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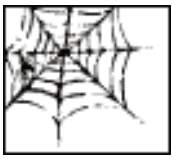

EPA promulgated regulations for Concentrated Animal Feeding Operations (CAFOs) in February 12, 2003 that expanded the number of operations covered by the CAFO regulations and included requirements to address the land application of manure from CAFOs. The rule became effective on April 14, 2003. NPDES-authorized states were required to modify their programs by February 2005 and develop state technical standards for nutrient management. On February 28, 2005, in response to litigation brought by various organizations, the Second Circuit court issued its decision in *Waterkeeper Alliance et al. v. EPA*, 399 F.3d 486 (2d Cir. 2005). EPA has updated the CAFO rule to reflect the changes requested by the Court. Visit www.epa.gov/npdes/caforule to view the 2008 CAFO Final Rule and supporting documents.

APPENDIX H - THE PHOSPHORUS INDEX: A PHOSPHORUS RISK ASSESSMENT TOOL

RATIONALE FOR A PHOSPHORUS INDEX

Agronomic soil test P levels and guidelines were developed to guide soil fertility management by approximating the pool of soil P available for crop growth. Specifically, agronomic soil test P interpretations (i.e., low, medium, optimum, high) are based on the expected response of a crop to P, and cannot be directly interpreted as estimates of environmental risk, such as runoff P enrichment potential. Recent research shows that when soils have not received recent additions of P from manure and/or fertilizer soil test P is strongly related to dissolved P in runoff. However, in typical U.S. agricultural systems, which rely on the use of organic and inorganic nutrient sources, agronomic soil test guidelines alone are inadequate to address water quality concerns associated with nutrient loss.

In considering alternatives to using agronomic soil test P guidelines alone to manage environmental quality, it is necessary to examine how nutrients, in this case P, move from the landscape to water. Within agricultural watersheds most nutrients, including P, are exported from a small part of the landscape during a few relatively large storms. This indicates that specific areas, known as hydrologically active areas, are responsible for a majority of P transport. These areas are not evenly distributed across the landscape and are typically determined by physical landscape properties such as soil type and topography. Where hydrologically active areas coincide with areas of high soil P or recent P applications, there is increased vulnerability and concern about P loss. These vulnerable areas or "critical P source areas" occur even in regions where subsurface flow pathways dominate P transport (e.g., some areas of the Coastal Plains). In these regions, critical P source areas contribute P to drainage waters and are localized to soils with high soil P saturation and hydrologic connectivity to the surface drainage network. In order to effectively manage nutrient related water quality concerns, these critical P source areas must be identified and managed. The identification of these areas needs to incorporate agronomic soil test P guidelines, but must also examine P application and P transport.

Concept of the Phosphorus Index

The P Index has been developed to assist field staff, watershed planners, and land users in evaluating various landscapes and management practices for potential risk of P movement to water bodies through the identification of critical P source areas. The Index is a simple qualitative assessment tool to rank site vulnerability to P loss, which can also be used to help identify agricultural areas or management practices that have the greatest potential to accelerate eutrophication. As such, the P Index will identify alternative management options available to land users, providing flexibility in developing remedial strategies. When the parameters of the Index are analyzed, it becomes apparent that an individual parameter or parameters can influence the Index disproportionately. These identified parameters can the basis for planning corrective soil and water conservation practices and management techniques. As a result, some general management recommendations can be given based on site vulnerability rating, however, P management is very site-specific and requires a well-planned, coordinated effort between farmers, extension agronomists, and soil conservation specialists. Ultimately, the P Index is an educational tool that brings interaction between the planner and farmer in assessing environmental management decisions required to improve the farming system on a watershed rather than political basis.

The P Index identifies critical P source areas or areas vulnerable to P loss by accounting for and ranking source and transport factors controlling P loss from a given site. Source and site management factors are typically well defined and reflect land use patterns related to soil P status, mineral fertilizer and manure P inputs, and tillage. Source factors include soil test P and rate method, timing and form of P applied. Transport factors mobilize P sources, creating pathways of P loss from a field or watershed and include erosion, surface runoff, subsurface flow, distance of the field to stream, presence of channelized flow pathways or ditches, and existence of implemented Best Management Practices.

The material contained in this appendix should be used for your informational purposes only. Specific P Index calculations should be completed by NRCS, your local extension, or a certified nutrient management planner.

Instructions on How to Use Your Phosphorus Index

Source Factors

Soil Test P Level

Definition:

A soil sample from the site is necessary to assess the level of "available P" in the surface layer of the soil. The available P is the level customarily given in a soil test analysis by the Cooperative Extension Service or commercial soil test laboratories. The user of the P Index must determine the soil test P level present at the site using a current soil test report. The soil test level for "available P" does not ascertain the total P in the surface soil. However, it does provide an indication of the amount of total P that may be present because of the general relationship between the forms of P (organic, adsorbed, and labile P) and the solution P available for crop uptake.

Where this information can be located:

Soil test P levels can be taken directly from a soil test report. Be sure to follow state or region specific soil sampling guidelines and use sampling depths recommended for the production system, an accredited soil testing lab, and a soil analysis recommended for the region and relevant soil types.

Fertilizer and Organic Source P Application Rate

Definition:

The P fertilizer or organic P application rate is the amount, in pounds of phosphate per acre (lb P_2O_5/acre), that is applied to the soil. Fertilizer and organic P source accounting in P Indices varies by state. Most commonly, there are separate categories for rates of fertilizer and organic P sources and the actual rate is entered into the P Index. However, there are Indices that combine fertilizer and organic P source rates and others that do not require an actual rate entry, but that assign a category to a range of P application rates. Therefore, carefully review the P Index being used and the associated guidance.

Where this information can be located:

Generally, the application rate of commercial fertilizer and organic sources of P can be taken directly from the farm records or nutrient management plan. In calculating the organic source P content, an analysis of the organic material or accredited book value estimate is needed. The P content by analysis is generally considered to be completely plant available.

Fertilizer and Organic Source P Application Method

Definition:

The manner in which P is applied from a fertilizer or organic P sources and the amount of time that the fertilizer is exposed on the soil surface until crop utilization effects potential P movement. The value categories of increasing severity, LOW to VERY HIGH, depict the longer surface exposure time between fertilizer application, incorporation, and crop utilization.

Where this information can be located:

Generally, the application rate of commercial fertilizer can be taken directly from the farm records or nutrient management plan.

Organic P Source Availability

Definition:

While the P content of organic sources is considered to be completely plant available, it is not considered to be completely environmentally available. Therefore, several P Indices account for the environmental availability of P in organic sources. Typically, a book value is assigned based on manure type.

Where this information can be located:

Manure type is indicated in the farm nutrient management plan or the farm records. Additionally, the availability book values are typically located in the state specific P Index guidance.

Transport Factors

Soil Erosion

Definition:

Soil erosion is defined as the loss of soil along the slope or unsheltered distance caused by the processes of water and wind. Soil erosion is estimated from erosion prediction models currently used (USLE or RUSLE for water erosion and WEQ for wind erosion; http://www.iwr.msu.edu/rusle/ & http://bioengr.ag.utk.edu/rusle2/). Erosion induced by irrigation is calculated by other convenient methods. These soil loss prediction models do not predict sediment transport and delivery to a water body. The prediction models are used in the P Index to indicate a movement of soil, thus potential for sediment and attached phosphorus movement across the slope or unsheltered distance and toward a water body.

Where this information can be located:

The soil loss values will need to be determined for each evaluated field based on current farm management practices. In some states, the actual erosion values are available in the farm's soil conservation plan.

Index Surface Runoff Class or Runoff Class

Definition:

The runoff class of the site can be determined from soil survey or NASIS data (National Soil Information System). Guidance in determining the runoff class is based on the soil saturated hydraulic conductivity (K_{Sat}) and the percent slope of the site (U.S. Department of Agriculture-Natural Resources Conservation Service, 1993). A more simplified table has been developed using soil permeability classes. The result of using the matrix relating soil permeability class or K_{Sat} and slope provides the value categories:

NEGLIGIBLE, VERY LOW, LOW, MEDIUM, HIGH, and VERY HIGH. Another method to determine runoff class is using the NRCS curve number (CN) method. The major factors that determine curve number incl the hydrologic soil group, landscape cover type, conservation treatment, hydrologic condition, and antecedent runoff conditions. The NRCS runoff curve number method is described in detail in (U.S. Department of Agriculture-Natural Resources Conservation Service, 1985).

Where this information can be located:

Runoff class values can be determined using NASIS or soil survey data and the conversion table for the chosen evaluation method. Standardized state runoff class tables may be developed in cooperation with the state NRCS agency using NASIS data.

Sub-surface Movement

Definition:

Sub-surface P movement refers to P movement down through the soil profile that has the potential to reach a receiving body. This type of P movement is accounted for based on either the leaching potential of the soil or based on the presence of artificial drainage. Leaching potentials are generally based on soil type and P Indices will provide information sources or a table to determine the leaching potential for their Index. The presence of artificial drainage typically depends on the examination of farm records or a field inspection.

Where this information can be located:

Sub-surface drainage information requires either knowledge of the soil type or presence of artificial drainage. This can be located in the farm records, soil survey information, or NASIS data.

Distance to Receiving Body of Water

Definition:

Distance to a receiving water body is a P Index category that has more recently been added to P Index evaluations. The distance category is used to estimate the potential of P reaching a body of water based on the concept that the closer a field is to a body of water the more likely it is that P in or on that field will reach a body of water. While the concept underlying the use of a distance factor is consistent from state to state, the methods used in determining the distance categories and the field reference point used in the measurement of a distance to a body of water varies from state to state.

Where this information can be located:

The distance of field to a receiving body of water can be obtained from a field inspection and measurement or by calculation of the distance using a farm map. In the determination of the distance, it is necessary to be familiar with the guidance associated with the P Index approach that you are using as different states use different field reference points (i.e., edge of field or concentrated flow path) in determining the distance.

P Index Procedure

To conduct a P Index evaluation of a field it is necessary to obtain all of the information needed to determine the source and transport characteristics. If one were using the Pennsylvania P Index (Table 1) to conduct the assessment, the following information would be needed:

- Soil test
- Fertilizer rates, methods, and timing of application
- Manure rates, methods, and timing of application and P availability
- Erosion
- Runoff potential
- Subsurface drainage
- Contributing distance
- Modified Connectivity – Practices such as buffer zones that impact the potential of P to move from a field to a body of water.

The information is used to determine all of the source and transport factors in the Pennsylvania P Index either using a directly measured value or selecting a category and weighting factor. Source and transport factors are then calculated using the equations listed below. The final P Index value is calculated by multiplying the Source Factor by the Transport Factor and then multiplying the product by 2. The final P Index value is then used to determine the appropriate management guidance for the field (Table 2).

Source Factor = Soil Test Rating + Fertilizer Rating + Manure Rating

Transport Factor = ((Soil Erosion + Runoff Potential + Sub-Surface Drainage + Contributing Distance)/22) x Modified Connectivity

P Index Value = Source Factor x Transport Factor x 2

Once the final P Index value has been calculated, there are two choices available to the producer and nutrient management plan developer: (1) follow the recommended nutrient management guidance (Table 2) or (2) examine best management practices that could be implemented to reduce both vulnerability to P loss from the site as well as the P Index value. Best management practices may include, but are not limited to the following: soil conservation practices, modification of organic and inorganic P application timing and incorporation, animal diet modification, and installation of buffer zones. The use of best management practices as a part of the P Indexing process offers producers flexibility in managing their manure on-farm while environmental protection. It is important to note that the initial P Index evaluation in many states, including Pennsylvania, accounts for the presence of certain best management practices.

Interpretations of Site Vulnerability Rating for the P Index

The guidance and P Index rating categories below in Table 2 were originally outlined in the USDA-USEPA Unified National Strategy and have been directly adopted by most states. The Low and Medium categories prescribed N-based nutrient management and High or Very High categories prescribe P-based management. Despite consistency in the management recommendations, differences can be seen the numeric P Index value categories that define Low, Medium, High, and Very High.

LOW - This site has a LOW potential for P movement from the site. If farming practices are maintained at current level, the probability of an adverse impact to surface water resources from P losses from this site would be low.

MEDIUM - This site has a MEDIUM potential for P movement from the site. The probability for an adverse impact to surface water resources is greater than that from a LOW vulnerability rated site. Some remedial action should be taken to lessen the probability of P movement.

HIGH - This site has a HIGH potential for P movement from the site. There is a high probability for an adverse impact to surface water resources unless remedial action is taken. Soil and water conservation as well as phosphorus management practices are necessary to reduce the risk of P movement and probable water quality degradation.

VERY HIGH - This site has a VERY HIGH potential for P movement from the site. The probability for an adverse impact to surface water resources is very high. Remedial action is required to reduce the risk of P movement. All necessary soil and water conservation practices plus a phosphorus management plan must be put in place to reduce the potential of water quality degradation.

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U.S. Department of Agriculture-Natural Resources Conservation Service. 1985. National Engineering Handbook number 4.

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Weld, J.L., D. Beegle, W.J. Gbuerk, P.J.A. Kleinman, and A.N. Sharpley. 2003. The Pennsylvania phosphorus index: Version 1. CAT UC 180 5M3/03ps4591. Publications distribution center, Pennsylvania State University, University Park, PA.

Table 1. The Pennsylvania Phosphorus Index: Version 1 (Weld et al., 2003)

PART A – SCREENING TOOL

	Evaluation Category	
Soil Test P	> 200 mg P kg^{-1}	**If yes to either factor then proceed to Part B**
Contributing Distance	< 150 ft	

PART B - SOURCE FACTORS

Soil test	Soil Test P (mg P kg^{-1})				
Soil Test P Rating = 0.20* Soil Test P (mg P kg^{-1})					
Fertilizer P rate	Fertilizer P (lb P_2O_5/acre)				
Manure P rate	Manure P (lb P_2O_5/acre)				
P source application method	0.2 Placed or injected 2" or more deep	0.4 Incorporated <1 week	0.6 Incorporated > 1 week or not incorporated April - October	0.8 Incorporated >1 week or not incorporated Nov. - March	1.0 Surface applied to frozen or snow covered soil
Fertilizer Rating = Rate x Method					
P source availability	0.5 Treated manure/Biosolids		0.8 Dairy	1.0 Poultry/Swine	
Manure Rating = Rate x Method x Source Availability Coefficient					
Source Factor = Soil Test P Rating + Fertilizer Rating + Manure Rating					

PART C - TRANSPORT FACTORS

Erosion	Soil Loss (ton/acre/yr)				
Runoff potential	0 Very low	2 Low	4 Medium	6 High	8 Very high
Sub-surface drainage	0 None		1 Some		2* Patterned
Contributing distance	0 > 500 ft.	2 500 to 350 ft.	4 350 to 250 ft.	6 150 to 250 ft.	8 < 150 ft.
Transport Sum = Erosion + Runoff Potential + Sub-surface Drainage + Contributing Distance					
Modified connectivity	0.7 Riparian buffer– applies to distance < 150 ft		1.0 Grassed waterway or none		1.1 Direct connection – applies to distance > 150 ft
Transport Factor = Modified Connectivity x (Transport Sum / 22)					

* Or rapid permeability soil near a stream

Phosphorus Index Value = 2 x Source Factor x Transport Factor

Table 2. The Pennsylvania Phosphorus Index: Version 1 Interpretations and Management Guidance (Weld et al., 2003).

Value	Rating	Management Guidance
0 to 59	Low	**Nutrients can be applied to meet the Nitrogen crop requirement.** *Low* potential for P loss. Maintenance of current farming practices is recommended to minimize the risk of adverse impacts on surface waters
60 to 79	Medium	**Nutrients can be applied to meet the Nitrogen crop requirement.** *Medium* potential for P loss. The chance for adverse impacts on surface waters exists. An assessment of current farm nutrient management and conservation practices is recommended to minimize the risk of future P losses.
80 to 99	High	**Nutrients can be applied to meet the Phosphorus crop removal.** *High* potential for P loss and adverse impacts on surface waters. Soil and water conservation measures and P-based management plans are needed to minimize the risk of P loss.
100 or greater	Very High	**No Phosphorus can be applied.** *Very high* potential for P loss and adverse impacts on surface waters. Conservation measures and a P-based management plan must be implemented to minimize the P loss.