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FOR LIVESTOCK PRODUCERS IN MANITOBA

Residual Soil Nitrate-N Limits: Guidance for Soil Sampling and Nitrogen Management in Complex Landscapes

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BACKGROUND: Residual Soil Nitrate and the Regulatory Limits

In 2004, the Livestock Manure and Mortalities Management Regulation (MR 42/98) was amended to include residual soil nitrate limits based on the dryland agriculture capability of the soil for fields that receive manure (Tables 1 and 2). In 2008, similar limits were incorporated into the Nutrient Management Regulation (62/2008) to capture synthetic fertilizer and other nitrogen (N) applications (Table 2).

Residual soil nitrate is the amount of nitrate-N that is present in the soil after the production of a crop. For annual crops, it is the amount of soil nitrate present after the crop has been harvested. The intent of the residual soil nitrate limits is to reduce the risk of nitrate leaching to groundwater. Soils that have better agriculture capability (Class 1 to 3) have fewer limitations for annual crop production and can support higher yields. High yielding crops require and remove greater quantities of N to reach their yield potential.

Because nitrate is completely soluble, when water moves through the soil, it carries nitrate with it. The risk of nitrate leaching and groundwater contamination is very low on deep clay soils because of the very slow downward movement of water through the matrix of these soils. Conversely, very thin soils and sands present a higher risk. Water can move downward more freely in sands, however, the risk of nitrate leaching can be mitigated on these soils when perennial forages such as alfalfa and grass are grown. This is because these crops have a very long growing season, deep and dense root systems, and high water and N demand. **The greatest risk of nitrate leaching or groundwater contamination is when annual crops are grown on low agriculture capability sands (Class 5M and 5M combinations), where the soils are very thin and permeable, or where fractured bedrock is shallow (Class 5R and 5R combinations).** Annual crops present a greater risk on these soils, in part because uptake of N and water slows dramatically in late summer and completely stops once the crop is mature. To minimize the risk of nitrate leaching or groundwater contamination from these systems, a higher level of management is required to ensure that residual soil nitrate levels remain low.

Agriculture capability classifications provide insight into the ability of a soil to produce annual crops based on inherent land characteristics and properties within the top metre of soil (Table 1). Agriculture capability classification maps for agri-Manitoba are available via the Manitoba Land Inventory and can be accessed using GIS software or the Agri-Maps viewer. Although some fields are more uniform than others, no agricultural field is completely uniform. Minor differences may have little impact on yield, while more significant differences will have greater impact on yield and, therefore, the agricultural capability classification. The level of detail displayed on a map is a function of field variability and the scale of the soil survey. Maps based on detailed 1:20,000 soil survey differentiate areas of variability in soil polygons down to five acres in size. Maps based on more general reconnaissance (1:126,000) soil survey show less detail and often group two or three soils together in larger areas or polygons. The minimum polygon size for 1:126,000 reconnaissance soil survey is 156 acres.

Table 1. Simplified Dryland Agriculture Capability Guidelines for Manitoba

Based on the Canada Land Inventory Soil Capability Classification for Agriculture (1965), with modifications made for soil application at larger mapping scales.

Subclass Limitations	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Depth to Consolidated Bedrock (R)	> 39 in. (100 cm)	> 39 in. (100 cm)	> 39 in. (100 cm)	20 – 39 in. (50 - 100 cm)	8 – 20 in. (20 – 50 cm)	< 8 in. (20 cm)	Bedrock at surface.
Moisture Limitation (M)	All soil textures except those identified in other classes. Good moisture holding capacity.	Loams Moderate moisture holding capacity	Loamy sands Low moisture holding capacity, prone to droughtiness	Sands Very low moisture holding capacity, very prone to droughtiness	Gravelly sands Very severe moisture deficiency, extremely prone to droughtiness	Stabilized sand dunes Almost continuously droughty	Active sand dunes Continuously droughty
Topography (T)	a, b 0 to 2%	c >2% to 5%	d >5% to 10%	e >10% to 15%	f >15% to 30%	g >30% to 45% Eroded slopes	h (>45% to 70%) i (>70% to 100%) j (> 100%)
Salinity (N)	NONE	WEAK Slight impact on crops	MODERATE (s) Crop growth and yield affected	STRONG (t) Crop selection is limited	VERY STRONG (u) Few crops can be grown. Yield and growth are severely limited.		Salt Flats. Crop growth is not possible.
Flooding (I)	None during growing season	Occasional (1 in 10 years)	Frequent (1 in 5 years) Some crop damage	Frequent Severe crop damage	Very frequent (1 in 3 years) Grazing > 10 weeks possible	Very frequent Grazing 5-10 weeks possible	Land is flooded for most of the season
Excess Water (W)	Well and Imperfectly drained		Loamy to fine textured wet soils with improved drainage	Coarse textured wet soils with improved drainage	Poorly drained soils withno improvements	Very Poorly drained soils	Open water, marsh
Stoniness (P)	Non-stony (0) and Slightly Stony (1)	Moderately Stony (2)	Very Stony (3)	Exceedingly Stony (4)		Excessively Stony (5)	Cobbly Beach
Erosion (E)	No apparent erosion	Moderate erosion (2)	Severe wind or water erosion (3) lowers the basic rating by one class to a minimum rating of Class 6.				

Table 2. Relationships between Agriculture Capability, Leaching and Groundwater Contamination Risk and Residual Nitrate Limits

Agriculture Capability Groupings (42/98)	Water Quality Management Zones (62/2008)	Crop Yield Potential	Leaching/Groundwater Risk	Residual Nitrate Limit
Class 1, 2 and 3 excluding Class 3 soils with an M designation	N1	High (Class 1) to fair (Class 3) productivity for both annual and perennial crops.	Low leaching risk when annual crops are grown on fine-textured soils, when nitrogen and water uptake is high. Low when perennial forages are grown.	140 lb nitrate N/acre
Class 3 with an M designation and Class 4 soils	N2	Class 3 soils with an M designation are sandy soils with moderate capability for annual crops and good potential for perennial forages. Class 4 soils have low to medium productivity for a narrower range of annual crops.	Moderate leaching risk when annual crops are grown on Class 4 soils or sands and residual nitrate is high. Low when perennial forages are grown.	90 lb nitrate N/acre
Class 5 soils	N3	Class 5 soils have low capability for annual crops and are best suited to perennial forages.	High when annual crops are grown on sands or where bedrock is within 20 to 50 cm of the ground surface and residual nitrate is present. Low when perennial forages are grown.	30 lb nitrate N/acre
Class 6	N4	No capability for annual crop production. Some capability for perennial forage production or pasture.	Very high on areas of Class 6 sands under annual crop production or when bedrock is within 20 cm of the ground surface.	Nutrient applications prohibited
Class 7 and unimproved organic soils	N4	No capability for arable agriculture or permanent pasture.	Very high on Class 7 sands or where bedrock outcrops are present.	Nutrient applications prohibited

NITROGEN FERTILIZATION AND RESIDUAL SOIL NITRATE LIMITS

Farmers take into consideration a variety of factors when making decisions about how to fertilize a field, including land capability, crop type and variety, soil test results, yield potential and equipment availability. At the time of fertilization, decisions about application may change because of poor weather or unfavourable soil moisture levels.

Nitrogen applications, whether from manure or synthetic fertilizer, should always be based on soil tests for nitrate-N and realistic crop yield targets. At the end of the growing season, the field's nitrate levels must be within the residual nitrate limit(s). To establish N application rates that satisfy crop needs without exceeding the residual nitrate limits, agronomists and producers must understand how the residual nitrate limits apply to each of their fields and then sample and fertilize accordingly.

In simple landscapes, field variability is less dramatic and crop yields may be relatively uniform, making soil sampling and fertilization decisions easier. In these landscapes, soil survey information may indicate that there are only one or two residual nitrate limits for the field. This may be because of the uniformity of the field itself, or it may be a function of map scale and the fact that the variability was not captured on the soil survey.

In complex landscapes, more distinct field variability can result in multiple residual soil nitrate limits within a field, especially if the area is covered by detailed soil survey. Variable rate applications of synthetic N fertilizer are one method to ensure crop needs are met and may provide greater assurance that multiple residual limits within a field can also be met. However, variable rate N applications are not always practical and are not yet available for manure. Many farmers manage each field uniformly, seeding the same crop variety and applying the same rate of manure or fertilizer to the entire field based on an estimated average target yield. In some instances, simplification of the residual nitrate limits is warranted for practicality, consistency and harmonization with recommended soil sampling strategies and fertilization methods.

OPTIONS FOR NITROGEN MANAGEMENT IN COMPLEX LANDSCAPES

The following strategies have been developed by industry, the University of Manitoba, Agriculture and Agri-Food Canada, Manitoba Agriculture and Manitoba Sustainable Development to provide guidance for soil sampling and N management in complex landscapes. Strategy 1 can be used where variable rates of N application are possible. Strategy 2 applies to fields that receive a single N application rate. The objective of these strategies is to simplify the interpretation and application of residual soil nitrate limits where possible, without presenting undue risk to groundwater from nitrate leaching.

Strategy 1: Applying Variable Rates of Nitrogen

In some instances, variable N rate application may be possible to account for differences in yield potentials and comply with the residual nitrate limits among soil survey polygons. This approach is much more practical for synthetic fertilizer than manure. When manure is used, a base rate of manure that targets the lowest yield potential could be applied to the entire field and the higher yielding areas could receive additional fertilizer N at seeding or later in the growing season to reach their yield potential. Residual nitrate limits could then follow soil survey polygons and should be sampled accordingly, using principles similar to landscape directed soil sampling (Manitoba Soil Fertility Guide, 2007).

Strategy 2: Managing the Field as a Single Unit with a Single Rate of Nitrogen

Many individual agricultural fields are managed uniformly. Composite soil samples (Manitoba Soil Fertility Guide, 2007) are often taken to reflect the soil nutrient status of the entire field. Yield variability, due to localized areas of salinity, moisture deficit, excess wetness or other limitations, is incorporated into an average target yield and a single rate of N fertilizer is determined for the whole field. When areas of variability are reflected on the soil survey, however, multiple residual nitrate limits may apply to the field, making it more challenging to integrate the limits into the soil sampling and fertilization program (Figure 1).

(a) Fields with Low to Moderate Risk of Nitrate Leaching

In some instances, it may be appropriate to divide a complex field into smaller, more uniform management units. Although this may simplify the residual soil nitrate limits, more than one residual soil nitrate limit may apply to each of the new fields, even after dividing the original field (Figure 2). Where the risk of nitrate leaching to groundwater is low to moderate, it is acceptable to apply the dominant residual soil nitrate limit to each field.

For decision making purposes, the risk of nitrate leaching to groundwater can be considered low to moderate (i) when perennial crops are grown; or (ii) when annual crops are grown, the field contains less than 20 per cent or 20 contiguous acres of the high risk, low agricultural capability soils (Class 5M, 5R, 5M combinations or 5R combinations).

A residual soil nitrate limit can be considered dominant when it covers at least 60 per cent of the cropped area. If none of the residual soil nitrate limits cover 60 per cent of the field, polygons with different residual nitrate limits may be combined until 60 per cent or greater of the field is included, provided that the lowest residual nitrate limit of the combined areas is then applied to the entire field (Figure 3).

(b) Fields with High Risk of Nitrate Leaching

The risk of nitrate leaching can be considered high when annual crops are grown and the field contains at least 20 per cent or 20 contiguous acres of the high risk, low agricultural capability soils (Class 5M, 5R, 5M combinations or 5R combinations). When annual crops are grown, these areas should be managed to remain within the very low residual nitrate limit of 30 lb nitrate N/acre. To keep soils within these very low residual nitrate limits, lower rates of manure or synthetic N fertilizer may be required. Higher residual nitrate limits cannot be applied to these areas.

EXAMPLES

The examples on the following two pages are based on the field below (Figure 1), which is complex and has multiple residual soil nitrate limits according to the detailed soil survey agriculture capability classifications (see Table 1).

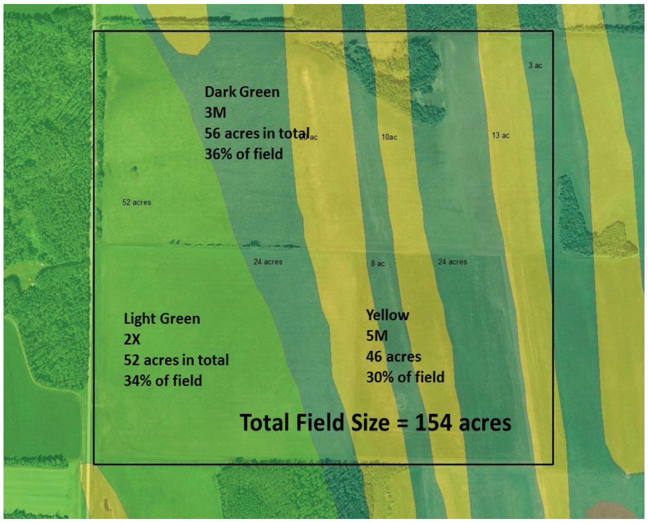

Figure 1: Complex agricultural field with areas of highly productive, prime agricultural land (green) as well as narrow ridges of low agricultural capability 5M sands (yellow). Note: 2X indicates Class 2 soils with a combination of limitations.

Example 1: Corn alfalfa-grass hay rotation. Manure applied to fertilize corn.

The production of an annual crop presents a greater risk of nitrate leaching to groundwater from low agriculture capability sands (5M) in this field than when a perennial forage is grown. For this reason, the low agriculture capability sands (yellow areas) should receive greater consideration with respect to N fertilization.

If variable rate fertilizer application is not feasible, the field could be divided into 2 fields to better isolate the yellow, low agriculture capability sands for lower fertilizer or manure N applications (Figure 2). Higher N applications could then be targeted to the higher yielding green areas. The 140 lb residual nitrate limit could then be applied to the newly delineated Field 1 because it contains over 60 per cent of the soils in Class 1 to 3 (except 3M combinations). Due to the sensitivity of the soils to nitrate leaching when annual crops are grown on Field 2, the 30 lb residual nitrate limit would be applied.

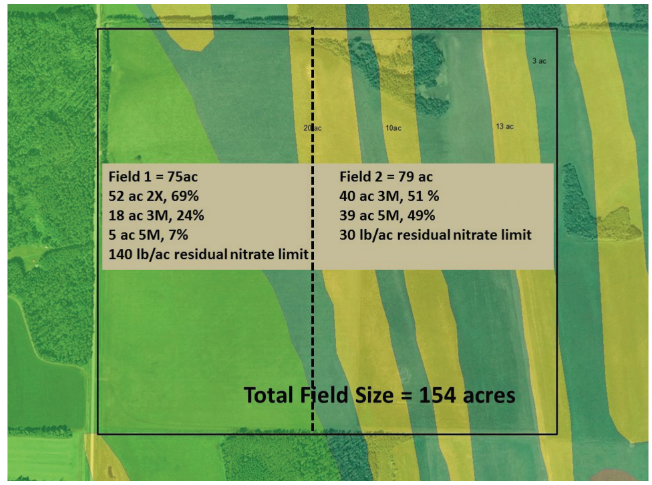

Figure 2: Under annual crop production, the field is divided in two and each field is managed separately to better isolate the yellow, higher risk 5M sands.

Example 2: Corn alfalfa-grass hay rotation. Manure applied to alfalfa-grass hay.

Perennial forages present little risk of nitrate leaching when fertilized according to crop uptake, even on sands. Because this field will produce alfalfa-grass hay, all soil types can be combined and the field can be managed as a single unit, provided the residual nitrate-N levels are kept below the lower 90 lb/acre limit (Figure 3).

Figure 3: Under perennial forage production, the prime agricultural lands (Class 2 and 3) are dominant and the 90 lb/acre residual nitrate-N limit is applied to the entire field.

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