

## **Alternative Management Tool (AMT)**

### **Precision Agriculture: Precision Nitrogen Management**

October 7, 2022, Revised May 13, 2024

***Alternative Management Tools (AMTs)** are specific agricultural practices and solutions, other than nitrogen fertilizer best management practices, that address groundwater nitrate problems. AMTs are described in the Groundwater Protection Rule and are approved by the Commissioner of Agriculture.*

#### **Introduction**

In areas where groundwater is vulnerable to nitrate contamination and in vulnerable drinking water supply management areas (DWSMAs), an effective strategy for reducing nitrate leaching is precision nitrogen management where the application of nitrogen (N) is matched with when the crop needs it. Precision nitrogen management falls within the broader scope of precision agriculture.

The precision nitrogen management practices described below meet the definition of alternative management tools (AMTs) in the Groundwater Protection Rule (MR 1573.0010). Specifically, the practices adjust nitrogen (N) application rate, source, placement, and timing to better align N supply with crop uptake needs.

In DWSMAs with elevated nitrate in the groundwater, the MDA is publishing maximum N fertilizer rates for crop production. More information about DWSMAs with published maximum N fertilizer rates is available at the MDA's website<sup>1</sup>.

This document outlines two options for rate exceedances that allow higher than the MDA published N fertilizer rate to be applied to soils with high yield potential:

- A basic option where an exceedance of up to **30 lb. N/ac** above the MDA published rate is allowed for conditions as outlined, and
- An advanced option reflecting advanced N management **without a limit** for the N application rate. To use this option the MDA must review the methods and preapprove. Without this documentation the advanced option will not be accepted. The information can be supplied by an agronomist, retailer, technology developer or provider or farmer.

#### **MDA Contact Information for Questions or Method Preapproval**

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<sup>1</sup> Available at: <https://www.mda.state.mn.us/pesticide-fertilizer/mitigation-level-determination>

## **Definition of Precision Agriculture**

Precision agriculture relies on geospatial technology to manage the variability of soils and crops, and informs decisions about inputs. According to the international Society of Precision Agriculture, the practice is defined as *“a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.”*

Precision nitrogen management follows the 4R principles of nutrient management, namely the right source, right rate, right time, and the right placement. Precision nitrogen management often includes site specific nutrient management and variable rate nitrogen (VRN) application.

## **AMT substitution for a Nitrogen Fertilizer Best Management Practice (BMP)**

See BMP/AMT matrix ([www.mda.state.mn.us/nitrogenamts](http://www.mda.state.mn.us/nitrogenamts)) for more information about how this AMT substitutes for nitrogen fertilizer BMPs.

## **Water Quality Benefits**

Precision N management is an increasingly common practice to reduce nitrate leaching loss by optimizing N fertilizer application to crop needs (Agvise, 2020). It is accomplished by mapping within-field spatial variability of N availability and crop N need using either grid or management zone approaches (Khosla et al., 2002) and outline management zones for variable rate N (VRN) application (Mulla, 1991). Splitting the N application and completing an in-season analysis of crop N need during the growing season adds additional refinement to the precision N management.

Optimizing N management is especially important in Minnesota where a substantial amount of nitrogen can be lost via leaching in the spring (Zak and Grigal, 2001). Wilson et al. (2017) compared nitrate leaching loss under variable rate nitrogen management to that of conventional N management on coarse textured soils and estimated a 13% reduction in N loss when using VRN. This result was later confirmed by Wilson et al. (2020) in three other agro-ecoregions in Minnesota.

## **The MDA has identified two precision nitrogen management options for applying N fertilizer above the MDA published rate for the DWSMA:**

### **Option #1: Basic Variable Rate Nitrogen**

This option applies to fields that have high yield potential compared to other, nearby fields. Following the requirements outlined below will allow for up to 30 lb. N/ac exceedance above the MDA-published N fertilizer rate for the DWSMA. The 30 lb. N/ac exceedance is calculated as the average rate for the field.

To qualify for the 30 lb. N/ac exceedance, these two requirements must be met:

- 1A. Justification showing a reasonable expectation of improved yields to substantiate the higher N rate, and
- 1B. N fertilizer must be applied using variable rate technology.

For requirement 1A it must be documented that the field as a whole can be considered to have high yield potential. The MDA has identified two methods to document this:

- Average yields for at least 2 of 3 years of that crop must be 15% greater than or equal to the USDA

County average for the corresponding year<sup>2</sup>. See the Record Keeping section below for data needed to document yields, or

- Work with a 4R Stewardship certified crop production retailer **and** use adaptive management practices accepted by the Minnesota 4R Nutrient Stewardship program (see appendix A).

The MDA recognizes that there may be other methods or new technologies that can document high productivity fields. Contact the MDA for verification that a new method not listed above provides adequate documentation for high productivity.

Requirement 1B is the use of variable rate N fertilizer technology (VRN). The MDA has included this option to encourage the use of VRN.

The variable rate nitrogen prescription must account for the field spatial variability. No more than 70% of the MDA-published N rate for the DWSMA can be applied before sidedress with the remaining being applied in-season as a variable rate application.

A minimum of two N management zones each with their own N application rates must be used. Use relevant information to develop N management zones, such as:

- Residual soil nitrate information from precision soil sampling (zone or grid based), or
- Soil electric conductivity (EC), Lidar DEM, yield maps, digital soil survey information, soil organic matter content, remote sensing, proximal sensing, or other geospatial data.

The total field average nitrogen rate applied during the entire growing season (including all sources of nitrogen including MAP, DAP, AMS or other fertilizers containing N, manure and credits from previous legume crop) may not exceed the N rate established for the DWSMA by more than 30 lb. N/ac.

### **Recordkeeping requirements for Option 1**

Records to document N fertilizer rates above the MDA published rate must be kept. The records must provide documentation of the method and data that was used to determine higher N rates were justified, how that data was interpreted and the as-applied maps of N fertilizer.

Actual yield can be documented based on e.g., a calibrated combine yield monitor, information from weigh wagons, weigh tickets, or approximation of truckloads of grain from specific fields. It is necessary to maintain yield records from at least two of the previous three growing seasons for that crop.

### **Option #2: Utilizing Advanced Technology for In-Season Nitrogen Management**

The MDA will also accept nitrogen fertilizer application rates above the MDA published rate if there is a documented need for additional nitrogen to meet crop N needs. The need must be determined annually in season based on advanced nitrogen management technologies. **The technology being used must have documentation for its efficacy and must be preapproved by the MDA before being used to prove it provides accurate estimates of additional N need under Minnesota crop production conditions.** See appendix B for more information about technology preapproval.

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<sup>2</sup> County yield averages from the actuarial information browser (AIB) from the USDA Risk Management Agency, <https://webapp.rma.usda.gov/apps/ActuarialInformationBrowser2022/CropCriteria.aspx> should be used. The County average is found by selecting commodity, year, insurance plan (Area Revenue Protection (05), State and County and click Get Report. Select the Prices and Yields tab and scroll down to find the county average for non- irrigated and irrigated crops. For example, for Dakota County the 2021 yields were 151 bu/ac for non-irrigated corn and 223.6 bu/ac for irrigated corn.

To qualify for the N rate exceedance, these two requirements must be met:

- 2A. Use of applicable in-season precision nitrogen technology showing a need for additional N, and
- 2B. N fertilizer must be applied using variable rate technology.

For requirement 2A, examples of applicable precision nitrogen technology that can be used in-season to justify higher N rates after they have been preapproved by the MDA include but are not limited to:

- **Pre-sidedress nitrate test** (PSNT) that is grid or zone based. Follow University of Minnesota guidance for precision soil sampling ([extension.umn.edu/nutrient-management/testing-and-analysis](https://extension.umn.edu/nutrient-management/testing-and-analysis)). The University of Minnesota has additional tips for Accurate Pre-Sidedress Nitrate Tests (Fernandez and Kaiser, 2017),
- **Precision tissue testing** that is grid or zone based,
- **Chlorophyll readings** that are grid or zone based,
- **Advanced crop models** with a spatial component to account for within-field spatial variability,
- **Remote sensing**-based estimates of normalized difference vegetation index (NDVI) or other vegetation indices including the thermal, near-infrared, visible and other spectral wavelengths,
- Other **proximal, aerial, or satellite**-based sensing of plant N status, or
- Third party N recommendation that is science-based, and that documents the technology and information used to develop the variable prescription.

Requirement 2B is the use of variable rate N fertilizer technology. The following requirements must be followed:

- No more than 70% of the MDA published N rate for the DWSMA can be applied before sidedress and the remaining must be applied in-season as a variable rate application.
- The variable rate nitrogen prescription must account for the field spatial variability based on the above-mentioned precision nitrogen technologies.

### **Recordkeeping requirements for Option 2**

Records to document N fertilizer rates above the MDA published rate must be kept, including as-applied maps of N fertilizer. The records must provide documentation of the method and data that was used to determine higher N rates were justified. The total N rate applied during the entire growing season must be documented (including all sources of nitrogen including MAP, DAP, AMS or other fertilizers containing N, manure and credits from previous legume crop).

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## Appendix A

### **Adaptive management practices accepted by the Minnesota 4R Nutrient Stewardship program**

The Minnesota 4R Nutrient Stewardship program is a certification program for agricultural crop production retailers. The program was launched by the Minnesota Crop Production Retailers and certifies retailers who follow best management practices and other predetermined standards to reduce nutrient loss from crop production in Minnesota. The program encourages the use of adaptive management practices of nutrient application.

To use this option, farmers must work with a 4R Stewardship certified crop production retailer **and** use one or more of the following adaptive management practices accepted by the Minnesota 4R Nutrient Stewardship program to document high soil productivity based on:

- A literature review of peer-reviewed papers or similar research-grade reports conducted using the same soil type and within 50 miles,
- Studies showing rates above and below the optimum with regression analysis,
- Self-designed projects to quantify water results at the edge of field and or in-field. The control comparison will be the land grant university recommendation compared to the adaptive management practice,
- Consultation with a water quality expert willing to provide the documentation (of high yield potential soils). University of Minnesota Agricultural Extension, Soil & Water Conservation Districts, or Land Grant institutions can assist, or
- Documenting advanced nitrogen BMP for rate with a goal of nitrogen use efficiency of less than 1.0 pound per bushel of corn or Nitrogen Use Efficiency of 0.6 - 0.8. On-farm nitrogen rate response trials using source, timing, and placement BMPs within reasonable proximity to farm are acceptable data sets.

The MDA is providing the above options in support of the Minnesota 4R Nutrient Stewardship program. For more information, please see <https://4rcertified.org/minnesota-about/>

## **Appendix B**

### **Evaluation process for advanced technologies for in-season nitrogen management**

For each proposed technology, the MDA will assess the accuracy of the technology for predicting nitrogen application. The MDA will produce a short report with a discussion of limitations, uncertainties, or specific conditions under which the technology must be used.

Contact one of the MDA scientists listed on page 1 to initiate the evaluation process.

The assessment will be developed based on a scientific review process and professional judgement of the MDA's technical review team based on:

- Technical information from the technology provider
- Review of scientific literature
- Computer modeling
- Consultation with University of Minnesota or other regional agricultural research experts
- Input from agricultural industry and commodity group leaders
- Other relevant sources of information, such as research trial data

Relevant technical information is required to evaluate claims and/or to provide evidence of accuracy for nitrogen recommendation when the technology is used as recommended or directed. Any experimental evidence provided to the MDA must relate to conditions in this state (environmental, application rates, soil, crop etc.) for which the technology is intended and must correspond to the actual technology intended to be evaluated. Technical report(s) will typically include at a minimum the materials and methods, results, an appropriate statistical analysis, and discussion. Other information sources including but not limited to; abstracts, incomplete articles, literature reviews of similar but different technologies, testimonials, news articles, pictures and fact sheets are generally insufficient as evidence for evaluating benefits.