Guidelines for Using the Revised Tennessee Phosphorus Risk Index

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The major environmental threat posed by phosphorus from agricultural sources is runoff from fields next to or close to surface waters such as streams, rivers and lakes. The phosphorus can be in either water soluble or insoluble form, with the former being more reactive and thus most likely to cause short-term water quality problems like algal blooms. Control of water-soluble phosphorus from fields near surface water is more difficult than controlling the more insoluble forms usually associated with phosphorus carried on soil or organic particles due to erosion or surface flushing.

The potential for phosphorus reaching nearby water in the runoff from agricultural fields depends on many factors and site conditions, which control both **transport** and **source** characteristics. These are taken into account in the Revised Tennessee Phosphorus Risk Index, an assessment management tool designed for use on a **field-by-field** basis. This approach was developed in 2000 and significantly revised in 2016. Table 1 shows the essential elements of the Index. The Index will not predict the quantity of phosphorus leaving a particular site or field, but will identify fields that have a high risk of phosphorus movement into nearby surface waters. If necessary, larger fields including various topographic features can be divided and assessed as sub-fields, which if necessary can be managed differently.

The Index was originally designed to educate land managers on the potential for phosphorus movement under a certain management practices. Generally, managers are required to apply the Index on fields if they are designated and regulated as a concentrated animal feeding operation (CAFO) in Tennessee, or if they are working with the Natural Resources Conservation Service (NRCS) and are required to follow the Nutrient Management Conservation Practice Standard (also known as the 590 Conservation Practice Standard). The Index is only required for sites with soils that test *high* or *very high* for soil phosphorus, and where the University of Tennessee Extension Soil, Plant and Pest Center (soilplantandpest.utk.edu) does **NOT** recommend further application of phosphorus.

Table 1. The Revised Tennessee Phosphorus Risk Index

TN Phosphorus Index*					
Part A: Phosphorus loss potential due to site and transport characteristics					
Transport	**Phosphorus Loss Rating**				**Value**
Runoff Class	(1 point)	(2 points)	(4 points)	(8 points)	
	Low	Medium	High	Very Hjgh	
Soil Erosion estimated using RUSLE2 (tons/ac/yr)	(1 point)	(4 points)	(8 points)	(16 points)	
	<5	5 - 10	10.1 - 15	>15	
Permanent Vegetative Buffer Width (ft)** *not required for commerical only operations*	(1 point)			(8 points)	
	≥35			<35	
Non-Application Width from Surface Water Conveyance (ft) *not required for commerical only operations*	(1 point)	(2 points)	(4 points)	(8 points)	
	>100	61 - 100	35 - 60	<35	
				Part A: Total Site Value:	
Part B: Phosphorus loss potential due to source and management characteristics					
Source	**Phosphorus Loss Rating**				**Value**
Soil Test P Value (lbs/ac) *(Choose One)*	(1 point)	(2 points)	(4 points)	(8 points)	
Mehlich 1 — OR —	0 - 30	31 - 120	121 - 300	>300	
Mehlich 3	0 - 60	61 - 210	211 - 420	>420	
P Application Rate (lbs P_2O_5/ac)					
	0.10 x	lbs P_2O_5/ac applied as commercial fertilizer			
	0.10 x	lbs P_2O_5/ac applied as manure, poultry litter, or biosolids			
	0.05 x	lbs P_2O_5/ac applied as alum to poultry litter at 100 lbs per 1000 sq. ft. rate			
	OR				
	0.02 x	lbs P_2O_5/ac applied as alum to poultry litter at 200 lbs per 1000 sq. ft. rate			
Application Timing	(1 point)	(2 points)	(4 points)	(8 points)	
	Actively growing crop or within 15 days before planting	16 to 45 days before planting	More than 45 days before planting	December, January, or dormant pastures/ hay	
Application Method	(1 point)	(2 points)	(4 points)	(8 points)	
	Injected	Incorporated within 5 days of application	Incorporated more than 5 days after application	Surface applied (no incorporation)	
				Part B: Total Management Value:	
Multiply Total Part A x Total Part B:					**P Loss Rating**

**Permanent Vegetative Buffers must be installed, constructed, and maintained in accordance with applicable NRCS Conservation Practice Standard.

*The index numbers and the interpretations, as well as the whole document will continue to be reviewed and evaluated, and are subject to modification as further field testing and validation of the index continues.

The Index is composed of eight "characteristics" that are each assigned a score. Four of the factors are "**site and transport**" factors, and four are "**source and management**" factors. The sum of all the transport factors is multiplied by the sum of all the source factors to produce a **Phosphorus (P) Loss rating** (Table 2).

Table 2. Generalized Interpretation of the Revised Tennessee Phosphorus Risk Index

Total Points From P Index	Generalized Interpretation of the P Index Points for the Site
<140	**LOW** potential for P movement from the field. If farming practices are maintained at the current level there is a low probability of an adverse impact to surface waters from P losses. Nitrogen-based nutrient management planning is satisfactory for this site. Soil P levels and P loss potential may increase in the future due to N-based nutrient management. *NOTE: When applying manure or biosolids, do not exceed the nitrogen need of the crop nor the total P need of all crops in the crop rotation interval (not to exceed 3 years) .*
140 - 270	**MODERATE** potential for P movement from the field. The chance for adverse impact to surface waters exists. *Nutrient management plans shall be designed not to exceed UT phosphorus recommendation or phosphorus removal rate.*
271 - 400	**HIGH** potential for P movement from the field. The chance for adverse impact to surface waters is likely unless remedial action is taken. Nutrient management planning based on the annual crop removal of phosphorus can be applied when the following requirements are met: **1)** A soil phosphorus drawdown strategy has been implemented, **AND** **2)** A site assessment of nutrients and soil loss has been conducted to determine if mitigation practices are required to protect water quality.
>400	**VERY HIGH** potential for P movement from the field. *Applications of phosphorus are strongly discouraged. NRCS participants are prohibited from further P application.*

Step-by-Step Instructions on Completing Part A of the Index Rating Sheet

Runoff Class

The runoff class is an assessment of the rainfall runoff potential from a field based on certain site conditions, as specified by a runoff Curve Number (CN) based on the soil hydrologic group, and land use and cover. Soil Hydrologic Groups are categorized during a soil survey based on general estimates of runoff potential, and fall into one of four groups:

i. Group A: Well-drained soils with a high infiltration rate and thus a lower potential for runoff.
ii. Group B: Moderately well-drained soils with a moderate infiltration rate and thus a moderate potential for runoff.
iii. Group C: Somewhat poorly drained soils with a slow infiltration rate and thus a higher potential for runoff.
iv. Group D: Poorly drained soils with a very slow infiltration rate and thus a relatively high potential for runoff.

Step 1: Identify Dominant Soil Map Unit

The soil survey is available as hard copies at your local UT Extension office, NRCS office, or library, or is available online at the Web Soil Survey at websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

Identify the dominant soil map unit in the field and determine the corresponding hydrologic group (A, B, C or D).

Step 2: Determine the field CN.

Three factors are used to determine the CN: cover type, land use (treatment), and the soil hydrological group. Use Table 3 to determine this value.

Step 3: Determine the runoff class of the field.

The final step is to estimate the average slope of the field and determine the runoff class based on the CN obtained from Table 3 and the slope of the field (Table 4). Use the result from Table 4 to set the Runoff Class value in Table 1.

Table 3. Runoff Curve Numbers (CN) for Agricultural Lands[1/]

Cover Description			CN for Hydrologic Soil Group			
Cover Type	**Cover Description Treatment[2/]**	**Hydrologic Condition[3/]**	**A**	**B**	**C**	**D**
Fallow	Bare Soil		77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (Sr)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured and Terraced	Poor	66	74	80	82
	(C & T)	Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or Broadcast Legumes or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80
Pasture, Grassland, or Range-continuous forage for grazing [4/]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80

1/ Average runoff condition.
2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.
3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good equals greater than 20 percent), and (e) degree of surface toughness. For conservation tillage poor hydrologic conditions (with factors impair infiltration that tend to increase runoff) are 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain). For conservation tillage good hydrologic conditions (with factors encourage average and better than average infiltration and tend to decrease runoff) are more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).
4/ Poor = <50% ground cover or heavily grazed with no mulch; Fair = 50 to 75% ground cover and not heavily grazed; Good = >75% ground cover and lightly or only occasionally grazed.

Table 4. Runoff Class Based on Site Slope and Curve Number

Slope %	Runoff Curve Number*						
	<60	**60-65**	**66-70**	**71-75**	**76-80**	**81-85**	**>85**
<1	L	L	L	L	L	L	L
1	L	L	L	L	L	L	M
2	L	L	L	L	M	M	M
3	L	L	L	M	M	M	M
4	L	L	L	M	M	M	H
5	L	L	M	M	M	M	H
6	L	L	M	M	M	H	H
7	L	M	M	M	M	H	VH
8	L	M	M	M	M	H	VH
9	L	M	M	M	M	H	VH
10	M	M	M	M	H	H	VH
11	M	M	M	M	H	H	VH
12	M	M	M	M	H	VH	VH
13	M	M	M	M	H	VH	VH
14	M	M	M	H	H	VH	VH
15	M	M	M	H	H	VH	VH
>15	M	M	M	H	H	VH	VH

*Runoff curve numbers are found in USDA NRCS National Engineering Handbook Part 630 Hydrology, Chapter 9 Hydrologic Soil-Cover Complexes

L = Low; M = Medium; H = High; VH = Very High

Estimated Soil Erosion Using RUSLE2

RUSLE2 is a tool used to estimate the potential sheet and rill erosion from a particular field, and should be used to estimate erosion losses from all row crop fields and for heavily eroded pastures. For producers wishing to apply manure or poultry litter on well-vegetated pasture or hay fields with at least 50 percent vegetative cover, you can assume a soil loss value of less than 5 tons per acre, which would yield a score of 1 in the RUSLE2 line in Table 1. The official NRCS version of RUSLE2 can be found at the following website: fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

Alternatively your local NRCS office can assist you in running this tool.

Use the soil loss estimates from RUSLE2 to fill in the appropriate box in Part A of Table 1 of the Index. Soil loss less than 5 tons per acre scores 1 point, 5 to 10 tons per acre 4 points, 10.1 to 15 tons per acre 8 points and more than 15 tons per acre 16 points.

Permanent Vegetative Buffer Width

Permanent vegetative buffers are strips of vegetation between the field and adjacent surface water conveyances such as streams, rivers, ditches, channels etc. For the purposes of the Index, a surface water conveyance includes any permanent, continuous, physical conduit for transporting surface water, including permanent streams, defined waterways and ditches that only flow intermittently during the course of the year. Vegetative buffers act as physical barriers that intercept runoff from fields, slow down erosion, encourage sedimentation and nutrient uptake, and by these mechanisms reduce pollutant transport to surface waters.

Filter strips, field borders, contour buffer strips (if they include a strip at the bottom of the field), and riparian forest buffers are all examples of vegetative buffers. It is recommended that permanent vegetative buffers be installed, constructed and maintained in accordance with applicable NRCS Conservation Practice Standard.

Non-Application Width from Surface Water Conveyance

The non-application width from surface water conveyance is the distance from the edge of the surface water conveyance to the nearest cropped area where any commercial fertilizer, biosolids, animal manure or poultry litter is applied.

Part A: Total Site Value: With all the information for Part A of the index completed as described above, sum up the scores to obtain a final figure for the site and transport characteristics.

Completing Part B of the TN Phosphorus Index Rating Sheet

Soil Test Phosphorus

Current soil test results from the University of Tennessee Extension Soil, Plant and Pest Center (soilplantandpest.utk.edu) or some other approved certified soil testing laboratory should be used. UT Extension recommends testing soils in row crop fields at least every three years and pasture crops every five years.

For a list of approved laboratories, refer to the North American Proficiency Testing Program (PAPT) at www.naptprogram.org/about/participants or the American Laboratories Proficiency program. If you are using a certified soil testing laboratory from the approved list, you must instruct the laboratory to use the Mehlich 1 or Mehlich 3 soil extractant. The UT Soil, Plant and Pest Center estimates the plant available phosphorus in each soil sample using a Mehlich-1 extractant.

The soil analysis will report a numeric value for phosphorus (expressed as P_2O_5) in pounds per acre as well as a phosphorus level in the soil. For the extractant used by your lab, use the result to determine the correct score in the Index.

Application Rate of Phosphorus

The amount and type of applied phosphorus will directly influence the runoff phosphorus content. The risk of phosphorus movement is higher where more phosphorus is applied than can be removed annually by the crop.

The application rate of phosphorus is the amount of phosphorus (as P_2O_5) applied per crop or crop rotation/sequence. Application rates shall be based on the University of Tennessee soil test recommendations or approved crop removal rates. The University of Tennessee recommendations can be found at the University of Tennessee Extension Soil, Plant and Pest center website: soilplantandpest.utk.edu. For information on crop removal rates, refer to the International Plan Nutrition Institute (IPNI) at www.ipni.net/app/calculator/home or Table 5.

In order to estimate the phosphorus content of animal manures or biosolids, a current analysis from a certified manure analysis laboratory should be used. Analyses should be converted to P_2O_5 from P (by multiplying P concentrations by 2.3). For approved certified manure analysis laboratories, refer to the Minnesota Department of Agriculture — Manure Analysis Proficiency (MAP) Laboratories for a list of approved lab at website: www2.mda.state.mn.us/webapp/lis/maplabs.jsp.

In cases where a phosphorus-based nutrient plan is required when applying manure, a low phosphorus application rate may not be practical with available equipment or may not be economically feasible. In such cases, a one-time application of manure can apply up to a three-year crop uptake of P as long as the resulting application rate does not exceed the one-year nitrogen needs of the crop. In the year of the one-time application, the soil loss value for the field shall be equal to or less than the soil loss tolerance.

Table 5. Summary of Crop Removal Rates for the Main Crops and Forages.

Crop	Yield Units	Nitrogen removed (lb/unit)	Phosphorous (as P_2O_5) removed (lb/unit)	Potassium (as K_2O) removed (lb/unit)
Alfalfa	Ton	56	15	60
Bermuda pasture	Ton	46	12	50
Corn grain	Bu	0.75	0.44	0.29
Corn silage	Ton	8.3	3.6	8.3
Cotton	Bale	32	14	19
Fescue hay or pasture	Ton	38	18	52
Grain sorghum	Bu	0.84	0.42	0.21
Grain sorghum silage	Ton	8.6	2.6	7.4
Native grass hay and pasture	Ton	19.8	38.9	42
Small grain	Bu	1.3	0.5	0.35
Soybean	Bu	4	0.8	1.4
Tobacco	CWT	4.3	0.43	4.7

Application Timing

It is recommended that phosphorus applications be timed to coincide with the optimum growth and nutrient uptake period of the crop. If possible, applications should be as close to planting the crop as practical, and not during the winter months (December and January) when pasture and hay crops are dormant, nor more than 45 days before crop planting.

Application Method

The application method considers the effect of phosphorus placement on increased risk of P movement. Index application method choices include surface application without incorporation, surface application with incorporation (for example by plowing the field to invert the soil and bury the applied phosphorus), or injection using specialized manure or poultry litter injection equipment.

Part B: Total Management Value: Once all the information required to complete Part B of the index has been entered, sum up the scores to obtain a final figure for the source and management characteristics.

Finalizing TN Phosphorus Loss Rating

For the field being assessed, calculate the Index Loss Rating by multiplying the sum from Part A by the sum from Part B.

Multiply Part A (____) x Part B (____) = _____ P Loss Rating

Refer to Table 2 for the rating and corresponding management recommendations.

For scores less than 140 a manure management plan based on nitrogen-application can be developed if that is appropriate. For scores greater than 140, manure management plans based on phosphorus-application or phosphorus removal should be developed. For scores greater than 400, additional application of phosphorus is strongly discouraged. If your field scores more than 400, best management practices that reduce soil erosion to less than 5 tons per acre should be used, as well as increasing the vegetative buffer widths to greater than 35 feet and no-application widths to greater than 100 feet. Further risk reduction by changes in application timing and methods should also be considered.

For land managers working with NRCS cost-share programs, further applications of phosphorus are prohibited on fields scoring higher than 400.

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