥10**
	Number of Wells			**Percent**
25,652	19,277	3,792	2,583	10.1

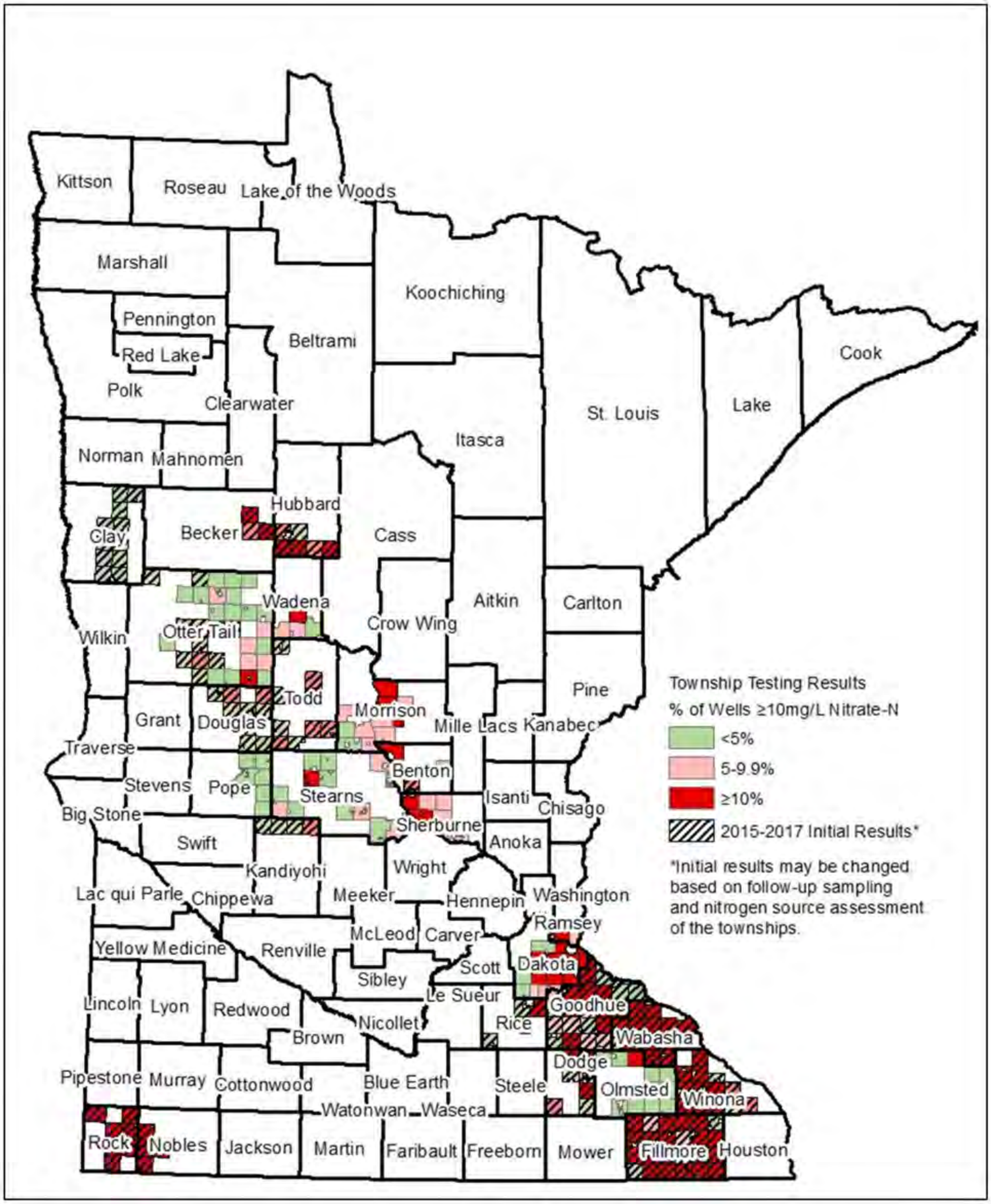


Figure III-3. Percentage wells in each Minnesota Township exceeding 10 mg/L nitrate-nitrogen MDH HRL at initial sampling.

2. Public wells

Various communities that use groundwater as their water source have exceeded the health risk limit for nitrate in recent years. According to the MDH, 15 community public water supplies had nitrate levels in groundwater above the health risk limit as of 2014. (MDH, 2015). The number of community water suppliers that treat for nitrate has increased from 6 systems serving 15,000 people in 2008 to 8 systems serving 50,000 people in 2014. Six non-community systems exceeded the 10 mg/L nitrate-nitrogen health risk limit in 2016, requiring corrective action (MDH, 2017). Non-community systems provide water to people in schools, lodging facilities, and businesses that are not connected to community water systems.

3. Monitoring wells

To monitor in areas with shallow groundwater, nested groundwater wells are installed by the MDA in or near areas with row crop agriculture. Monitoring these areas aids in early detection if chemicals are present, and is considered a preventive and proactive approach to protecting Minnesota's waters. Although the MDA's current groundwater monitoring program was originally designed for pesticides, the MDA collects and analyzes samples for nitrate to provide information about the potential environmental impact to groundwater associated with agricultural activities in the state. A description of the networks is available in the Nitrogen Fertilizer Management Plan (MDA, 2015)

In 2004, the MDA groundwater monitoring program, with assistance from the University of Minnesota, established a regional monitoring network that divided the state into ten regions. These regions were developed to facilitate water quality monitoring efforts, pesticide management, and BMP development, promotion, and evaluation. These regions were termed Pesticide Monitoring Regions (PMRs).

A 2012 report provided a summary of the MDA's nitrate groundwater monitoring activities (MDA, 2012). The nitrate data were compiled and analyzed on an annual basis for each region. The Central Sands area (PMR 4) and the Southeast karst area (PMR 9) were determined to be the most vulnerable to and the most impacted by nitrate contamination. Nitrate was detected in 94% to 100% of the samples from 2000 to 2010 in PMRs 4 and 9. According to the most recent data available, nitrate was detected in all samples from the two regions. Seventy-six percent of the samples collected in the Central Sands area (PMR 4) exceeded the HRL along with 26 percent in the southeast karst area (MDA, 2017).

The monitoring wells described here are properly constructed for monitoring and are not located near nitrogen point sources. They are located at the edges of fields. Therefore, it is reasonable to conclude nitrate is coming from agricultural practices.

Figure III-4. Minnesota Pesticide Monitoring Regions (NFMP, 2015).

4. Southeast and Central Sands Private Well Volunteer Monitoring Networks

The MDA and partners have worked with private well owners to sample their wells for nitrate, and have found there can be variability in monitoring data in individual wells from year to year. The Southeast Volunteer Monitoring network has been in place since 2008 in 9 counties. Between 2008 and 2015, ten sampling events occurred representing approximately 4,300 samples. During this period, the percentage of wells exceeding the health risk limit for each sampling event ranged between 8 and 15 percent. Each year, between 373 and 519 wells were sampled. The MDA launched a similar project in the Central Sands area of Minnesota, which includes 14 counties. From 2011 to 2015, 3 to 4 percent of the wells exceeded the health risk limit. The number of wells sampled annually during this period ranged from 402 to 534.

The MDA in cooperation with other state agencies have done extensive monitoring of groundwater. Based on the above, MDA has complied with all its requirements under 103H, and has determined that the implementation of the BMPs has proven ineffective as it relates to Nitrogen fertilizer.

D. Nitrogen Fertilizer Management Plan (NFMP)

1. Development Process

The MDA uses the state's NFMP (MDA, 2015) as the blueprint for prevention and minimization of the impacts of nitrogen fertilizer on groundwater. The NFMP, revised in 2015, was developed using a multi-stakeholder advisory committee and a public review process. It emphasizes involving local farmers and agronomists in problem-solving for local groundwater concerns when nitrate from fertilizer is a key contributor. Nitrogen fertilizer BMPs are the cornerstone of the NFMP and the proposed Rule. Authority for the proposed Rule comes from the Groundwater Protection Act, Minn. Stat. § 103H.275. The plan lays out education and promotion activities, how the MDA monitors groundwater and provides the framework for the proposed Rule.

The first NFMP was adopted in 1990. The original 1990 NFMP was created with the guidance of the Nitrogen Fertilizer Task Force. This Task Force was made up of a diverse group of representatives from agriculture, environmental groups, and local and state governments. The Task Force was responsible for reviewing current information regarding the impact of nitrogen fertilizer on water resources and for making recommendations on ways to minimize these effects (MDA, 2015). In 2010, the MDA began the process of revising the 1990 NFMP to reflect current agricultural practices and activities, apply lessons learned from implementation activities and other work, and to better align it with current water resource conditions and program resources. The MDA assembled an Advisory Committee with 18 members, including three members from the original Task Force. The MDA hosted eighteen Advisory Committee meetings between 2011 and 2012 to review information related to the nitrogen cycle, nitrate contamination of ground and surface water, hydrogeologic conditions, crop production, nitrogen management, research, and implementation. Before the final version of the plan was released the MDA had a final public comment period. During this comment period, the MDA received 32 comments from various stakeholders. These comments were addressed before releasing the final version of the NFMP (MDA, 2015). The NFMP is attached as appendix 9 and is available online at http://www.mda.state.mn.us/nfmp. The general approach used by the NFMP to address nitrate in groundwater consists of the following activities: prevention, monitoring and assessment, and mitigation.

With the updated NFMP in place the MDA has decided to adopt water resource protection requirements to support the state's plan to reduce nitrate in groundwater. The proposed Rule follows the process outlined in the NFMP and works with local farmers to make sure they are following the nitrogen fertilizer BMPs before moving to regulation.

IV. The MDA has determined that the Implementation of BMPs Related to Nitrogen Fertilizer is not Effective.

Minn. Stat. § 103H.275, subd. 1, states that the MDA may adopt water resource protection requirements by rule that are consistent with of Minn. Stat. § 103H.001 and are commensurate with the groundwater pollution if the implementation of BMPs has proved to be ineffective. This section will address the implementation of nitrogen fertilizer BMPs throughout the state.

The MDA is the designated lead state agency through Minn. Stat. chap.18C for the regulation of commercial fertilizers. Additional responsibilities, as stated in Minn. Stat. chap. 103H, require the MDA to protect groundwater from the use of nitrogen fertilizer. As part of these requirements, the MDA is required to assess the status of nitrogen fertilizer BMP implementation. Accurate nitrogen fertilizer BMP assessments are a critical component of the NFMP. Since 1993, the MDA has developed innovative assessment tools and techniques to determine the implementation of the nitrogen fertilizer BMPs at the statewide, regional, and local scales. Over the past 25 years, the MDA has interviewed thousands of Minnesota producers who represented different geologic settings, climatic regimes, crop rotations, and livestock operations. These various assessment tools help MDA and the agricultural community understand how farmers manage their nitrogen inputs including fertilizers, manures, and legume credits, as well as the rate, timing, placement, and sources of nitrogen fertilizers. The MDA also has developed several different groundwater monitoring systems to monitor the presence of pesticides and fertilizers in groundwater around the state. One of these systems uses edge of field monitoring wells, with no nearby point sources, indicating there is a high presence of nitrate in groundwater.

It has been established that Nitrogen fertilizer sales have increased over the years as the amount of nitrogen-demanding plants has replaced more nitrogen friendly plants. It has also been proven that Minnesota has seen an increase in nitrogen in the groundwater in some areas vulnerable to groundwater contamination, including DWSMAs. The surveys described in this section have been important for educating to farmers. The education process is an important tool, but by itself, is not effective in securing nitrogen fertilizer BMP adoption or stopping the increase in nitrates in groundwater, especially in areas where nitrate levels are the highest. The MDA concludes that excessive rates are used in some locations, credit for existing nitrogen is not always taken, and the excess of nitrate in groundwater in some agricultural areas needs to be decreased by requiring the adoption of water resource protection requirements. This data proves that the implementation of the BMPS is ineffective.

A. Data shows that producers are over-applying nitrogen fertilizer, including miscalculating how much nitrogen is applied when manure is used.

The MDA has authored and published numerous reports using the localized and highly detailed Farm Nutrient Management Assessment Program (FANMAP) (MDA, n.d. (b)) approach as well as a broader phone-based approach in partnership with the National Ag Statistics Service (NASS) (MDA, n.d. (i)). Through these assessment tools and routine monitoring of fertilizer tonnage sales, the MDA has developed extensive knowledge on nitrogen fertilizer trends and associated management practices in Minnesota. These various assessment tools help understand how farmers manage their nitrogen inputs including fertilizers, manures, and legume credits as well as the rate, timing, placement and sources of nitrogen fertilizers.

The MDA has authored and published numerous reports through the FANMAP which provides highly detailed information about agricultural inputs such as fertilizer, manure, and pesticides. This tool is extremely useful when working with farmers in different regions across Minnesota.

In order to conduct a FANMAP survey, it is critical to develop a representative sampling population. In all FANMAP activities, County Educators (Minnesota Extension Service) and SWCD staff from the appropriate counties are contacted and individually interviewed. The purpose of the interviews is to inform them of the specifics of the particular project and overall goals; obtain pertinent county information (i.e. locations and demographics); and identify potential candidates (farmers) and their agronomic management skills as perceived by the County Educator. Information about on-farm management and inputs is collected by a personal visit to each farm and typically requires one to two hours of contact. Since its inception, thousands of Minnesota farmers have shared valuable information about their farming practices. For more information, please visit the MDA's FANMAP website (MDA, n.d. (b)).

More recently, the MDA has partnered with the USDA National Agricultural Statistic Service (NASS) and U of M researchers to collect information about fertilizer use and farm management on a broader scale than FANMAP (MDA, n.d. (i)). Partners have pioneered a survey tool for characterizing fertilizer use and associated management on a regional and statewide scale. Surveys are conducted over the phone. Enumerators from NASS are highly skilled at obtaining critical information over the phone with minimal time and burden on the producer. Over the past 25 years, the MDA has interviewed thousands of Minnesota producers who represented different geologic settings, climatic regimes, crop rotations, and livestock operations. The first attempt using this technique was in 2010 and has been conducted on a yearly basis since then. NASS enumerators surveyed approximately 1,500 corn farmers from across the state to gather information about commercial fertilizer use. The statewide fertilizer use survey alternates every other year. Much of the focus is on corn production, where 70% of the commercial inputs are used. During alternate years, the survey focuses on regional issues in areas of the state where there is a high risk of groundwater contamination. Reports are compiled and available on the MDA's website. While the MDA has conducted numerous fertilizer use surveys, for purposes of this SONAR, much of the supporting documentation is derived from three extensive NASS surveys conducted in 2010, 2012 and 2014, which included thousands of Minnesota's corn producers.

In summary, the following general practices which directly threated groundwater quality are routinely observed on both a statewide level and on a localized (DWMSAs) scale. While there are many areas where Minnesota farmers have made great improvements in nitrogen management, a very significant number of cropland acres are using practices that threaten groundwater resources.

- *Lack of Nitrogen Crediting from Legumes:* The MDA found that 18 – 38 pounds in excess of U of M guidelines are commonly applied after growing soybeans. Soybeans are a legume and can put nitrogen back into the soil, so less nitrogen is needed for the next crop.

- *Lack of Nitrogen Crediting from Other Fertilizers:* The total amount of nitrogen fertilizer from all sources needs to be taken into account, or credited, when calculating the total amount of nitrogen applied to a crop. Phosphorus fertilizer sources that also contain nitrogen, such as monoammonium phosphate (MAP) or diammonium phosphate (DAP), and more recently ammonium sulfate, are seldom credited when they should be.

- *Lack of Manure Crediting:* Similar to not taking crediting for other fertilizers or legumes, manure sources are not being properly credited when producers are calculating the total amount of nitrogen applied to a crop. Over-application rates are frequently compounded when in tandem with legume crops.

- *Fall Applications:* Surveys indicate that 30-40% of all nitrogen is applied in the fall. Different areas of the state have different nitrogen fertilizer BMPs when it comes to fall application. The nitrogen fertilizer BMPs specify where and when fall application is appropriate. The surveys show concerns about improper nitrogen source selection, lack of using a nitrification inhibitor when recommended, applications made prior to proper soil temperatures, and application onto inappropriate soil types.

- ***Collectively, Excessive Nitrogen Fertilizer Use:*** Across the various rotations and different scenarios, it is conservatively estimated that Minnesota producers use 10-15% more nitrogen fertilizer then necessary to maintain optimum yields. Nitrogen sales should be reduced by approximately 100,000 tons/year to not only improve water quality but also reduce the financial burden on producers.

There is a very strong body of knowledge indicating that BMPs are not being adopted to an acceptable level and an equally strong body of knowledge on the related impacts to groundwater quality. Therefore is it needed and reasonable for MDA to move forward with Part One and Part Two of the proposed Nitrogen Rule.

The amount of nitrogen fertilizer that is used can have a great impact on the amount available to leach into groundwater (MDA. n.d. (d)). Rates are generally viewed as the most important single factor impacting both economic and environmental perspectives in comparison to the other remaining practices of right source, right placement and right timing. The choice of the appropriate rate is not easy to determine because of the transient nature of nitrogen in soil (Kaiser et al, 2016).The amount of nitrogen fertilizer that is used can have a great impact on the amount available to leach into groundwater.

The U of M has based their recommendations for nitrogen fertilizer rate on the maximum return to nitrogen (MRTN). This is determined using the ratio between the price per pound of nitrogen divided by the price per bushel of corn in order to determine the rate of nitrogen fertilizer that should be used in order for a farmer to get the greatest return from their crop (Kaiser et al., 2016). Numerous factors influence the price per pound of nitrogen and the price per bushel of corn which will vary over time and across individual farm operations. It is generally accepted that over the long haul, the prices of grain and fertilizers are closely linked within the marketplace and for most situations, the 0.10 ratio is highly appropriate for corn production when manure resources are not used.

By further examining the application rates for various crop rotations and comparing these rates with the U of M fertilizer recommendations, it is possible to make estimates on the amount of excess nitrogen that is applied during selected rotations. Appendix 1 shows the calculations used to determine over-application of nitrogen fertilizer in various rotations.

There are appreciable over-application rates found in the corn-soybean rotation. Over-application rates within this rotation range from 18 to 38 lb/A, depending up which top rate U of M recommendation is used. Statewide across all associated acres in this rotation, this translates into excessive nitrogen inputs between 32,000 and 67,000 tons of N per year. This was between 4 to 9% of the statewide N sales for 2014.

In rotations where manure is applied, an additional 3-4% of nitrogen fertilizer, conservatively, is over-applied. It is important to note that the acres of this over application are relatively small but the rate of over-application occurring on this land is high. In the continuous corn rotation, the excessive nitrogen inputs are minimal (1,765 to 3,437 tons per year) which is less than 0.4% of the statewide N sales for 2014.

When these two rotations are considered collectively, 55,000 to 100,000 tons of nitrogen fertilizer is used in excess of the U of M nitrogen fertilizer recommendations. This is 7 to 12% of the annual nitrogen fertilizer sales in the state of Minnesota. Based on the studies cited above, we know that this over-application threatens the quality of Minnesota’s groundwater.

Below are summaries from the 2010, 2012 and 2014 NASS survey’s documenting how the nitrogen fertilizer rate BMPs are ineffective based on crop rotation.

NASS Survey: Corn following Corn

Statewide, nitrogen fertilizer application rates for corn following corn averaged 158 lbs of nitrogen per acre (MDA and NASS, 2014, 2016, and 2017). The current U of M MRTN rate is 155 lbs with a range of 145-170 lbs of nitrogen per acre (Figure IV-1).

The average percentage of fields in a corn following corn rotation that exceed the guidelines in the past 3 surveys is 37%. Nitrogen rates in excess of the University of Minnesota guidelines frequently result in excessive residual soil nitrates at the end of the growing season. There is an increased probability that this extra nitrogen will be leached below the root zone by the following spring.

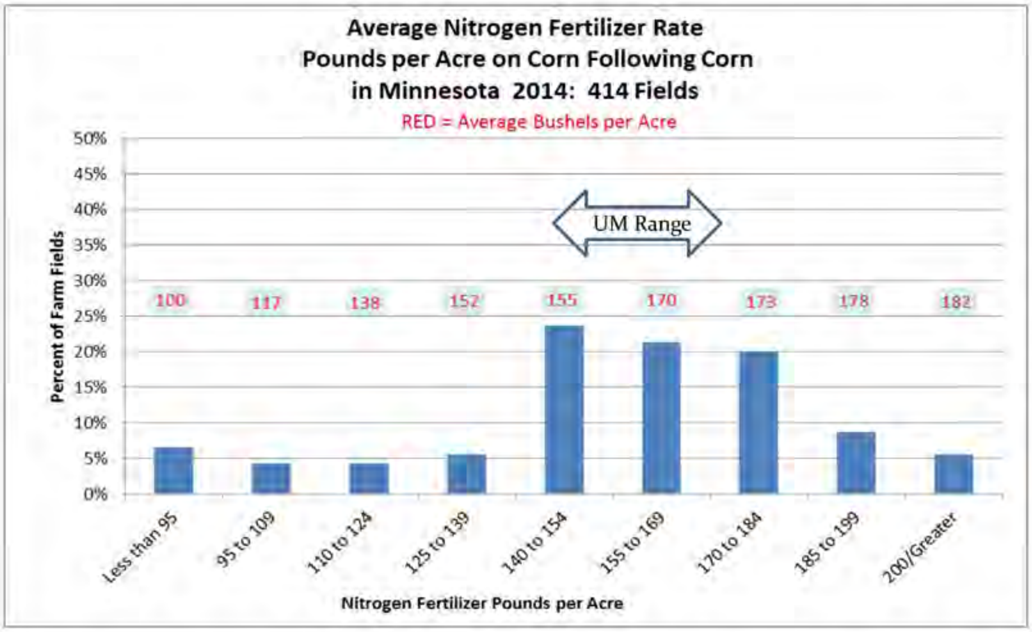


Figure IV-1. Percent fields within U of M recommended nitrogen rate ranges for corn following corn.

NASS Survey: Corn following Soybeans

Statewide, nitrogen fertilizer application rates for corn following soybeans averaged 145 lbs nitrogen per acre (MDA and NASS, 2014, 2016 and 2017). The current U of M MRTN rate is 120 lb with a range of 105 to 130 lb nitrogen per acre (Figure IV-2).

The percentage of fields in a corn following soybeans rotation exceeding the guidelines averages 65%. Surveys found that farmers were applying 20-40 lb in excess of the U of M guidelines in a corn following soybean rotation, which means there is extra nitrate present on the fields available that is leaching into groundwater.

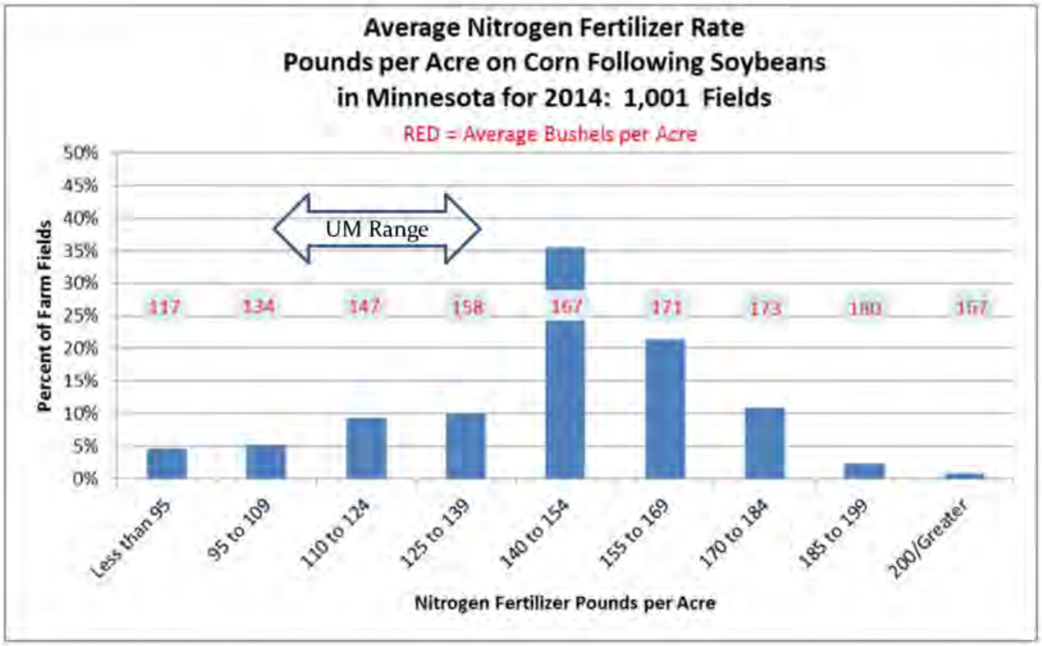


Figure IV-2. Percent fields within U of M recommended nitrogen rate ranges for corn following soybeans.

NASS Survey: Corn following Manure

Generally, 15-20% of the corn acres in the state will get a manure application either the fall before or just prior to spring planting. These percentages will vary significantly based on local livestock densities. Manure crediting is much more difficult to predict than other nitrogen sources. The nitrogen content of the manure is highly dependent on the type of manure, climatic conditions, how the manure was stored, and many other variables. Because of the high number of uncertainties associated with manure nitrogen credits, livestock producers and agricultural professionals tend to be conservative in their estimates of need and frequently over-apply manure in combination with nitrogen fertilizer.

Additionally, the manure applications are frequently made by either the producer or a commercial manure applicator. Proper nitrogen crediting requires that manure records are shared with the fertilizer dealer, so they can accurately reduce commercial inputs. However, even though the sharing of this information is required, the surveys show that it is not commonly communicated, and over-applications frequently occur.

A 2012 survey (MDA and NASS, 2016) documented the frequency and magnitude of nitrogen inputs on manured acres on corn (Figure IV-3). For purposes of the survey, manured acres are defined as those acres that had manure applied in the previous fall (after harvest) through applications made in the spring before planting. The survey documented average nitrogen inputs from manure at 120 lb/acre and from commercial nitrogen fertilizer at 76 lb/acre, totaling 196 lbs per acre. The current U of M MRTN rate is 155 lb per acre with a range of 145 to 170 lbs nitrogen per acre (Figure IV-3).

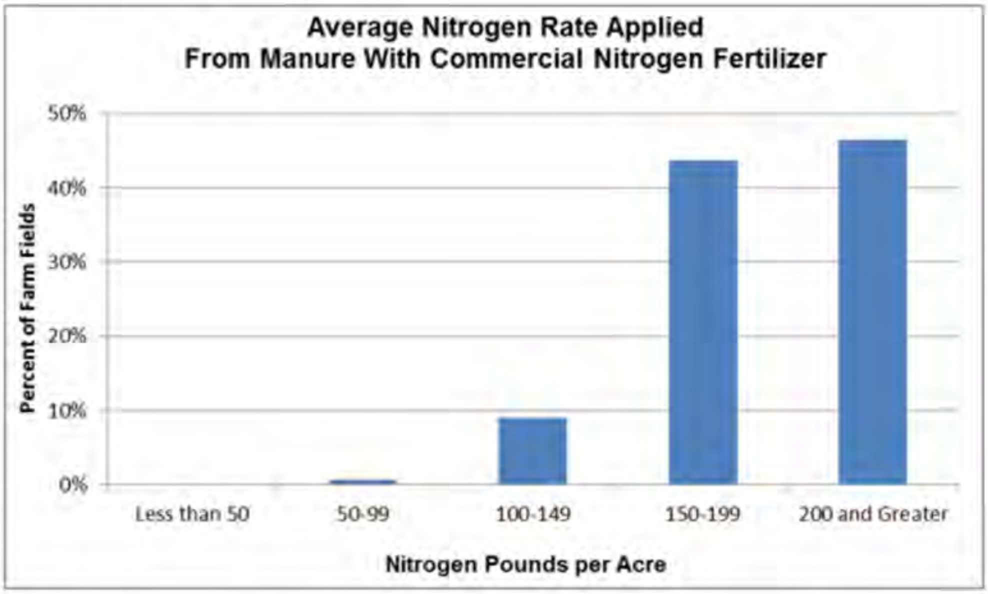


Figure IV-3. Average nitrogen inputs (fertilizer and all forms of manure) statewide.

Corn following Alfalfa, with Manure

Despite the large nitrogen credit typically provided by the killing of alfalfa (75-150 lb/acre), producers frequently apply manure before planting corn on fields with killed alfalfa. In a recent joint study, the U of M and USDA-ARS found fields where manure was applied to killed alfalfa prior to the first year of growing corn, the over-application rates were frequently found to be 100-200 lb nitrogen per acre over U of M guidelines (Figure IV-4, Yost et al., 2015).

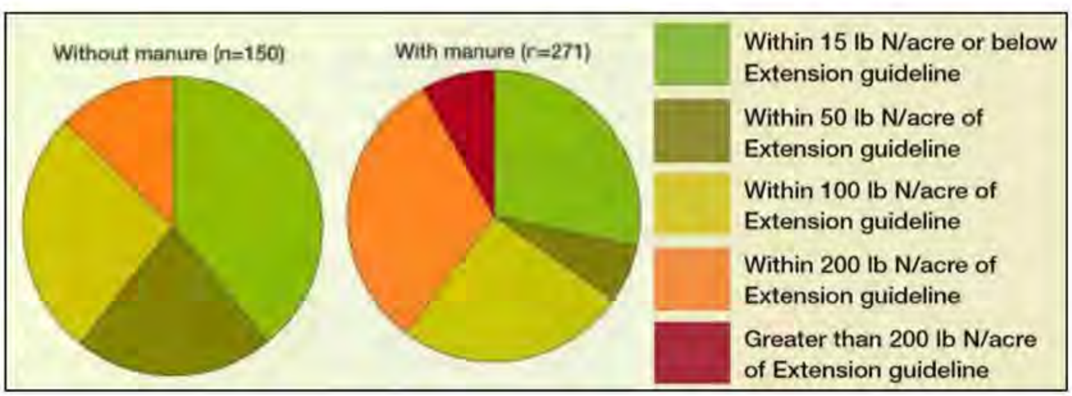


Figure IV-4. Applications of nitrogen fertilizer with or without manure on first-year corn following alfalfa.

Based on the NASS survey results presented above, there is ample evidence that nitrogen fertilizer is being over applied and that the BMP implementation is ineffective.

BMP Adoption Assessments within DWMSAs

Results from FANMAP surveys have been used to design focused water quality educational programs for localized areas such as DWMSAs. Data collected in the program's infancy were used as a baseline to assist in determining if voluntary BMPs are being adopted. Over the years, hundreds of farmers have volunteered two to four hours of their time to share information about their farming operations.

Since Part 2 of the proposed nitrogen Rule is very specific to DWMSAs, it is highly relevant to present DWMSA information on BMP adoption in a similar fashion to the statewide assessments previously provided. Most of MDA's experience and knowledge on BMP adoption evolved from working closely with farmers within DWMSAs. A listing of individual FANMAP reports can be found by going the following web link: http://www.mda.state.mn.us/protecting/soilprotection/fanmap.aspx).

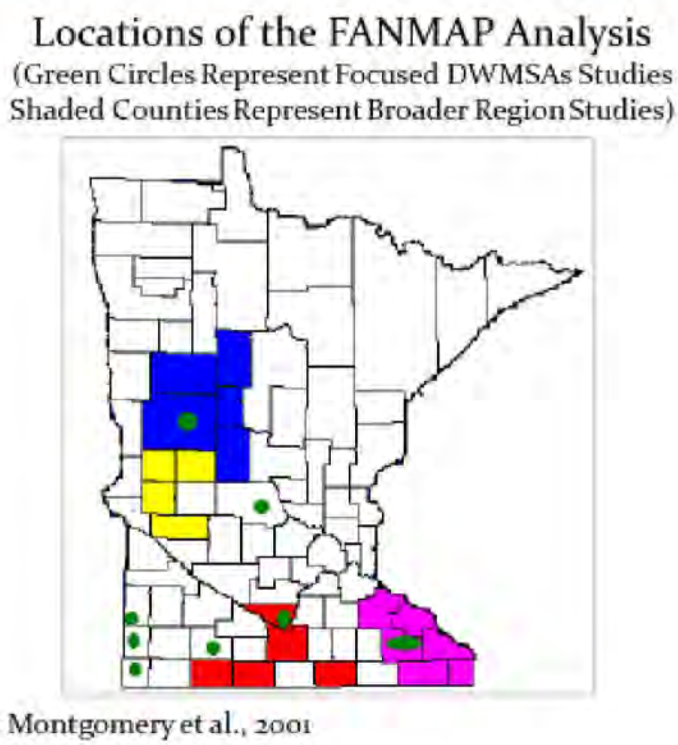


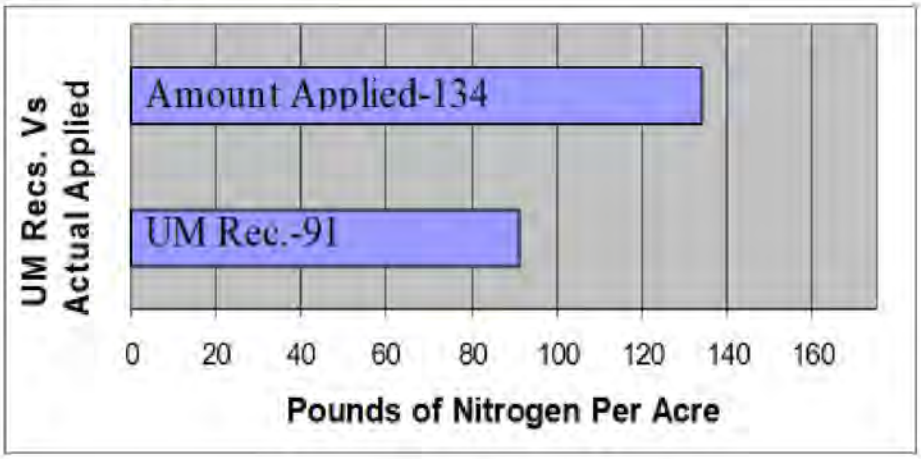
Figure IV-5. Locations of FANMAP Analysis

A general FANMAP overview is provided in Minnesota's Nonpoint Source Management Plan 2001 (Montgomery et al., 2001). While the results represent a composite of studies across the state, many of the farmers were located within DWMSAs. The communities of Perham, St.

Peter, Cold Spring, and the Lincoln-Pipestone Rural Water System are strongly represented in the 2001 report. The shaded counties shown were broader regional studies with various commodity groups.

1. FANMAP Assessment within DWMSAs

Corn following Soybeans

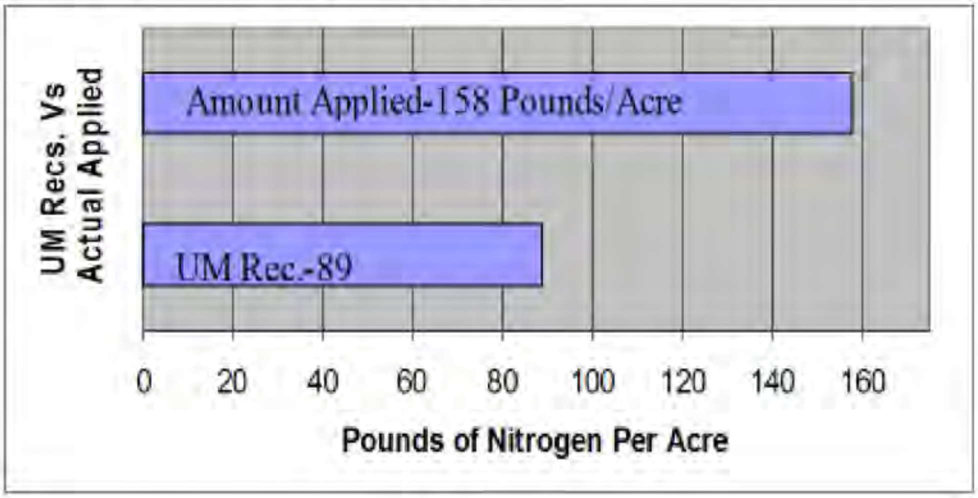


Data Source: Montgomery et al., 2001

Figure IV-6. FANMAP results across multiple DWSMAs. Actual applied nitrogen rates vs U of M recommended nitrogen rates for corn following legumes.

It is common to find corn in rotation with soybeans. In the 2001 report (Montgomery, 2001), 61% of the corn acres were in rotation with soybeans. Very similar to the previously reported statewide assessment (Figure VII-2) for this rotation, a significant amount of over-application was observed due to lack of proper crediting. In these early FANMAP assessments, over-application rates were commonly between 20-40 lb. N/A. This is very similar to the over-applications reported in the statewide MDA/NASS reports (MDA and NASS, 2014, 2016, and 2017).

Corn following Manured Legume Crops



Data Source: Montgomery et al., 2001

Figure IV-7. FANMAP results across multiple DWSMAs. Actual applied nitrogen rates vs U of M recommended nitrogen rates for corn following a manured legume crop.

Within the DWMSAs and other locations (Montgomery, 2001), over-application rates of nitrogen fertilizer averaged 70 lb. /A.

B. Studies have found that fall application of fertilizer in certain soil conditions can lead to groundwater leaching

The specific nitrogen fertilizer BMPs for the five nitrogen fertilizer BMP Regions contain detailed information on the timing recommendations which are highly linked to nitrogen source and soil type. Appropriate timing of nitrogen applications is variable due to soil texture, annual precipitation, and geologic considerations.

It is important to time the application of nitrogen fertilizer to when it can best be used by the plants. The more nitrogen that is used by the plants on the field, the less there will be available to leaching into groundwater. On some soil types, nitrogen fertilizer can be placed in the fall and still be available for plant uptake in the spring. With other soil types, such as coarse textured soils, nitrogen fertilizer must be applied in the spring. In some cases, it can be best to divide the nitrogen fertilizer application into several applications. Nitrogen fertilizer can even be applied between the rows of a growing crop. This type of application is called sidedressing.

The greater the time from application to actual crop uptake, the more opportunities for nitrogen loss. For this reason, farmers who rely on fall application frequently use higher nitrogen rates (additional 10-30 lb/A) compared to spring applications in the same region. Under Minnesota climatic conditions, nitrates left at the end of the growing season are frequently prone to leaching loss which result in potential groundwater contamination. Nitrates left in the soil have been shown to be 40% higher when a nitrogen fertilizer rate of 150 lbs of nitrogen per acre is used, compared to the U of M recommendation of 120 lb of nitrogen per acre (Carlson et al., 2013).

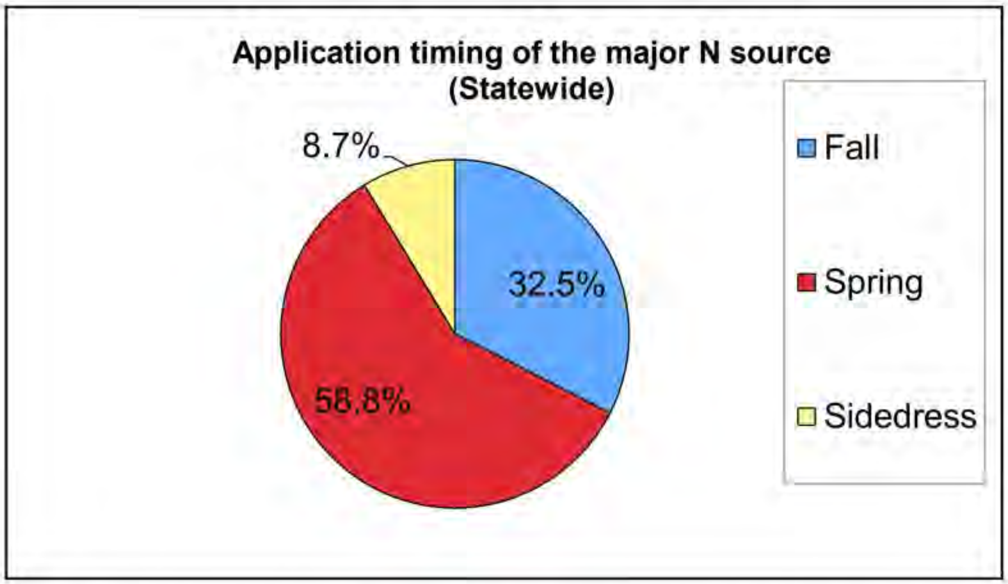


Figure IV-8. Nitrogen fertilizer application (non-manure) timing on corn statewide.

Secondary sources of nitrogen fertilizer: Timing and Crediting

The crediting and timing of secondary nitrogen sources are frequently overlooked in the nutrient planning process. Secondary nitrogen sources are fertilizers that primarily contain large amounts of other nutrients important for plant growth, such as phosphorus and potassium. In many cases these fertilizers also contain nitrogen, and this nitrogen should be subtracted from the total amount of nitrogen applied to the crop. Examples of secondary nitrogen sources include phosphorus fertilizers such as MAP (containing 11% nitrogen in addition to its phosphorus) and DAP (containing 18% nitrogen in addition to its phosphorus). In the past five years, there have been large increases in the use of sulfur products. Some of these products, such as ammonium sulfate (containing 21% nitrogen in addition to its sulfur) need to be managed appropriately for their nitrogen.

C. Conclusion

Based on the evidence provided above, the MDA has determined that the implementation of the BMPs has proven ineffective. Farmers are not taking proper credit for existing nitrogen in the ground and, in addition, are applying nitrogen fertilizer at rates over the recommended levels. This has resulted in leaching of nitrates into the groundwater. Strong evidence has shown that the groundwater in certain areas of the State are over the MDH recommendations. The evidence gathered demonstrates that the implementation of the BMPs as it relates to nitrogen has proven ineffective, and therefore, MDA can proceed with the proposed rule.

V. Statutory Requirements

A. Statutory Authority

Authority for the proposed Rule comes from Minn. Stat. § 103H.275, which was adopted in 1989. All sources of statutory authority for the proposed Rule were adopted and effective before January 1, 1996 and have not been revised by the Legislature, so Minn. Stat. § 14.124 does not apply per Minnesota Laws 1995, chap. 233, article 2, section 58.

Under these statutes, the MDA has the necessary statutory authority to adopt the proposed Rule.

Minn. Stat. § 103H.275, subd. 1(b).
"...the commissioner of agriculture may adopt water resource protection requirements under subdivision 2 that are consistent with the goal of section 103H.001 and are commensurate with the groundwater pollution if the implementation of best management practices has proven to be ineffective."

Minn. Stat. § 103H.275 lists requirements that the MDA must follow when adopting rules for water resource protection requirements.

Minn. Stat. § 103H.275, subd. 2.
"Adoption of water resource protection requirements. (a) ...for agricultural chemicals and practices, the commissioner of agriculture shall adopt by rule water resource protection requirements that are consistent with the goal of section 103H.001 to prevent and minimize the pollution to the extent practicable...The water resource protection requirements must be based on the use and effectiveness of best management practices, the product use and practices contributing to the pollution detected, economic factors, availability, technical feasibility, implementability, and effectiveness. The water resource protection requirements may be adopted for one or more pollutants or a similar class of pollutants.

"(b) Before the water resource protection requirements are adopted...the commissioner of agriculture...must notify affected persons and businesses for comments and input in developing the water resource protection requirements.

"(c) Unless the water resource protection requirements are to cover the entire state, the water resource protection requirements are only effective in areas designated by the commissioner of the Pollution Control Agency by order or for agricultural chemicals and practices in areas designated by the commissioner of agriculture by order. The procedures for issuing the order and the effective date of the order must be included in the water resource protection requirements rule.

"(d) The water resource protection requirements rule must contain procedures for notice to be given to persons affected by the rule and order of the commissioner. The procedures may include notice by publication, personal service, and other appropriate methods to inform affected persons of the rule and commissioner's order.

"(e) A person who is subject to a water resource protection requirement may apply…for agricultural chemicals and practices [to] the commissioner of agriculture, and suggest an alternative protection requirement. Within 60 days after receipt, the agency or commissioner of agriculture must approve or deny the request. If the Pollution Control Agency or commissioner of agriculture approves the request, an order must be issued approving the alternative protection requirement.

"(f) A person who violates a water resource protection requirement relating to pollutants, other than agricultural chemicals, is subject to the penalties for violating a rule adopted under chapter 116. A person who violates a water resource protection requirement relating to agricultural chemicals and practices is subject to the penalties for violating a rule adopted under chapter 18D."

B. Regulatory Analysis

In some places, Statewide Water Resource Protection Requirements will be referred to as Part 1 of the proposed Rule; and Drinking Water Supply Management Area: Mitigation Level Designations will be referred to as Part 2 of the proposed Rule.

1. Persons affected

A description of the classes of persons who likely will be affected by the proposed Rule, including classes that will bear the costs of the proposed Rule and classes that will benefit from the proposed Rule.

Classes of persons affected by the proposed Rule
The regulatory portions of the proposed Rule apply to "Responsible Parties," defined as an owner, operator, or agent in charge of cropland.

Bear the costs of the proposed Rule
There are two parts to the proposed Rule: Part 1 restricts fall application in areas vulnerable to groundwater contamination; and Part 2 requires the adoption of nitrogen fertilizer BMPs if they are not adopted voluntarily, and can require AMTs if they are funded, as well as other practices within scope of Minn. Stat. § 103H.275, subd. 2 if the nitrogen fertilizer BMPs are not adopted or if nitrate concentrations in soil below the root zone or in groundwater continue to increase. For purposes of Part 2, the nitrogen fertilizer BMPs are designed specifically to be economically viable and their adoption in most cases will not result in any increased costs and should result in

increased profitability to farmers. The adoption of AMTs if they are funded also will not result in increased costs, as they would be funded. The requirements under Minn. Stat. § 103H.275, subd. 2 directs the MDA to consider economic factors and implementability, among other considerations before requiring a practice, and therefore are also unlikely to impose significant costs on Responsible Parties.

Under Part 1 of the proposed Rule, land owners, operators, and suppliers of nitrogen fertilizer could bear some cost. Restrictions on fall application in vulnerable groundwater areas have been a U of M recommended nitrogen fertilizer BMP for many years. The MDA believes that a large majority of farmers in southeast and central Minnesota, where most vulnerable groundwater areas occur, do not currently fall apply nitrogen fertilizer. In these areas there should be very little or no increased cost. It could even result in some savings by not losing nitrogen fertilizer to leaching.

Shifting from fall to spring application could possibly result in some additional costs for some farmers if fertilizer prices increase due to increased demand and a shorter time period for application. This is likely to be more of an issue in the western part of the state. Comments received during the listening sessions indicated that farmers fall apply in these areas, although there are far fewer vulnerable groundwater areas in these parts of the state, so this would not affect the majority of farmers (Bierman et al., 2011). It is possible that farmers or applicators could incur labor costs if they need to hire additional labor to apply in the spring; however, this was an issue primarily in the northwest part of the state, which is excluded from Part 2 of the proposed Rule. The MDA also heard comments about inadequate bulk dry fertilizer storage capacity and an extremely short spring planting season in some parts of the state. The climate exclusion should help alleviate the majority of these concerns.

The logistics of switching from fall to spring application in vulnerable groundwater areas might be more difficult and more expensive for some facilities in western Minnesota than in other parts of the state. The effective date of January1, 2020 is intended to provide additional time to adjust to these changes.

As for the Drinking Water Supply Management Area: Mitigation Level Designations, land owners, operators, and suppliers of nitrogen fertilizer could bear some cost if the DWSMA in which they raise crops are designated as regulatory mitigation levels and are required to follow the nitrogen fertilizer BMPs or water resource protection requirements. Since the nitrogen fertilizer BMPs are generally economically viable, those costs generally should not be substantial. If water resource protection requirements are imposed at mitigation level 4, then owners and operators could be affected, depending on what is contained in a mitigation level 4 commissioner’s order. The proposed Rule requires the commissioner to consult with local advisory teams, with the goal of creating water resource protection requirements that are specifically tailored to the region and minimize the burdens or costs to the responsible parties.

Benefit from the proposed Rule

High nitrate-nitrogen concentration in drinking water can pose a health risk for infants. When an infant consumes water with nitrate, it is converted into another compound called nitrite. Nitrite causes the hemoglobin in the blood to change into a substance called methemoglobin. This reduces the ability of the blood to carry oxygen, causing a condition known as methemoglobinemia, or “blue baby syndrome.” In severe cases, nitrate poisoning can be fatal (MDH, n.d.). The MDH HRL of 10 mg/L nitrate-nitrogen in drinking water was developed based on epidemiological studies published in the 1950s and 1960s. Methemoglobinemia is not a reportable disease so is not tracked by the Center for Disease Control or the MDH. The proposed Rule will provide the greatest direct health benefit to infants under 6 months of age and to community water suppliers and private well owners who need, or are required by law, to provide water that is safe for infants or a general population which includes infants.

Various epidemiological and animal studies have reported a wide range of negative health effects attributable to consumption of water with elevated nitrate-nitrogen including birth defects, miscarriages, hypertension, stomach and gastro-intestinal cancer, and non-Hodgkin’s lymphoma (MDH, 2014).

The proposed Rule will benefit citizens served by public water suppliers as well as private well owners in DWSMAs. This will occur by reducing nitrate in groundwater where nitrate levels are elevated and preventing it from occurring in areas where it is not. Preventing and reducing nitrate in groundwater decreases the costs public water suppliers spend to provide drinking water to the public.

There is a large social benefit to the general public from having groundwater with nitrate-nitrogen concentrations below the MDH HRL. This benefit is difficult to quantify but is important for Minnesota with the high value that citizens put on the quality of the waters in the state. One way the value is demonstrated resulted in an amendment to Minnesota’s Constitution. In 2008, Minnesota’s voters passed the Clean Water, Land and Legacy Amendment increasing the state sales tax. Two of the goals include the protection of drinking water sources and the restoration of groundwater, among others (LCC, n.d.).

Another way this value is demonstrated is through the passage of the Groundwater Protection Act in 1989. The Groundwater Protection Act states. “*It is the goal of the state that groundwater be maintained in its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities the degradation prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged.*” The Groundwater Protection Act gives the MDA the authority to adopt the proposed rule.

2. Probable costs to state agencies

The probable costs to the MDA and to any other agencies of the implementation and enforcement of the proposed Rule and any anticipated effect on state revenues.

What is the cost to implement Statewide Water Resource Protection Requirements?
The primary cost for implementing Part 1 of the proposed Rule is the cost of education and enforcement. Education is needed to inform people about the locations of vulnerable groundwater areas and requirements of the proposed Rule. Enforcing the fall application and frozen soil restrictions will take place in 1) quarter-sections where 50% or more of the acres are designated as vulnerable groundwater areas; and 2) DWSMAs that exceed 5.4 mg/L nitrate-nitrogen. The MDA expects to enforce this part of the proposed Rule on a complaint-driven basis.

What is the cost to implement Drinking Water Supply Management Area: Mitigation Level Designation?
Total costs for the MDA to implement and enforce the Drinking Water Supply Management Area: Mitigation Level Designation section of the proposed Rule will vary depending on the number of DWSMAs that are found to have high nitrate. The MDA will bear the costs of evaluating the nitrogen fertilizer BMPs adopted in the DWSMA, establishing any groundwater monitoring networks, as well as providing education within the DWSMAs about the nitrogen fertilizer BMPs and providing financial and technical assistance to facilitate the local advisory team and associated activities. Enforcing the proposed Rule will also be a cost.

Additionally, if DWSMAs move to regulatory status, there will be costs for public notice and hearings.

There are minor or no increased costs to other agencies since where other agencies have roles related to the proposed Rule, the additional work should be limited in scope or should fit into current MDA responsibilities. Other Minnesota state agencies such as the MPCA and MDH will be invited to provide staff to advise regarding technical aspects of the projects. This will occur when topics involve their authority such as manure management or public water suppliers, respectively. The MDA will use nitrate-nitrogen concentration well data that is collected by MDH, but this information is already required to be collected by the federal Safe Water Drinking Act. No additional monitoring or sampling will be required by the MDH. SWCDs are also invited to participate in local advisory teams on a voluntary basis. Their participation is important but not mandatory, and the additional staff costs would be modest. The MDA has already convened several local advisory teams under the NFMP and has provided funding for SWCD participation.

There are no anticipated effects on state revenue associated with the proposed Rule.

3. Less costly or intrusive methods

Determination of whether there are less costly methods or less intrusive methods for achieving the purpose of the proposed Rule.

The MDA considered the cost and potential burden of the proposed Rule. The purpose of the proposed Rule is to reduce nitrate in groundwater and maintain the quality of groundwater to the extent practicable in its natural condition. There are many possible approaches that could be taken to meet this goal. When drafting the NFMP, the MDA convened an advisory committee to provide extensive review and input on the draft plan, which provided the conceptual framework for the proposed Rule.

Statutory requirements also influence the approach for the proposed Rule. Minn. Stat. § 103H.275 specifies that nitrogen fertilizer BMPs be promoted in areas where groundwater pollution is detected. Water resource protection requirements need to be consistent with the goal of Minn. Stat. § 103H.001 and be commensurate with the groundwater pollution if implementation of nitrogen fertilizer BMPs has proven to be ineffective before adopting the proposed Rule. Additionally, the water resource protection requirements must be designed to prevent and minimize pollution to the extent practicable and prevent pollution from exceeding the MDH HRL for nitrate-nitrogen, which is why these requirements are included in the proposed Rule and the reason for not taking a "less costly" approach or using "less intrusive methods."

Less Costly

Not adopting the proposed Rule would be less costly for the MDA. However, there would be costs for others as described in this SONAR (Section 2) and the goals of the Groundwater Protection Act would not be met. There might be less costly methods to accomplishing parts of the purpose of the proposed Rule, but these processes would not address either the presence and/or increase of nitrate in groundwater and would result in higher costs to society in the long run. For example, it might be less costly to install nitrate removal systems in all private and public drinking water systems to address the issue of public health. While this would provide safe drinking water for those individuals, the approach would not meet the goals of Minn. Stat. chap. 103H, which requires *"...groundwater be maintained in its natural condition, free from any degradation caused by human activities,"* and the water quality problems due to nitrates in groundwater would continue to increase.

The MDA has provided promotion and education on the nitrogen fertilizer BMPs since they were adopted in 1991. Nitrate in groundwater continues to be an issue and in some places has increased significantly over the past 25 years. During a comment period on the proposed Rule, a number of commenters stated that the Groundwater Protection Act's purpose could be achieved through continued and additional research and education. While the MDA strongly supports ongoing and increasing research and education efforts, the MDA also believes that such efforts,