



MINNESOTA NRCS AGRONOMY TECHNICAL NOTE 32

Nutrient Management Planning

Table of Contents

Introduction.....	2
Purpose.....	2
Soils Information.....	2
General Nitrogen Information.....	5
Evaluating Nitrogen Loss Potential.....	7
Table 1: Long Term Annual Relative Nitrogen Loss Potential.....	8
Table 2: Risk Mitigation Level Based on Nitrogen Loss Potential Rating.....	8
General Phosphorus Information.....	9
Evaluating Phosphorus Loss Potential.....	10
Table 3: Phosphorus Loss Potential and Manure Application Rates.....	11
Table 4: Interpreting P-Index Results.....	12
Table 5: Minimum Setback Requirements for Manure Application in Sensitive Areas.....	13
References.....	14
Appendix A- Acronyms.....	16



Introduction

Nitrogen (N) and Phosphorus (P) are essential for agricultural production. Unnecessary operational costs and negative water quality impacts could result when these nutrients are lost. Nutrient loss to surface water under certain conditions may result in excessive algae growth and produce toxins that can harm human health, animals, aquatic ecosystems, and the economy. Nitrate-nitrogen loss to groundwater used for drinking water is a public health concern. N and P can require additional conservation practices and/or nutrient management BMPs to reduce the loss risk. The N and P risk assessment processes are to be used to evaluate loss risk. This ensures sufficient conservation measures are in the conservation plan to mitigate this loss risk as part of the Minnesota Nutrient Management Conservation Practice Standard (590). This document provides the detailed procedures for nutrient loss risk assessment in Minnesota. The customer is ultimately responsible to check with local and state entities for further requirements or restrictions related to the application of nutrients.

Purpose

This technical note provides guidance related to the nutrient loss risk assessments to support the implementation of the MN 590 practice standard according to the 4Rs- the right rate, placement, source, and timing of nutrient applications and soil amendments. This includes the identified soil properties and other sensitive features to be referenced during the inventory and analysis phases of the conservation planning process. The 590 practice and associated plan is a voluntary process initiated by the customer.

Soils Information

The 590 standard requires the planner to create soil survey maps and legend along with map unit descriptions and applicable interpretations. The soils information in the map unit descriptions report includes available water capacity, depth to water table, drainage class, flooding frequency, permeability (Ksat), ponding frequency, restrictive features, and surface texture. These soil property indicators are important throughout the nutrient management planning process; but will primarily be used during the inventory and analysis phase as depicted in Diagram 1. The planner will use the information gathered through the evaluation of the soil property reports to develop the sensitive features map, and alternative towards the 4Rs of nutrient applications.

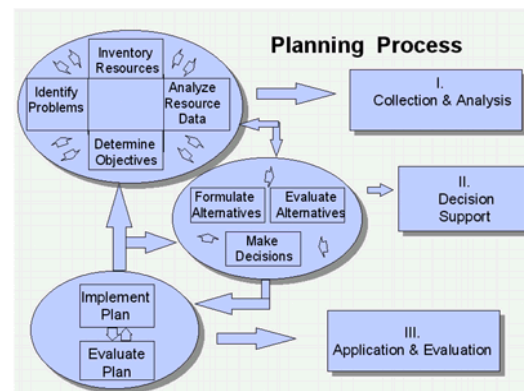


Diagram 1: NRCS Conservation Planning Process; an illustration of the dynamic nature of the planning process.

Drainage class refers to the frequency and duration of wet periods under conditions like those under which the soil formed. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the Soil Survey Manual. The amount of water within the soil profile has a direct impact as to how fast or slow processes within the nitrogen cycle will occur. Leaching potential increases as drainage class increases. Nitrate-nitrogen

can be lost to denitrification under poor drainage conditions. It is important to note that drainage class is defined by using natural conditions. Subsurface drainage in the field can affect natural conditions and should be taken into consideration.

Permeability is saturated hydraulic conductivity (Ksat) which refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability helps provide a clue as to how fast nutrients could move downward in the soil profile given the soil characteristics observed in the field. Higher Ksat levels indicate higher potential of nutrient loss through leaching; therefore, the direct timing and amount of nutrients applied should be evaluated. Refer to Soil Survey Technical Note 6, [Soil Survey Technical Note 6 | NRCS Soils \(usda.gov\)](#) for further information.

Available water capacity refers to the quantity of water that the soil can store for use by plants. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, cation exchange capacity, bulk density, and soil structure. This is described as the area between field capacity and permanent wilting point (Diagram 2). The wilting point is the minimum moisture content of the soil that can support plant growth and below which plants cannot recover. Runoff occurs once field capacity is met. Available water capacity information is important in nutrient management to help assess runoff and leaching risk potentials. Diagram 2 indicates the fineness of soil texture on the x-axis and the inches of water/foot of soil depth on the y-axis. Cation exchange capacity increases as clay percentage increases. Higher clay percentages in soil reduce leaching risk but increase runoff risk once a soil reaches field capacity. Pore space within the soil profile impacts the total available water capacity. This information is needed when deciding how much liquid manure can be applied to a field.

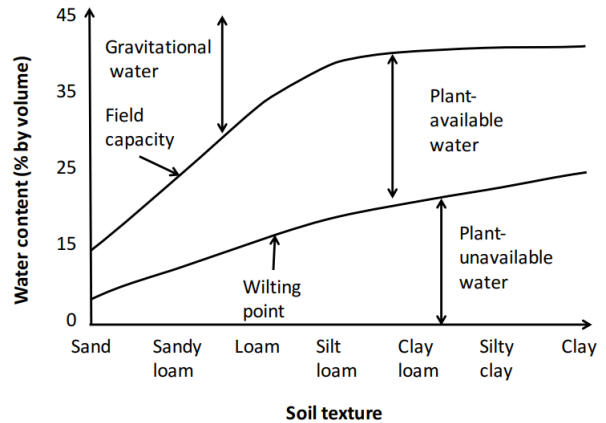


Diagram 2: Relationship between available water and soil texture. Source: VA Extension Publication BSE-194P

Depth to restrictive feature / depth to any restrictive layer is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, clay layers, and frozen layers. Water moves with the least restrictive path; therefore, so does crop roots. When it comes to nutrient applications a shallow depth to restrictive feature or layer may equal a direct pathway for nutrients or pathogens to enter ground and surface water.

Depth to water table: A water table refers to a saturated zone in the soil that lasts more than a month. The location of the field on the landscape is important for many reasons. Refer to Diagram 3 for illustrations of the following information. The depth to the water table is usually shallower in the soil profile if the field is in the discharge area near streams. Shallow depth to the water table can increase the risk of nutrients and pathogens reaching surface or ground water. As a result, it is recommended to keep at least 24” of depth between water table and surface manure application (after incorporation if applicable). Another way to reduce pollution is by adding edge of field practices such as buffers to capture nutrients before moving through the soil profile to the stream in discharge areas. Upland groundwater recharge areas are also illustrated on Diagram 3. Recharge areas are more sensitive to public or private well contamination because there is less opportunity for the water to be treated before reaching the groundwater. The increased sensitivity in recharge areas is due to the downward movement of water with limited vegetative buffering below the crop root zone. The MDH Wellhead Protection Program has approved scientifically delineated Drinking Water Supply Management Area (DWSMA) boundaries across the state to protect community public water supply wells and the aquifer used. DWSMAs identified as being highly vulnerable to surface or near surface contaminants will require additional considerations for nutrient management and may have restrictions that need to be included in the nutrient management plan related to the State Groundwater Rule (Nutrient management planners should consult with the Minnesota Department of Agriculture Pesticide & Fertilizer Management Section for DWSMAs that are regulated and impacted by the State Groundwater Rule). Karst regions are sensitive areas and do not usually follow the flow patterns shown in Diagram 3. The NRCS State Geologist can help a planner determine groundwater flow paths if needed. Nutrients lost through leaching in recharge areas that reach the water table can flow towards drinking water sources and surface waters over time.

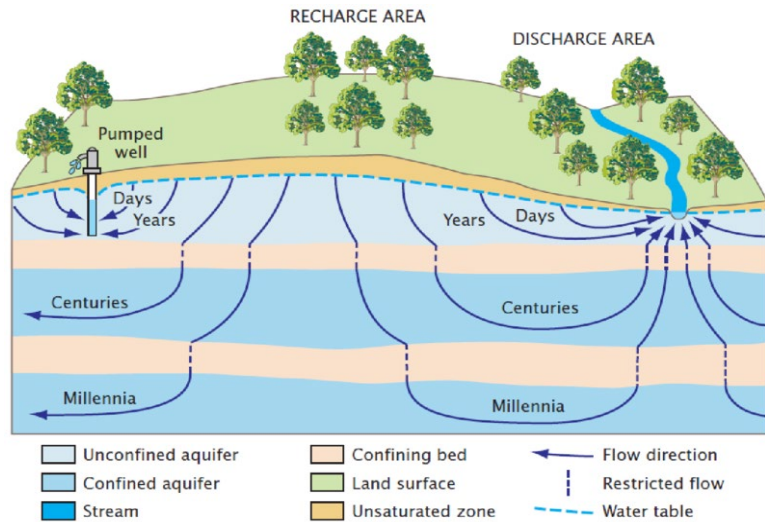


Diagram 3: Water movement potentials through the ground to recharge area, discharge area or wells. (PDF) Methodologies for Investigating Gas in Water Bores and Links to Coal Seam Gas Development (researchgate.net)

Nutrients lost through leaching in recharge areas that reach the water table can flow towards drinking water sources and surface waters over time.

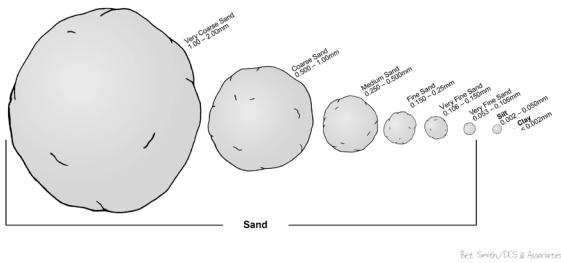
Flooding frequency is the frequency of temporary inundation of an area caused by overflowing streams or runoff from adjacent slopes. Flooding is associated with the landscape positions of foot or toe slope. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. The chances of nutrients entering surface water during flooding events increases as flooding frequency increases. The timing of nutrient applications should be planned outside months where flooding potential is high as noted in the soil survey.

Ponding frequency is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding frequency classes are based on the number of times that ponding occurs over a given period. Frequency is

expressed as none, rare, occasional, and frequent. Ponding can happen within any portion of the landscape position. Nutrient loss potential increases with an increase in ponding frequency. Pathogens can enter surface and ground water if manure enters ponded water. Adding permanent vegetation or continuous cover crops in areas where water intersects at the surface (ponding situations) increases denitrification of nitrogen.

Slope is the inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance. The steeper the slope the higher the runoff potential. Consider well locations and the steepness of the slope towards that well. Recommending split applications or lower rates and timing of nutrient applications or practices that slow the flow of water down the slope will minimize nutrient loss risks. Planners need to consider slope, sheet and rill erosion and gully erosion when developing a nutrient management plan. There may be restrictions related to slope that need to be considered during the development of a nutrient plan.

Surface texture is the representative texture class and modifier of the surface horizon. Coarse textured surfaces have a higher potential for nutrient loss through leaching. Coarse texture is associated with sandier soils. Coarse textured soils within an aquifer recharge area have a high risk of deep aquifer contamination. Nutrient application recommendations are dependent upon the texture of the soil and the combined nutrient loss risks associated.



The soil properties outlined above will help the planner utilize this information as it relates to evaluating potential risk of nutrient loss, properly identify the resource concern, and providing effective alternative mitigation measures to the producer. The planner will document those soil properties that are applicable to each field on the sensitive features maps; as well as, documenting findings regarding alternatives towards the right rate, the right source, the right placement, and the right timing of nutrient applications within the conservation assistant notes. Further interpretations of these soil properties are available through the Web Soil Survey and may be useful to the nutrient management planner.



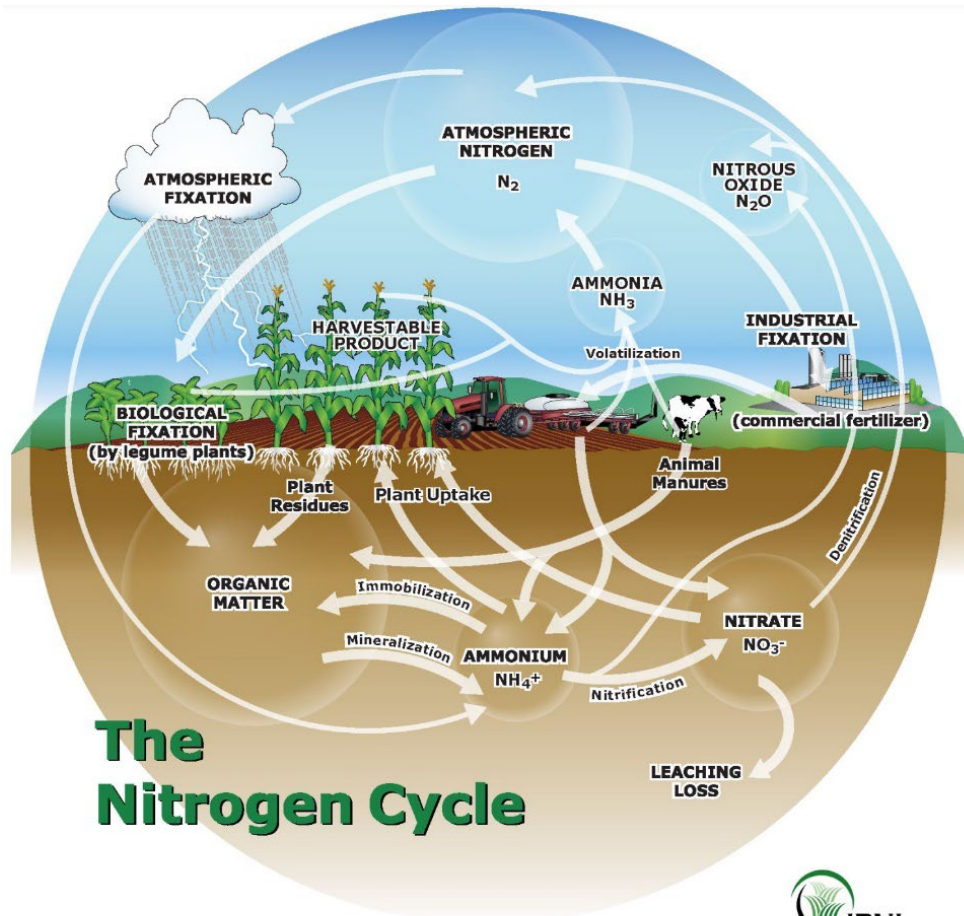
*Commercial Fertilizer Spreader.
Photo credit USDA*

General Nitrogen Loss Information

Nitrogen is an essential nutrient needed for crops to thrive. It is a major component of plant growth, development, and reproduction. Nitrogen supply must be adequate for crops annually for proper growth and productivity. Nitrogen gas is very abundant in the atmosphere but cannot be utilized by plants in that form. Plants utilize ammonium and nitrate forms of nitrogen. Ammonium can also be converted to nitrate through nitrification.

Nitrate is the most usable form of nitrogen to the growing crops. Nitrate is highly soluble in water and moves with water within the soil profile. Heavy rains can move nitrates down through the soil profile. Leaching into the water table occurs when the movement of nitrates goes below the plant root zone. Mobility of nitrate with water through the soil profile and into groundwater is why the potential nitrogen loss risk needs to be evaluated.

Most inorganic fertilizer sources start out in the ammonia form of nitrogen. The conversion from ammonia to nitrate through the nitrification is temperature dependent and slows at temperatures below 50 degrees Fahrenheit. Denitrification accelerates when saturated soils reach 50 degrees or warmer converting the nitrates to a nitrogen gas. The denitrification process slows down when soils are dryer.



Evaluating Nitrogen Loss Potential

The potential off-field nitrogen transport must be evaluated for every field where nutrient management is planned. Risk assessment for nitrogen loss potential is based on information provided by the University of Minnesota Extension (UME) and NRCS soils information.

The UME Best Management Practices (BMP's) for Nitrogen Use in Minnesota, publications 08554, 08555, 08556, 08557, 08558, 08559, and 08560, will be utilized by the planner on all fields receiving commercial fertilizer to select mitigation activities to reduce nitrogen loss potential. Each BMP publication accounts for the main commodity crops grown within those regions. The planner should use the rates for the crop with the closest nutrient requirements for recommendations if not listed. BMPs are divided into 3 categories:

1. Recommended- Utilize regional BMPs under this category whenever possible.
2. Acceptable but with greater risk- Nitrogen fertilizer management options to reduce loss potential will be documented if a BMP under this category is selected. Examples may include changing application timing, or changing the nitrogen fertilizer source, or using a nitrification inhibitor where appropriate.
3. Not Recommended- Application of nitrogen is restricted for any BMP listed in this category. Nutrient applications under this category do not meet the 590 standard.

Refer to Table 2 for the level of management needed once the loss potential has been determined using Table 1.

Note: Additional commercial fertilizer timing and form guidance related to fertilizers with phosphorus are listed in these publications.

Considerations for Manure: Manure applications are not subject to the nitrogen BMPs applicable to commercial fertilizers. The BMP's can be used as a guide to limit impacts from manure applications. UME has a "Guidelines for Manure Application Rates" website the planner can reference if applicable. There are additional nitrogen restrictions that apply to feedlots operating with a NPDES permit.



Irrigation System with Water Tower in Background. Photo Credit USDA

Table 1: Long Term Annual Relative Nitrogen Loss Potential

Fig. 1 Legend	Region	Application Timing	Soil Texture ¹	
			Coarse	Medium & Fine
	A	Fall Spring preplant Sidedress or split ²	R H M	R M L
	B	Fall Spring preplant Sidedress or split ²	R H M	M M L
	C	Fall Spring preplant Sidedress or split ²	R H M	L L L
	D			L L L
	E	Fall Spring preplant Sidedress or split	R L L	L L L

¹ Coarse: sand, loamy sand, loamy coarse sand, fine sand, loamy fine sand, loamy very fine sand, very fine sand, or any soil modified by the word “gravelly”. The entire planning unit will be considered susceptible to leaching if at least 33% coarse textured soils are present either in the surface soil or subsoil.
² Loss rating is reduced to Low on coarse textured soils if applied after June 15th.

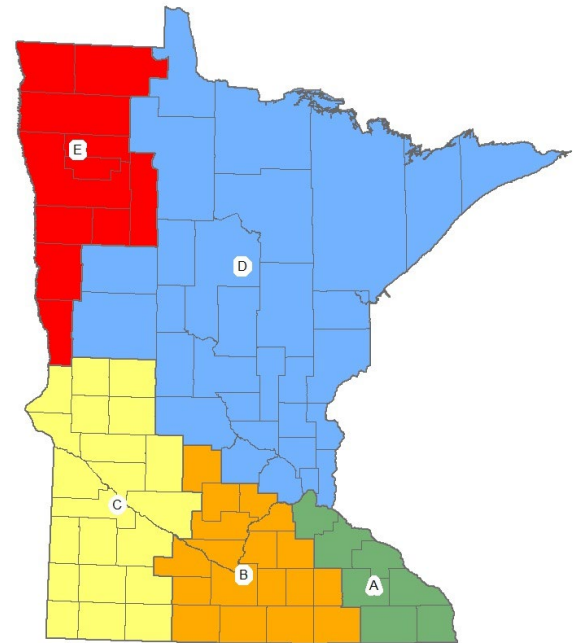


Figure 1: Nitrogen Loss Regions

Table 2: Risk Mitigation Level Based on Nitrogen Loss Potential Rating

Rating Label	Loss Potential Rating	Level of Best Management Practice to Follow:
R	Restricted	<ul style="list-style-type: none"> Fall application is not allowed.
H	High	<ul style="list-style-type: none"> Follow category 1 recommended BMP’s on UME publications listed in this TN.
M	Moderate	<ul style="list-style-type: none"> Follow category 1 recommended BMP’s on UME publications listed in this TN. BMP’s in category 2 are acceptable as long as nutrient management plan documents mitigation strategies.
L	Low	<ul style="list-style-type: none"> Apply to nitrogen needs if Table 4 allows.

Additional nitrogen application restrictions may be applicable. Consult the following:

1. Tables 3 & 5 if manure is to be applied to the field(s).
2. The Minnesota Department of Agriculture’s (MDA) Groundwater Protection Rule parts 1 and 2.
 - a. Refer to the MDA website for an interactive map. Updates of any restrictions listed in part 1 of the rule is posted on an annual basis by January 15th. Fall restrictions begin on September 1 of each year.
 - b. Part 2 of the rule corresponds to Drinking Water Supply Management Areas (DWSMA) which are public water supply wells with elevated nitrate and applies to the protected area around a public well which already have elevated nitrate.

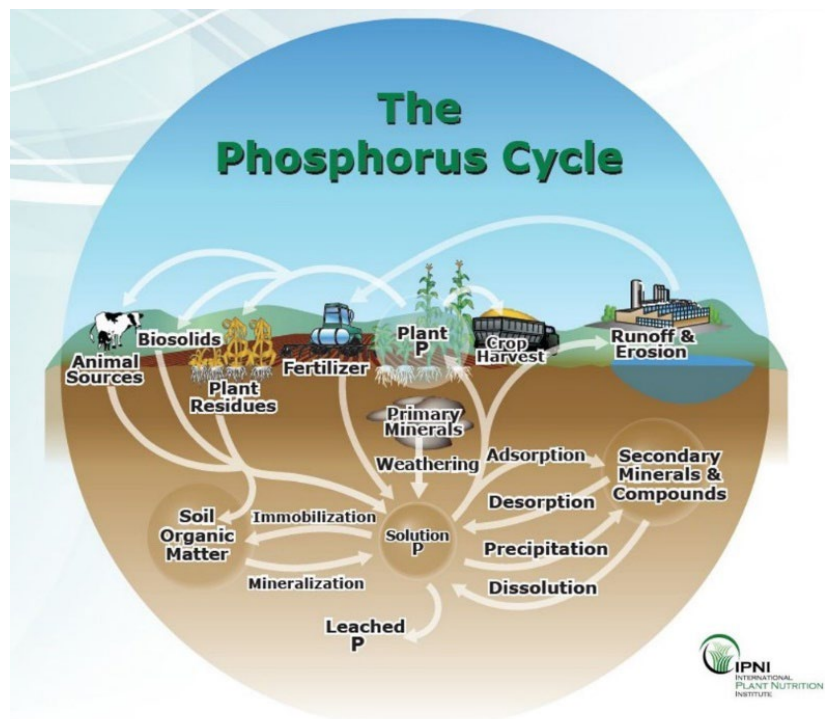
3. Minnesota Pollution Control Agency (MPCA)- for manure applications.
 - a. 7020 Feedlot Rule
 - i. Refer to the “Land Application of Manure: Minimum State Requirements” publication (wq-f8-11) if manure is being applied as a source of nutrients.
 - b. Feedlots with NPDES or SDS permits may also have additional restrictions applicable to manure applications, including winter application restrictions and some nitrogen management requirements. Consult the facilities permit for the specific requirements.

Note: The MN 590 standard does not allow for exemptions based on climate or percentage of agriculture alone.

General Phosphorus Loss Information

Phosphorus primarily moves towards surface waters by attaching itself to soil particles; the soil particle is moved by wind or water. This movement of soil particles by wind or water is why the appropriate soil loss assessment tool results are needed to evaluate the risk of phosphorus loss potential.

UME research has shown there is no economic justification for building soil test phosphorus levels above 20 ppm (Bray) or 16 ppm (Olsen) and the potential for phosphorus loss increases once soils test levels reach 16 ppm (Bray) and 12 ppm (Olsen). The MN 590 Standard requires the following information to be documented in the nutrient management plan if soil P levels are expected above an agronomic level (i.e., when N-based rates are used):



- Soil P levels at which it is desirable to convert to P-based planning.
- A long-term strategy and proposed implementation timeline for soil test P drawdown from the production and harvesting of crops.
- Management activities or techniques used to reduce the potential for P transport and loss. For AFOs, a quantification of manure produced in excess of crop nutrient requirements.

Evaluating Phosphorus Loss Potential

Table 3: Phosphorus Loss Potential and Manure Application Rates is a tool to evaluate risk of off-field P transport for any planning land unit receiving or proposed to receive manure or other organic by-products. It is designed to assist planners to quickly identify the level of risk associated with applying manure in relation to proximity to surface water, current levels of phosphorus based on up to date soil tests, erosion and the presence of a 100' vegetative buffer. The planner's objective in the nutrient management plan is that the application rate and frequency over six-year periods will not result in soil P build-up.

Low risk potential allows for application for nitrogen needs based upon UME recommendations for non-legume crops and the annual crop removal rates for legumes.

Medium risk potential indicates when P_2O_5 removal rates will be used based upon the quantity removed in the harvested portion of a specific crop or by a crop rotation up to 6 years. Crop removal rate is the amount of a nutrient removed in the harvested grain or forage.

There are 3 scenarios in the table where application is restricted unless the MN Phosphorus Index (P-Index) is used to determine if the P loss risk is low. The P-Index is a tool that calculates phosphorus loss risk through multiple pathways. Planners may use the high sensitivity screening tool of the Rapid Phosphorus Index (RPI) to eliminate low risk fields and only run the P-Index where the screening tool shows a possible result of greater than 2.

There are 4 scenarios in Table 3 where application is restricted. The planner should work with the customer to identify potential additional conservation practices needed on those individual fields.

The current NRCS standard requires the P-Index to be run for manure or commercial fertilizer on planning land units located in a watershed impaired because of phosphorus (shown on MPCA's Inventory of Impaired Waters with the "pollutant or stressor" identified as "nutrients"). Table 4 explains the phosphorous risk rating categories based on the P-Index results and recommended level of need for mitigation actions.





Table 3: Phosphorus Loss Potential and Manure Application Rates

Distance to Surface Water (feet)	Soil Test Phosphorous (STP) Levels		Sheet and Rill Erosion Tons/Acre/Yr.	100' Buffer/ Filter Strip	
	Bray P1 (ppm)	Olsen (ppm)		No	Yes
				Base Manure Application on:	
NA			> 5	High No Application	
Land Units located in Impaired Watershed for Nutrients*			NA	High² No Application Or P-Index	
< 300 Feet	≤ 21	≤ 16	≤ 5	Low Nitrogen Needs	
	22 – 75	17 – 60	≤ 2	Medium P ₂ O ₅ Removal	Low¹ Nitrogen Needs
			2 - 5	Medium P ₂ O ₅ Removal	
	76 – 150	61 – 120	≤ 4	Medium P ₂ O ₅ Removal	Medium P ₂ O ₅ Removal
			≤ 5	High No Application	Medium P ₂ O ₅ Removal
	> 150	> 120	≤ 2	High No Application	Medium P ₂ O ₅ Removal
			> 2	High No Application	
	> 300 Feet	≤ 150	≤ 120	≤ 5	Low Nitrogen Needs
> 150		> 120	≤ 4	Low Nitrogen Needs	
			4-5	High² No Application Or P-Index	Medium P ₂ O ₅ Removal
			> 5	High² No Application Or P-Index	

¹ This “Low” option with a filter strip was added for flexibility to apply manure at nitrogen recommendations if soil loss is below 2 tons per acre. This is validated by Table 1 within CPS 393 Filter Strip.

² Fields with a high potential of P loss cannot have manure applied except when the current or proposed management results in a MN P-Index value of ≤ 2.0. Then, manure can be applied on a P₂O₅ removal basis.

* The MPCA updates this list on a regular basis (about every 2 years). The most current approved list at plan development will be used. NRCS will provide a GIS layer upon request.



The P-Index is a relative rating for P loss potential. MN NRCS will allow fields within 10 ppm P soil test levels, with same soil texture, and are under the same management to be grouped together for P-Index assessment. MPCA permitted facilities need to reference their permit for guidance.

Table 4: Interpreting P-Index Results for Organic and Inorganic P Applications

Total P Index	Risk Rating	Mitigation Action
≤ 2	Low	Manure can be applied at rates to supply P at greater than crop requirement not to exceed the N requirement for the succeeding crop. AND/OR Follow UME recommendations for inorganic fertilizer applications.
2-4	Moderate	Manure can be applied at rates not to exceed crop P removal rate or the soil test P recommended rate for the planned crops in rotation. AND/OR Do not exceed P removal rates for planned crop for inorganic fertilizer applications.
> 4	High	The sum of Phosphorus sources can be applied at rates not to exceed crop P removal rate if the following requirements are met: <ol style="list-style-type: none"> 1. A soil P drawdown strategy has been developed, documented, and implemented for the crop rotation. 2. Implementation of all mitigation practices determined to be needed by site-specific assessments for nutrients and soil loss to protect water quality. 3. Any deviation from these high-risk requirements that would increase the risk of P runoff requires the approval of the Chief of the NRCS.





Setback Requirements for Sensitive Areas

Table 5 is the state minimum requirements for manure applications in sensitive areas. There may be other state or local laws that the planner needs to account for when creating the setback maps in a nutrient management plan. Information related to surface texture, drainage class, permeability, available water capacity, depth to water table, restrictive features, flooding frequency, and ponding frequency are important to consider during the nutrient management planning process and can be found in the Map Unit Description Report from Web Soil Survey.

TABLE 5: Minimum 590 Setback Requirements for Manure Application in Sensitive Areas					
Sensitive Areas	Winter Setbacks	Non-Winter Setbacks			Other Requirements
		A: Surface Application	B: Incorp. + P mgmt**	C: Incorp. NO P mgmt**	
Streams & lakes	300'	*300'	25'	*300'	
Intermittent streams, wetlands, & drainage ditches	300'	*300'	25'	*300'	
Open tile intakes	300'	300'	0'	0'	
Well, mines and quarries	50'	50'	50'	50'	Document mitigation actions in plan.
Sinkholes (without berms or diversions)	50' downstream 300' upstream	50' downstream 300' upstream	50'	50'	
Road ditches, waterways, & other direct conduits to surface or ground water	—	—	—	—	No application into any direct conduit to surface or ground water. Document mitigation actions in plan if applicable.
A = Surface application with NO incorporation within 24 hours B = Injection or incorporation within 24 hours AND phosphorus management** C = Injection or incorporation within 24 hours with NO phosphorus management** — = No specific requirements. * Setbacks can be reduced if permanent vegetative buffers are planted along the waters and will not have manure applied. Setbacks are reduced from 300' to 100' for lakes and perennial streams and 50' for wetlands, drainage ditches and intermittent streams. **Phosphorus management means that the application rate and frequency over six-year periods will not result in soil P build-up where soil P already exceeds 21 ppm Bray P1 or 16 ppm Olsen.					
Operations that are required to have a NPDES or SDS permit may have additional setback requirements.					
Minnesota Groundwater Rule may have additional requirements for nutrients applied within a mitigation DWSMA. The Department of Health has an interactive map of these areas.					
Table adapted from "Land Application of Manure: Minimum State Requirements" publication from the MPCA May 2011.					



Agronomy Technical Note #32 Reference List with Website

Natural Resources Conservation Service

Topic	Website
590 Nutrient Management	https://efotg.sc.egov.usda.gov/api/CPSFile/34165/590_MN_CPS_Nutrient_Management_2021
Web Soil Survey	https://websoilsurvey.nrcs.usda.gov/app/

Minnesota Department of Agriculture

Topic	Website
Groundwater Protection Rule	https://www.mda.state.mn.us/nfr
Nitrogen Fertilizer BMP's for Agricultural Lands	https://www.mda.state.mn.us/pesticide-fertilizer/nitrogen-fertilizer-bmps-agricultural-lands
Interactive Fall Nitrogen Restriction Map	https://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/mitigation/wrpr/wrprpart1/vulnerableareamap

Minnesota Pollution Control Agency

Topic	Website
Feedlot Program (7020 Rule)	https://www.pca.state.mn.us/water/feedlots
Land Application of Manure: Minimum State Requirements (wq-f8-11)	https://www.pca.state.mn.us/sites/default/files/wq-f8-11.pdf
Manure Application at NPDES Permitted Feedlots (wq-f8-53)	https://www.pca.state.mn.us/sites/default/files/wq-f8-53.pdf
MN Impaired Waters List	https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list
Applying Manure in Sensitive Areas	https://www.pca.state.mn.us/sites/default/files/feedlots-manureapplication.pdf

University of Minnesota

Minnesota Phosphorus Index	https://hdl.handle.net/11299/48349
MN Rapid Phosphorus Index	https://extension.umn.edu/phosphorus-and-potassium/minnesota-phosphorus-index-assessing-risk-phosphorus-loss-cropland#when-to-use-the-rpi-617760

Minnesota Department of Health

Source Water Protection Web Map Viewer and Information	https://www.health.state.mn.us/communities/environment/water/swp/mapviewer.html
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Agronomy Technical Note #32 Reference List with Website continued

University of Minnesota Extension BMP Publications

Publication Title	Website
Best Management Practices for Nitrogen Use in Minnesota- 08560	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3032/datastream/PDF/view
Best Management Practices for Nitrogen Use on Coarse Textured Soils- 08556	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3028/datastream/PDF/view
Fertilizing Corn in Minnesota	https://extension.umn.edu/crop-specific-needs/fertilizing-corn-minnesota
Fertilizing Corn Grown on Irrigated Sandy Soils- AG-NM-1501	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3033/datastream/PDF/view
Best Management Practices for Nitrogen Use in Northwestern Minnesota- 08555	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3027/datastream/PDF/view
Best Management Practices for Nitrogen Use in South Central Minnesota- 08554	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3026/datastream/PDF/view
Best Management Practices for Nitrogen Use in Southeastern Minnesota- 08557	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3029/datastream/PDF/view
Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota- 08558	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3030/datastream/PDF/view
Best Management Practices for Nitrogen Use: Irrigated Potatoes- 08559	https://wrl.mnpals.net/islandora/object/WRLrepository%3A3031/datastream/PDF/view
MN Report 186- 1983	Nitrogen Loss Potential & Nitrogen Fertilizer Management of Minnesota Soils
Guidelines for Manure Application Rates	https://extension.umn.edu/manure-management/manure-application-rates
Manure Management	https://extension.umn.edu/livestock-operations/manure-management
Agronomic and Environmental Management of Phosphorus	https://extension.umn.edu/phosphorus-and-potassium/agronomic-and-environmental-management-phosphorus





Appendix A- Acronyms

Abbreviation	Definition
7020 Rule	Minnesota Feedlot Rules (Minnesota Rules Chapter 7020)
BMP	Best Management Practice
CPS	Conservation Practice Standard
DWSMA	Drinking Water Supply Management Areas
Ksat	Saturated Hydraulic Conductivity
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MPCA	Minnesota Pollution Control Agency
N	Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
P	Phosphorus
P-Index	Minnesota Phosphorous Index
RPI	Rapid Phosphorus Index (screening tool)
SDS	State Disposal System
SWPA	Source Water Protection Area
UME	University of Minnesota Extension
UMN	University of Minnesota
USDA	United States Department of Agriculture

