

TECHNICAL NOTES

NATURAL RESOURCES CONSERVATION SERVICE – WYOMING

AGRONOMY NO. 15

March 2013

SUBJECT: Phosphorus Index

Beginning in the mid-1980s, scientists researching soluble movement of phosphorus in surface runoff began documenting a relationship between soil phosphorus levels and phosphorus movement in runoff solution. There is now a substantial body of research addressing the relationship between soil phosphorus levels, phosphorous transport and phosphorus impact on aquatic ecosystems.

The Phosphorus Index (PI) is a site-specific, qualitative, vulnerability assessment tool. The PI is to be used to assess the potential movement of phosphorus from Agricultural Waste application sites, to identify those sites which should be considered for more careful management of phosphorus, and to aid in the determination of manure application rates.

Factors other than soil test phosphorus levels impact potential off-site losses of phosphorus. Factors such as soil erosion, soil test phosphorus levels, and rate, timing and method of application differentially impacts the potential for phosphorus loss. However, phosphorous will not be applied when Olsen soil test levels are greater than 150 ppm.

PROCEDURE FOR USING THE INDEX

The site characteristics which impact potential phosphorus loss have been placed in categories and assigned a weight factor based on their relative impact on potential phosphorus movement from the site. Instructions are provided for each category; however, **only** categories that apply to the site receiving manure application are to be used.

PHOSPHORUS LOSS CATEGORIES AND WEIGHTING FACTORS

- Soil Erosion (Wind Erosion or Sheet & Rill (Water) Erosion) (2.0)
- Furrow Irrigation Efficiency (1.0)
- Flood Irrigation Efficiency (1.0)
- Sprinkler Irrigation Efficiency (1.0)
- Runoff Class (1.0)
- Soil Test Phosphorus Level From 6 – 8 Inch Depth (2.0)
- Commercial Phosphorus Fertilizer Application Method (1.5)
- Commercial Phosphorus Fertilizer Application Rate (1.5)
- Manure/Organic Phosphorus Application Method (1.5)
- Manure/Organic Phosphorus Application Rate (1.5)
- Distance to Surface Water (1.0)
- Soil Phosphorus Sorption Capacity (1.0)

RISK RATINGS FOR EACH CATEGORY ARE AS FOLLOWS

- None = 0 (Not applicable = NA)
- Low = 1
- Medium = 2
- High = 4
- Very High = 8

CATEGORY INSTRUCTIONS

Individual sections from Table 4 are shown for each category to assist in determining the weighted risk factor for the category.

Soil Erosion

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Soil Erosion	<1 ton/ac	1 – 2 ton/ac	2 – 4 ton/ac	4 – 10 ton/ac	>10 ton/ac		X 2.0	

Soil erosion is the detachment and transport of soil from the site. This category is expressed as the actual soil loss for a given soil. Soil erosion should be predicted using currently approved erosion prediction technology found in Section I of the NRCS Field Office Technical Guide. The type of erosion prediction tool to be used depends on whether wind or sheet & rill (water) erosion is the prevalent form of erosion. Erosion estimates consider climate, soil characteristics, slope length and percentage, unsheltered distance, crop rotation, tillage system, and other practices such as contouring or cross-slope farming, and soil roughness. **(Note: If users of the PI are not familiar with the use of erosion prediction tools, they are encouraged to contact the nearest NRCS field office, or contact the State Conservation Agronomist).**

Irrigation Efficiency

Flow and application rates, as well as land-slope, all impact the potential off-site movement of phosphorus via irrigation. Irrigation efficiency (absolute efficiency, NOT potential efficiency) directly or indirectly impacts this potential off-site movement. Efficiency values should be determined using the Farm Irrigation Rating System (FIRS). If any irrigation system, regardless of efficiency has a tailwater recovery system that is properly operated and maintained, and prevents all off-site movement of irrigation water, the Risk Value shall be zero (0). **(Note: Evaluate only the irrigation type most representative of the site).**

Furrow Irrigation Efficiency

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Furrow Irrigation Efficiency	>65% Efficiency	55 – 65% Efficiency	45 – 55% Efficiency	35 – 45% Efficiency	<35% Efficiency		X 1.0	

Flood Irrigation Efficiency

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Flood Irrigation Efficiency	>50% Efficiency	40 – 50% Efficiency	30 – 40% Efficiency	20 – 30% Efficiency	<20% Efficiency		X 1.0	

Sprinkler Irrigation Efficiency

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Sprinkler Irrigation Efficiency	>80% Efficiency	70 – 80% Efficiency	60 – 70% Efficiency	50 – 60% Efficiency	<50% Efficiency		X 1.0	

Runoff Class

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Runoff Class	Negligible	Very Low or Low	Medium	High	Very High		X 1.0	

The runoff class of a site is based on the **least** permeable soil layer in the top three feet. Permeability classes for specific soils can be found in the soil map unit description in the county soil survey. Soil survey information is available through the local NRCS office. Slope and soil permeability class must be determined to calculate the runoff class. See Table 2 to determine Runoff Class.

Table 2 – Runoff Class

Slope %	Soil Permeability Class				
	Very Rapid (141.14 micro meters/sec.)	Moderately Rapid (14.11-42.34) and Rapid (42.34-141.14 micro meters/sec.)	Moderate (4.23-14.11) and Moderately Slow (1.41-4.23 micro meters/sec.)	Slow (0.42 – 1.41 micro meters/sec.)	Very Slow (0.1 – 0.42 micro meters/sec.)
Runoff Class					
Depressions	Negligible	Negligible	Negligible	Negligible	Negligible
0 – 1%	Negligible	Negligible	Negligible	Low	Low
2 – 5%	Negligible	Very Low	Low	Medium	High
6 – 10%	Very Low	Low	Medium	High	Very High
11 – 20%	Very Low	Low	Medium	High	Very High
>20%	Low	Medium	High	Very High	Very High

Soil Phosphorus Test Level

Site Category	Very Low (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Olsen Soil Test	<20 ppm	20-40 ppm	40-60 ppm	60-80 ppm	>80 ppm		X 2.0	
Bray Soil Test	<30 ppm<10 ppm	30 – 50 ppm	50 – 70 ppm	70 – 90 ppm	>90 ppm		X 2.0	

The Olsen (sodium bicarbonate) soil test is normally utilized on soils with a pH greater than 7.0 and contain calcium carbonate (CaCO₃). Since most Wyoming soils fall into this category, soil phosphorus levels should normally be determined using this method. In addition, the University of Wyoming Guide to Fertilizer Recommendations bases phosphorus application recommendations on the Olsen extractant method. Bray P1 soil tests are typically used on soils with pH <7.0. (Note: Use either the Olsen or Bray method; do NOT use both tests).

Commercial Phosphorus Fertilizer Application Method

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Commercial Phosphorus Fertilizer Application Method	None Applied	Placed with planter or injected deeper than 2 inches	Incorporated <3 months prior to planting or surface applied during the growing season	Incorporated >3 months prior to planting or surface applied < 3 months before crop	Surface applied >3 months before crop		X 1.5	

Method of phosphorus fertilizer placement, time to incorporation, and stage of crop all effect potential phosphorus losses. The categories are intended to quantify the potential effects on off-site losses of surface exposure time, incorporation and crop uptake to commercially applied phosphorus fertilizer.

Commercial Phosphorus Fertilizer Application Rate

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Commercial P Fertilizer Application Rate	None Applied	<20 lbs/acre P ₂ O ₅	21 – 50 lbs/acre P ₂ O ₅	51 – 100 lbs/acre P ₂ O ₅	>100 lbs/acre P ₂ O ₅		X 1.5	

Commercial phosphorus fertilizer application rate is the amount in pounds per acre (lbs/ac) of phosphate fertilizer (P₂O₅) that is applied. This does not include phosphorus from organic sources.

Manure/Organic Phosphorus Application Method

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Manure and/or Organic Phosphorus Application Method	None Applied	Injected deeper than 2 inches	Incorporated <3 months prior to planting or surface applied during the growing season	Incorporated >3 months prior to planting or surface applied < 3 months before crop	Surface applied >3 months before crop		X 1.5	

Method of manure/organic placement, time to incorporation, and stage of crop all effect potential phosphorus losses. The categories are intended to quantify the potential effects on off-site losses of surface exposure time, incorporation and crop uptake to land-applied manure/organic fertilizer.

Manure/Organic Phosphorus Fertilizer Application Rate

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Manure and/or Organic P Fertilizer Application Rate	None Applied	<20 lbs/acre P ₂ O ₅	21 – 50 lbs/acre P ₂ O ₅	51 – 100 lbs/acre P ₂ O ₅	>100 lbs/acre P ₂ O ₅		X 1.5	

Manure/organic phosphorus fertilizer application rate is the amount in pounds per acre (lbs/ac) of phosphate fertilizer (P₂O₅) contained in manure and/or organic fertilizer that are applied. This does not include phosphorus from commercial sources. Refer to Agronomy Tech Note 14 or site-specific manure tests for information on the nutrient content of agricultural wastes.

Distance to Surface Water

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Distance to Surface Water	>2640 feet with permanent, actively growing grass/legume cover	2640 – 1320 feet, or >2640 feet without grass/legume cover	1320 – 660 feet	660 – 100 feet	<100 feet		X 1.0	

This category is an estimate of distance between the application site, and surface water and assesses the potential of off-site phosphorus movement to surface water resulting from storm-induced runoff. Use zero for the distance if manure or fertilizer is applied directly to a concentrated flow area that delivers runoff water to an intermittent or perennial stream, or lake or other water body.

Soil Phosphorus Sorption Capacity

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Soil Phosphorus Sorption Capacity	Very High	High	Medium	Low	Very Low		X 1.0	

The soil parameters pH and surface texture affect a soil’s phosphorus sorption ability. See Table 3 to determine the Soil Phosphorus Sorption Capacity.

Table 3 – Determining Soil Sorption Capacity

pH	Soil Texture Class		
	Coarse Textured (S, LS, SL)	Medium Textured (Si, SiL, L, SCL)	Fine Textured, Organic and High Lime (SC, CL, SiCL, SiC, C)
< 6.0	Very Low	Low	Medium
6.1 – 7.0	Low	Medium	High
7.1 – 8.0	Low	High	Very High
> 8.0	Medium	Very High	Very High

Table 5 – Site/Field Vulnerability to Phosphorus Loss

Total of Weighted Values	Site Vulnerability Rating	Site/Field Number(s)
<20	LOW	
20 – 40	MEDIUM	
40 – 60	HIGH	
>60	VERY HIGH	

Vulnerability Definitions and Application Guidelines

LOW – The site has low potential for off-site movement of phosphorus.

MEDIUM – This site has some potential for off-site movement of phosphorus. There is a greater potential of impact to surface water than the LOW category. Phosphorus management practices (applying manure at lower rates, installing filter strips, injection/incorporation changes) should be considered as an alternative.

HIGH – This site is likely to have some off-site movement of phosphorus. Phosphorus management practices will be documented in the alternatives section of the conservation plan and manure application rates will be phosphorus-based.

VERY HIGH – This site is very likely to have some off-site movement of phosphorus. Phosphorus management practices will be documented in the alternatives section of the conservation plan and no additional manure applications will be made on the site until such time as remedial action is taken to reduce the site’s risk assessment rating.

Conservation Practices to minimize potential phosphorus off-site movement vary by site. Site categories having the highest loss potential are the most critical, and should be addressed first.

Table 6 – Manure Application Guidelines

Phosphorus Index Rating	Manure or Organic Application
Low	Nitrogen-based
Medium	Nitrogen-based
High	Phosphorus-based up to crop removal
Very High	No Application

Table 7 – Olsen Soil Test Phosphorous Levels

Olsen soil test levels	Commercial, Manure, or Organic Application
0-6 ppm	Nitrogen-based
7-25 ppm	Phosphorous-based
26-150 ppm	Phosphorus-based, up to crop removal
Over 150 ppm	No Phosphorous Application

Completing the Risk Assessment

Each category factor in Table 4 is multiplied by the weighting factor to get a weighted value. All applicable categories are rated, and the risk assessment rating is the sum of these products. Once a rating is determined, record the rating in Table 5, and use Table 6 for application guidelines.

Table 4 – Phosphorus Index Site Vulnerability

Site Category	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Risk Value (0, 1, 2, 4, 8)	Weight Factor	Weighted Risk Factor
Soil Erosion	<1 ton/ac	1 – 2 ton/ac	2 – 4 ton/ac	4 – 10 ton/ac	>10 ton/ac		X 2.0	
Choose one → → →	Furrow Irrigation Efficiency, or	>65% Efficiency	55 – 65% Efficiency	45 – 55% Efficiency	35 – 45% Efficiency	<35% Efficiency		X 1.0
	Flood Irrigation Efficiency, or	>50% Efficiency	40 – 50% Efficiency	30 – 40% Efficiency	20 – 30% Efficiency	<20% Efficiency		X 1.0
	Sprinkler Irrigation Efficiency	>80% Efficiency	70 – 80% Efficiency	60 – 70% Efficiency	50 – 60% Efficiency	<50% Efficiency		X 1.0
Runoff Class	Negligible	Very Low or Low	Medium	High	Very High		X 1.0	
Choose One → →	Olsen Soil Test, or	<20 ppm	20-40 ppm	40-60 ppm	60-80 ppm	>80 ppm		X 2.0
	Bray Soil Test	<30 ppm	30-50 ppm	50-70 ppm	70-90 ppm	>90 ppm		X 2.0
Commercial Phosphorus Fertilizer Application Method	None Applied	Placed with planter or injected deeper than 2 inches	Incorporated <3 months prior to planting or surface applied during the growing season	Incorporated >3 months prior to planting or surface applied < 3 months before crop	Surface applied >3 months before crop		X 1.5	
Commercial P Fertilizer Application Rate	None Applied	<20 lbs/acre P ₂ O ₅	21 – 50 lbs/acre P ₂ O ₅	51 – 100 lbs/acre P ₂ O ₅	>100 lbs/acre P ₂ O ₅		X 1.5	
Manure and/or Organic Phosphorus Application Method	None Applied	Injected deeper than 2 inches	Incorporated <3 months prior to planting or surface applied during the growing season	Incorporated >3 months prior to planting or surface applied < 3 months before crop	Surface applied >3 months before crop		X 1.5	
Manure and/or Organic P Fertilizer Application Rate	None Applied	<20 lbs/acre P ₂ O ₅	21 – 50 lbs/acre P ₂ O ₅	51 – 100 lbs/acre P ₂ O ₅	>100 lbs/acre P ₂ O ₅		X 1.5	
Distance to Surface Water	>2640 feet with permanent, actively growing grass/legume cover	2640 – 1320 feet, or >2640 without grass/legume cover	1320 – 660	660 – 100 feet	<100 feet		X 1.0	
Soil Phosphorus Sorption Capacity	Very High	High	Medium	Low	Very Low		X 1.0	
Site/Field Total								