

## **Guidelines for Manure Application and Water Quality**

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Manure is an unavoidable waste product from dairy and other livestock operations. If managed well, it can be a valuable resource, providing crop nutrients and improving the physical and biological properties of soil. But if mismanaged it can contribute to water quality problems such as nitrate leaching of ground water and phosphorus runoff into surface waters.

Comprehensive whole-farm nutrient management planning is necessary to maximize utilization of all on-farm and purchased nutrient inputs (manure, plow-down legumes, fertilizer, etc.) and to balance economic and environmental goals. Part of that process involves prioritizing fields to receive manure and avoiding those with high risk of contributing to water quality degradation. These guidelines present an approach for field-by-field assessment of fields for that purpose.

Two tools available for field assessment of water quality impacts of nutrient application are the Phosphorus Index and the Nitrate Leaching Index. Most of the land area of Vermont drains into surface waters that are phosphorus-limited. This means that the growth of algae and other nuisance plants are limited by the concentration of available P in the water. Additions of phosphorus from point and non-point sources (such as agriculture) can lead to excessive algae growth and what are called eutrophic conditions. The P Index can help identify fields where manure application presents a high risk for P runoff, as well as those where manure can be safely applied. The Nitrate Leaching Index is used to classify fields as to the amount of leaching expected under typical conditions.

Because of the phosphorus and nitrogen content of manure relative to crop need, application rates based on P are generally lower than those based on N (for N-demanding crops such as corn or grass hay) and are not likely to create nitrate leaching problems. In fact, supplementary fertilizer N will often be required.

### ***Nitrogen-limited Manure Application Rates***

In situations where P runoff is not a major concern, manure application rates may be based on nitrogen crop need. The crop N need is determined based on the specific crop, expected yield, soil drainage, previous crop, and past manure applications. Nitrogen available from manure should be based on lab analysis, adjusted for manure properties and field management practices. Use the Pre-Sidedress Nitrate Test (PSNT) to evaluate N availability for corn and to determine if additional sidedress N is needed. (See UVM Extension publication BR 1390, Nutrient Recommendations for Field Crops in Vermont (Jokela et al., 1998) for information on determining crop N need, including the PSNT, and on manure N availability.) The Nitrate Leaching Index (Table 1) can identify fields where nitrate leaching into groundwater is a particular concern. It is

calculated from Soil Hydrologic Group, annual precipitation, and non-growing season precipitation (Pierce et al., 1991; NRCS, 1999). Those fields with a High or Very High index require more restrictive N management – avoiding fall manure application, careful attention to application rate (e.g. limit pre-plant N rate and use PSNT for additional fertilizer N need), etc. Note: Some restrictions on P application may still be appropriate on high runoff/erosion potential fields.

- 1) Does the field drain into phosphorus-sensitive surface waters?
  - a) Yes → Go to #2 (P Runoff Screening Matrix)
  - b) No → Do nitrate leaching index.
    - (1) Low or Moderate → Use N-based manure application.
    - (2) High → Use N-based manure application with additional N management restrictions (timing, rate, etc.)

Table 1. Nitrate Leaching Index. (Pierce et al., 1991. NRCS, 1999)

	Leaching Index Class		
	Low	Moderate	High
Leaching Index, inches	0-2	2.1-10	>10

***Phosphorus-limited Manure Application Rates***

The Phosphorus Index is a field-based tool designed to give a relative rating (Low, Medium, High, Very High) of individual fields as to the risk of P runoff. The Index accounts for various sources of runoff P (soil, organic/manure, fertilizer) and different mechanisms for transport of that P from the field (erosion, runoff, flooding) and combines them as a comprehensive Phosphorus Index (See the fact sheet, *The Phosphorus Index: A Tool for Management of Agricultural Phosphorus in Vermont*). Developing a P Index requires a site visit to measure slope and other field characteristics needed for determining soil erosion, in addition to data that is accessible from the soil survey database. This may make it impractical to run a P Index on all fields where nutrient management planning is being implemented on a large scale, whether by legislation, cost-share requirements, or other reasons. Consequently, it is desirable to have a screening tool to prioritize those fields most likely to have P runoff problems and, therefore, having the greatest need for a P Index.

Several states have policies or legislation that use a soil test for crop-available phosphorus (a P test threshold), either alone or in conjunction with a P Index, to restrict manure application (Lory and Scharf, 1999). Use of a P soil test has the advantage of being an easily quantifiable measure that is already in common usage. And fields with

higher P soil tests tend to have runoff with higher *concentrations* of soluble P (though not necessarily higher *quantities* of P). However, the main consideration should be to avoid applying manure on fields where manure application would result in the greatest *increase* in P runoff. This is primarily a function of runoff and erosion potential and is not dependent on soil test P. Consequently, we are recommending use of a Phosphorus Runoff Screening Matrix (PRSM), which can be determined directly from soil survey data and soil test P, perhaps supplemented by limited farmer information (Table 2). The P Runoff Screening Matrix, or PRSM, can be used to assess the need for determining a full P Index.

- 2) Is the Phosphorus Runoff Screening Matrix Rating High?  
 a) No → Use N-based manure application  
 (See #1 above, including Nitrate Leaching Index)  
 b) Yes → Run P Index

Table 2. Phosphorus Runoff Screening Matrix (PRSM)

	Low	Medium	High
Runoff Class	Very Low or Low	Medium	High
HEL Class (Highly Erodible Land)	Non-HEL	Potentially HEL	HEL
Flooding Frequency	None/Rare	Occasional	Frequent
Soil Test P, ppm (Mod. Morg.)	7 or less	7.1-20	>20
<b>P Runoff category is determined by the highest category of any individual parameter.</b>			

If the PRSM rating is High, then the P Index needs to be run to more fully assess the P runoff potential. The full P Index includes several parameters (soil erosion, vegetative buffers, fertilizer and manure management) that can be managed by the farmer to lower the P Index. The P Index rating for a field determines whether manure is to be applied at an N-based rate (Low or Medium), at a P-based rate (High), or not at all (Very High). Refer to UVM Extension publication BR 1390, Nutrient Recommendations for Field Crops in Vermont (Jokela et al., 1998) for information on determining soil test-based crop nutrient need and estimating manure nutrient availability.

- 3) What is the P Index rating for the field?
  - a) Very High → No manure can be applied. Implement soil conservation practices.
  - b) High → P-based manure application (Rate to supply P crop need; P crop removal as maximum). Implement soil conservation practices.
  - c) Medium or Low → N-based manure application.

This use of the P Index for this purpose raises an interesting question. Since one of the parameters in the P Index calculation is manure application rate, how can the P Index be used to determine what the application rate should be? One approach for dealing with this would be to first calculate a P Index with only manure that has already been applied for the season (e.g. fall-applied). Then, depending on the resulting P Index, calculate a new P Index with the proposed manure rate. If the resultant P Index rating is too high to be acceptable then reduce the manure application rate (or adjust other management factors) and recalculate the P Index.

A description and explanation of calculations for the P Index are detailed in *The Phosphorus Index: A Tool for Management of Agricultural Phosphorus in Vermont*.

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- 1) Does the field drain into phosphorus-sensitive surface waters?
  - a) Yes → Go to #2
  - b) No → Do Nitrate Leaching Index.
    - (1) Low or Moderate → Use N-based manure application.
    - (2) High → Use N-based manure application with additional N management restrictions (timing, rate, etc.)
  
- 2) Is the Phosphorus Runoff Screening Matrix Rating High?
  - a) No → Use N-based manure application  
(See #1 above, including leaching index)
  - b) Yes → Run P Index
  
- 3) What is the P Index rating for the field?
  - a) Very High → No manure to be applied. Implement soil conservation practices.
  - b) High → P-based manure application (P crop removal as maximum). Implement soil conservation practices.
  - c) Medium or Low → N-based manure application allowed. See 1) a) above.

## References

Jokela, B., F. Magdoff, R. Bartlett, S. Bosworth, and D. Ross. 1998. Nutrient recommendations for field crops in Vermont. Br. 1390. Univ. of Vermont Extension, Burlington, VT. Web: <http://ctr.uvm.edu/pubs/nutrientrec/>

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