The Delaware Phosphorus Site Index

Technical Guidance Manual

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Table of Contents

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The Delaware Phosphorus Site Index Technical Guidance Manual: Introduction

Why is Phosphorus a Concern for Delaware?

Nutrients from point and nonpoint sources negatively affect water quality in Delaware. The nutrients of greatest concern are nitrogen (N) and phosphorus (P). Efforts to reduce nutrient enrichment of ground and surface waters are a high priority for state and federal agencies and of considerable importance to all nutrient users and nutrient generators in the state. Two actions in particular highlight the importance of this issue in Delaware:

- Total Maximum Daily Load (TMDL) Program: Section 303(d) of the Federal Clean Water Act (CWA) of 1972 requires states to develop a list of waterbodies that need pollution reduction beyond that achievable with existing control measures. These waterbodies are referred to as “Water Quality Limited” and are compiled by each state on a “303(d) list.” States are required to develop a “total maximum daily load (TMDL)” for a number of pollutants (including nutrients) for these “water quality limited” waters. A TMDL is defined as “the level of pollution or pollutant load below which a waterbody will meet water quality standards and thereby allow use goals such as drinking water supply, swimming and fishing, or shellfish harvesting.” In 1996, a consortium of environmental groups sued USEPA for “failure to perform its mandatory duties to identify and then improve water quality” in Delaware. In 1997, the state of Delaware, through the Department of Natural Resources and Environmental Control (DNREC), negotiated a Total Maximum Daily Load (TMDL) agreement with the U.S. Environmental Protection Agency (USEPA). This agreement established a 10-year schedule to develop TMDLs for all affected waterbodies and to then promulgate “pollution control strategies” to ensure that pollutant loadings are below TMDL values (DNREC, 1997). In Delaware, TMDLs are promulgated as regulations. By 2006, the Delaware Department of Natural Resources and Environmental Control (DNREC) established TMDLs for the majority of waters within the state that were listed as impaired by nutrients and bacteria. Additionally, TMDLs for other pollutants or harmful conditions like zinc, polychlorinated biphenyls (PCBs), and temperature were established in some parts of the state. In 2010, the EPA also established a TMDL for nitrogen, phosphorus, and sediment for the entire Chesapeake Bay watershed, including the portion of Delaware that drains to the Chesapeake Bay (in these areas, the TMDL that is more stringent supersedes). A complete listing of Delaware TMDLs is maintained on DNREC’s website, along with their technical support documents and accompanying regulations.

- State of Delaware 1999 Nutrient Management Act: Agriculture has been identified as a major nonpoint source of nutrient pollution of ground and surface waters in Delaware. In 1998, an Agricultural Industry Advisory Committee on Nutrient Management (AIACNM) was appointed by then Governor Carper to address the issue of agricultural nonpoint source pollution. This committee issued a series of recommendations that led to the passage in 1999 of House Substitute Bill 1 for House Bill 250 that established a Delaware Nutrient Management Commission (DNMC) to develop and implement a State Nutrient Management Program. One of the factors that led to the drafting of this legislation, and ultimately Delaware's Nutrient Management Program, was the development of TMDLs for several of Delaware's watersheds and the focus on the agricultural community as one of the primary sources of nutrients. The Delaware Nutrient Management Program draws on the TMDL process by targeting priority areas for nutrient management activities and tracking water quality improvements from those activities. Both the AIACNM and the new state law stressed the importance of reducing nonpoint source pollution of ground and surface waters by P. For example, the State Nutrient Management Act of 1999 mandates that "application of P to high P soils cannot exceed a three-year crop removal rate." The specific definition of a "high P" soil was left to the DNMC. However, a key recommendation of the AIACNM was the need for a reliable Phosphorus Site Index to identify the risk of P transport from fields to waterways, based on the properties and management of all P sources (fertilizers, manures, biosolids), soil properties, hydrology, and soil and crop management practices. In December of 2000, the DNMC concurred and, based on P Site Index assessments conducted by the universities of Delaware and Maryland on approximately 880 farm fields, formally adopted the P Site Index as a "best management practice" (BMP) for Delaware. The Phosphorus Site Index (PSI) has been in effect in Delaware since that time. Maryland updated the PSI to the Phosphorus Management Tool in 2015.

What is a Phosphorus Site Index?

In 1990, the U.S. Department of Agriculture (USDA) Soil Conservation Service (now the USDA Natural Resources Conservation Service or USDA-NRCS) formed a national working group of scientists from universities, Cooperative Extension, and USDA Agricultural Research Service to develop a P indexing procedure that could identify soils, landforms, and management practices with the potential for unfavorable impacts on water bodies because of P losses from agricultural soils. The long-term goals of this national work group were to:

- Develop an easily used field rating system (the Phosphorus Site Index) for Cooperative Extension, Natural Resources Conservation Service (NRCS) technical staff, crop consultants, farmers or others, that rates soils according to the potential for P loss to surface waters.
- Relate the P Site Index to the sensitivity of receiving waters to eutrophication. This is a vital task because soil P is primarily an environmental concern when a transport process exists to carry particulate or soluble P to surface waters where eutrophication is limited by P.
- Facilitate adaptation of the P Site Index to site-specific situations. The variability in soils, crops, climates, and surface waters makes it essential that each state or region modify the parameters and interpretation given in the original P Site Index to best fit local conditions.

- Develop agricultural management practices that will minimize the buildup of soil P to excessive levels and the transport of P from soils to sensitive waterbodies.

The Phosphorus Site Index is designed to provide a systematic assessment of the risks of P loss from soils, but does not attempt to estimate the actual quantity of P lost in runoff. Knowledge of this risk not only allows us to design best management practices (BMPs) that can reduce agricultural P losses to surface waters, but to more effectively prioritize the locations where their implementation will have the greatest water quality benefits. Prioritization of effort is important in Delaware for three reasons. First, soil test summaries have shown that many of Delaware's soils are now rated as "optimum" or "excessive" in P, from an agronomic standpoint (Sims and Vadas, 1997a). Second, mass balance analyses clearly indicate that P surpluses are common in Delaware, particularly in situations where animal agriculture predominates (Sims et al., 1998). The existence of these P surpluses means that P application was historically, and will continue to, exceed crop needs unless additional economically viable alternatives to land application of manures are developed. Third, P losses by runoff (surface and subsurface) and erosion depend not only on the amount of P in or added to a soil, but also the transport processes that control soil and water movement from fields to waterways (Gburek et al., 1996).

Therefore, it is important that we not focus on strictly one measure of P, such as an agronomic or environmental soil test P value when assessing the risk of P loss from soil to water. Rather, a much broader, multi-disciplinary approach is needed. This approach must recognize that P loss will vary among watersheds and soils, due to the rate and type of soil amendments used, and due to the wide diversity in soils, crop management practices, topography, and hydrology (Sims, 1998a; Sims et al., 1998). At a minimum, any risk assessment process for soil P should include the following:

- Characteristics of the P source (fertilizer, manure, biosolids) that influence its solubility and thus the potential for movement or retention of P once the source is applied to a soil.
- The concentration and bioavailability of P in soils susceptible to loss by erosion.
- The potential for soluble P release from soils into surface runoff or subsurface drainage.
- The effect of other factors, such as hydrology, topography, soil, crop, and P source management practices, on the potential for P movement from soil to water.
- Any "channel processes" occurring in streams, field ditches, etc. that mitigate or enhance P transport into surface waters.
- The sensitivity of surface waters to P and the proximity of these waters to agricultural soils.

In summary, when resources are limited, it is critical to target them at areas where the interaction of P source, P management, and P transport processes results in the most serious risk of losses of P to surface and shallow ground waters. *This is the fundamental goal of the P Site Index.*

The Origin and Evolution of the Phosphorus Site Index

The Original P Site Index

The first P Site Index developed by the national P index working group was published by Lemunyon and Gilbert (1993) and included the following parameters known to influence P availability, retention, management, movement, and uptake (Table 1):

1. Soil erosion (1.5)
2. Irrigation erosion (1.5)
3. Soil runoff class (0.5)
4. Soil test P (1.0)
5. P fertilizer application rate (0.75)
6. P fertilizer application method (0.5)
7. Organic P application rate (1.0)
8. Organic P application method (1.0)

Each site characteristic was assigned a weighting factor (shown in parentheses above) based on the reasoning that some site characteristics are more important than others in controlling the potential for P loss from a site. Each site characteristic was also assigned a relative loss rating of low (=1), medium (=2), high (=4) or very high (=8) that was used to make a site-specific ranking of the severity of conditions found at individual locations. To make a risk assessment for P loss using the P Site Index, the weighting factor for each of the eight site characteristics was first multiplied by the site-specific relative loss rating. Then, the resulting values for all eight characteristics (weighting factor × loss rating) were summed to determine the P Site Index value for an individual site. Comparison of the final P Site Index value with the site vulnerability chart (Table 2) categorized the risk of P loss as low, medium, high, or very high. Interpretations and recommendations for soil and nutrient management were then developed in accordance with the level of risk. This original P Site Index has an additive structure.

The Phosphorus Site Index: A Long-Term National Effort by SERA-17

After the development of the original Phosphorus Site Index, interest grew within the P index working group to expand the scope of research and extension activities related to P management for water quality protection. The efforts of the P index working group were formalized in 1993 by establishing a USDA research and information group (SERA-17). The main goal of SERA-17 was to "bring together a diversity of disciplines to discuss, disseminate, coordinate, and facilitate the research and management needs related to the management of nutrients (particularly P), transport in surface and subsurface flows, and their impact on the quality of receiving waters." In 2013, SERA-17 was reauthorized as a multi-state research and education activity and has over 200 members from the U.S., Canada, and the European Union with expertise in disciplines ranging from soil science and corn genetics to hydrology and limnology.

Table 1. The original Phosphorus Site Index published by Lemunyon and Gilbert (1993).

SITE CHARACTERISTIC (Weighting Factor	***PHOSPHORUS LOSS RATING* (Value)**				
	NONE (0)	**LOW (1)**	**DIUM (2)**	**GH (4)**	**Y HIGH (8)**
Soil Erosion (1.5)	N/A	<5 tons/acre	5-10 tons/acre	10-15 tons/acre	>15 tons/acre
Irrigation Erosion (1.5)	N/A	Infrequent irrigation on well-drained soils	Moderate irrigation on soils with slopes <5%	Frequent irrigation on soils with slopes of 2-5%	Frequent irrigation on soils with slopes >5%
Soil Runoff Class (0.5)	N/A	Very Low or Low	Medium	High	ery High
Soil Test P (1.0)	N/A	Low	Medium	Optimum	Excessive
P Fertilizer Application Rate (lb P_2O_5/A) (0.75)	None Applied	<31	31-90	91-150	150
P Fertilizer Application Method (0.5)	None	Placed with planter deeper than 2 inches	Incorporated immediately before crop	Incorporated >3 months before crop or surface applied <3 months before crop	Surface applied to pasture or applied >3 months before crop
Organic P Source Application Rate (lb P_2O_5/A) (1.0)	None Applied	<31	31-90	91-150	150
Organic P Source Application Method (1.0)	None	Injected deeper than 2 inches	Incorporated immediately before crop	Incorporated >3 months before crop or surface applied <3 months before crop	Surface applied to pasture or applied >3 months before crop

Table 2. Site vulnerability ratings and interpretations obtained from the summation of the weighted products using the original Phosphorus Site Index (Lemunyon and Gilbert, 1993).

Total of Weighted Rating Values	Site Vulnerability
<8	**LOW** potential for P movement from the site. If farming practices are maintained at their current level, there is a low probability of an adverse impact on surface waters from P losses at this site.
8 – 14	**MEDIUM** potential for P movement from the site. The chance for an adverse impact on surface waters exists. Some remedial action should be taken to lessen the probability of P loss.
15 – 32	**HIGH** potential for P movement from the site and for an adverse impact on surface waters unless remedial action is taken. Soil and water conservation as well as P management practices are necessary to reduce the risk of P movement and water quality degradation.
>32	**VERY HIGH** potential for P movement from the site and for an adverse impact on surface waters. Remedial action is required to reduce risk of P movement. All necessary soil and water conservation practices, plus a P management plan must be put in place to avoid the potential for water quality degradation.

A Phosphorus Site Index for Delaware and the Mid-Atlantic States

It was always recognized and recommended, by both the P Index working group and SERA-17, that the P Site Index be modified to reflect local or regional conditions. In 1997, a regional effort was initiated by university and USDA scientists from Delaware, Maryland, Pennsylvania, and Virginia to develop a P Site Index that could assess the relative risk of P loss from agricultural fields in the Chesapeake Bay watershed. In particular, Delaware and Maryland worked together to develop a P Site Index for the Delmarva Peninsula. One of the most significant changes that resulted from this cooperative effort was the separation of the P Site Index into two components:

(i) Part A: P Site and Transport Factors: soil erosion, soil surface runoff, subsurface drainage, leaching potential, distance from edge of field to surface water, and priority of receiving water.
(ii) Part B: P Source and Management Factors: soil test P, P fertilizer application rate and application method, and organic P source application rate and application method.

Separating the P Site Index into two parts makes it possible to assess the risk of P loss based on (i) site and transport factors, and (ii) P source and management practices. Instead of adding these together, as in the original P Site Index, the sums of each part are multiplied to prevent overemphasis of one set of factors. This type of P Site Index has a multiplicative structure. For example, a field with a very high P source potential (i.e., a high soil test P value) but a low transport potential would not likely receive a high P Site Index rating because there is a low probability that environmentally significant quantities of P would be lost to water.

In September of 2000, the state of Maryland incorporated the P Site Index (similar to the one described in Tables 3 and 4 of this manual) into nutrient management regulations. In December of 2000 the University of Delaware officially recommended that the P Site Index be the approach used in Delaware to identify "high P" soils when the goal is prioritizing efforts to protect water quality; (iii) based on this recommendation the Delaware Nutrient Management Commission (DNMC) formally adopted, in December of 2000, the P Site Index as a BMP for Delaware's State Nutrient Management Program; (iv) in April of 2002 the P Site Index was formally adopted by USDA-NRCS in their Code 590 Nutrient Management Standard as the recommended approach to guide P-based management for Delaware; (v) in August 2015 the Delaware P Site Index Technical Guidance Manual (this document) was revised to address scientific and regulatory advances to date. Any future updates made to improve Delaware's P Site Index will be based purely on the results of research that increases our understanding of how P is moving in the flat, artificially-drained fields of the Delmarva.

Developing the Next Generation P Site Index – An Ongoing Statewide, Regional, and National Effort

The SERA-17 group remains a valuable informational resource for agencies (USEPA, USDA) and state universities that continue to address the need for BMPs to prevent nonpoint source pollution of surface waters by agricultural P. This includes information on how to best evaluate and revise existing P indices (as new research results become available) to ensure high quality results from all P indices. Somewhat recently, concerns were raised about the continued use of the P index for nutrient management planning. These concerns were based on research that identified large variations in performance of individual state P index ratings when using the same input values (Benning and Wortmann, 2005; Osmond et al., 2006) and concerns that use of the P index is not resulting in improved water quality (Sharpley et al., 2012). To address these concerns, the SERA-17 group sponsored a symposium entitled *Evaluation and Validation of Phosphorus Indices* at the international meetings of the American Society of Agronomy and the Soil Science Society of America in 2011 (published in Journal of Environmental Quality in 2012 and summarized by Nelson and Shober, 2012). Ultimately, SERA-17 scientists determined that P indices remain an excellent tool for understanding risk of P loss, but that indices need to be updated to incorporate the results of P loss modeling studies and better understanding of P loss methods (e.g., erosion, runoff, subsurface drainage). In addition, SERA-17 sponsored the symposium *Phosphorus Fate, Management, and Modeling in Artificially Drained Systems* at the international meetings of the American Society of Agronomy and the Soil Science Society of America in 2013.

The USDA-NRCS funded several national Conservation Innovation Grants in 2012 to regional teams to foster improvement of P Indices. One of these grants was awarded to a team of scientists from Penn State University, USDA-ARS, Cornell University, Virginia Tech, University of Delaware, and West Virginia University to "refine and harmonize P Indices within the Chesapeake Bay Watershed". This work is on-going. During this same time frame, Maryland scientists were independently updating their P Site Index to meet requirements of their Watershed Implementation Plan (related to the Chesapeake Bay TMDL). In 2015, Maryland adopted the Phosphorus Management Tool (PMT), a component index to assess field scale P loss potential that identifies the specific P source and transport factors that contribute to each P loss pathway (e.g., surface runoff, subsurface runoff, and erosion); each pathway score is then summed to get an overall PMT score. In Delaware, researchers recently launched a statewide field study to begin updating the surface runoff and erosion components of the Delaware P Site Index. In addition, research on subsurface P losses in artificially drained fields is underway because researchers suggest that subsurface transport may be a dominant P loss pathway in Delaware (as well as on the Delmarva Peninsula). Future updates to the Delaware P Site Index will take into account the results of this ongoing research. Until such time, the Delaware P Site Index outlined in this manual remains the state-approved BMP for assessing field-scale risk of P loss from agriculture.

The Delaware Phosphorus Site Index Technical Guidance Manual: The Delaware Phosphorus Site Index

The Delaware Phosphorus Site Index

The Delaware P Site Index has two separate components. Part A characterizes the risk of P loss to waters based on soil properties and hydrologic considerations at a site, including the priority of the receiving waterbody. Part B characterizes the risk of P loss based on past and current nutrient management practices that affect the concentration of P in the soil (soil test P) and the potential for P loss due to management of inorganic (fertilizer) and organic (manures, biosolids, composts) P sources. Each part is summarized below, followed by detailed discussions and descriptions of each component of the two parts.

Part A: Phosphorus Loss Potential due to Site and Transport Characteristics

Surface transport mechanisms (i.e., soil erosion and runoff) are normally the main mechanisms by which P is exported from agricultural fields to receiving waters. In some areas, subsurface transport of P can also be a significant method of P export, especially in areas with artificial subsurface drainage (e.g., tiles, mole drains) or extensive systems of drainage ditches. Therefore, consideration of the methods of P transport and factors affecting these transport mechanisms is critical to an understanding of P losses from watersheds. Part A of the Delaware P Site Index includes the following six factors: (i) soil erosion; (ii) soil surface runoff class; (iii) subsurface drainage; (iv) leaching potential; (v) distance from edge of field to surface water; and (vi) priority of receiving water (Table 3).

Part B: Phosphorus Loss Potential due to Management Practices and P Source Characteristics

Phosphorus losses are also related to the amount and forms of P at a field site that can potentially be transported to ground or surface waters. The main sources of P at any site that must be considered when assessing the risk of P loss are (i) soil P (particulate and dissolved), a reflection of natural soil properties and past management practices; and (ii) P inputs as inorganic fertilizers and organic P sources (manures, composts, biosolids). Also of importance are the management practices used for all P inputs, such as the rate, method, and timing of fertilizer and manure applications, as these factors will influence whether or not P sources will have negative impacts on water quality. Part B of the Delaware P Site Index includes five factors: (i) soil test P fertility index value (FIV); (ii) P fertilizer application rate; (iii) P fertilizer application method and timing; (iv) organic P source application rate and the relative P availability/mobility of the organic P source based on a P source coefficient (PSC); and (v) organic P source application method and timing (Table 4).

Table 3. Site fators affecting transport of phosphorus as used in Part A of the Delaware Phohorus Site Index.

Characteristi	Phosorus Loss Rating					Value
PART A: SITE AND TRANSPORT CHARACTERISTICS						
Soil Erosion	[Soil erosialue from RUSLE (tons/acre)]					
Soil Surface Runoff Class	Very Low 0	Low 2	Medium 4	High 6	Very High 8	
Subsurface Drainage	Very Low 0	Low 2	Medium 4	High 6	Very High 8	
Leaching Potential	Low 0		Medium 2	Hh 4		
Distance from Edge of Field t Surface Wat	>100 ft	< 100 ft AND > 50 ft vegetated buffer OR < 100 ft AND > 25 ft vegetated buffer AND > 25 ft additional no P application zone	< 100 ft AND > 25 ft vegetated buffer AND < 25 ft additional no P application zone	< 100 ft AND < 25 ft vegetated buffer AND > 25 ft additional no P application zone	< 100 ft AND < 25 ft vegetated buffer AND < 25 ft additional no P application zone	
	0	2	4	6	8	
Priority of Receiving Water	All receiing waters in Delaware 4					4
Part A Calculions	Sum of Sitransport Characteristics					
	Scaling Factor					×0.02
	Total Site and Transport Values for Part A					

Table 4. Phosorus source and management practices affecting the risk of phosphorus ls as used in Part B of the Delaware Phosphorus Site Index.

Characteristcs	Phophorus Loss Rating					Value
PART B: PHOSPHORUS SOURCE AND MANAGEMENT PRACTICES						
Soil Test P Fertility Index Value (FIV)	0.2 × [FIV fromniversity of Delaware Soil Test]					
P Fertilizer Application Rate	0.6 × [bs P $_2O_5$ applied per acre]					
P Fertilizer Application Method and Timing	None	Injected or banded below surface at least 2"	Incorporated within 5 days of application	Surface applied March through November OR incorporated in >5 days after application	Surface applied December through February	
	0	15	30	45		
Organic P Application Rate	PSC ×lbs P $_2O_5$ applied per acre]					
Organic P Application Method and Timing	None	Injected or banded below surface at least 2"	Incorporated within 5 days of application	Surface applied March through November or incorporated in >5 days after application	Surface applied December through February	
	0	15	30	45	60	
Total P Soure and Manament Value for Part B						

Phosphorus Site Index Ratings and Generalized Interpretation

Once the risk assessments for P transport from a site (Part A) and for P source and management practices (Part B) are calculated, the final P Site Index Rating is determined by the following equation:

PSI Rating = [Part A Total] × [Part B Total]

Based on the final P Site Index rating, sites are assigned to one of four categories. Each category includes a generalized interpretation of the P loss potential and appropriate P management actions. The P Site Index categories and generalized interpretations are:

- *Phosphorus Site Index Rating < 50.* **LOW** potential for P movement from the site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from the site. Nitrogen-based nutrient management planning is satisfactory for the site. Soil P levels and P loss potential may increase in the future due to N-based nutrient management.
- *Phosphorus Site Index Rating= 50 – 75.* **MEDIUM** potential for P movement from the site given current management practices and site characteristics. Practices should be implemented to reduce P losses by surface runoff, subsurface flow, and erosion. Nitrogen-based nutrient management should be implemented no more than one year out of three. Phosphorus-based nutrient management should be implemented two years out of three during which time P applications should be limited to the amount expected to be removed from the field by crop harvest or soil test based P application recommendations, whichever is greater.
- *Phosphorus Site Index Rating = 76 – 100.* **HIGH** potential for P movement from the site given current management practices and site characteristics. Phosphorus-based nutrient management should be used for the site. Phosphorus applications should be limited to the amount expected to be removed from the field by crop harvest or soil test based P application recommendations. All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion should be implemented.
- *Phosphorus Site Index Rating > 100.* **VERY HIGH** potential for P movement from the site given current management practices and site characteristics. No P should be applied to the site. Active remediation techniques should be implemented in an effort to reduce the P loss potential from the site.

Part A: Phosphorus Loss Potential due to Site and Transport Characteristics

Phosphorus is strongly sorbed by soils, therefore erosion of soil particles dominates the movement of P in many landscapes (Burwell et al., 1977; Garbrecht and Sharpley, 1992; Ritter, 1986; Schuman et al., 1973). Nationally, sediment-bound P accounts for up to 90% of the P transported from cropland (Sharpley and Beegle, 2001). During detachment and movement of sediment in runoff, the finer-sized fractions of source material are preferentially eroded. Thus, the P content and reactivity of eroded particulate material is usually greater than the source soil (Sharpley et al., 1993). Therefore, to minimize P loss in the landscape, it is essential to control soil erosion. Particulate P movement in the landscape is a complex function of rainfall, irrigation application, soil properties affecting infiltration and runoff of rainfall and snowmelt, and soil management factors affecting erosion. Numerous management practices that minimize P loss by erosion are available, including buffer strips, riparian zones, terracing, contour tillage, cover crops, constructed wetlands, and impoundments or small reservoirs (Sims and Vadas, 1997b).

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 such as the Revised Universal Soil Loss Equation (RUSLE) for water erosion and the Wind Erosion Equation (WEQ) for wind erosion. The erosion value is reported in tons of soil loss per acre per year (tons/acre/year). While soil loss prediction models do not predict sediment transport and delivery to a waterbody, they do indicate the potential for sediment and attached P movement across the slope or unsheltered distance toward a waterbody.

Determination of Soil Erosion for the P Site Index: Soil erosion loss by sheet and rill erosion is determined using RUSLE. In some cases, this value may be directly available from a local soil conservation district office, while in others it must be calculated from the following formula:

$$A = [R \times K \times LS \times C \times P]$$

Where:

A = Average annual soil loss (tons/acre/year)
R = Rainfall and runoff factor
K = Soil erodibility factor
LS = Slope length / slope steepness factor
C = Cover and management factor
P = Supporting practice factor

All factors for the RUSLE calculation can be obtained from the web soil survey, a few readily determined field measurements (slope, cover, etc.), and information on past field management practices (crop rotations). All information needed to calculate RUSLE values for Delaware is found in the Appendix of this manual. The soil erosion value determined by RUSLE is then multiplied by 2 to obtain the field value used in the calculation of the P Site Index.

Soil Surface Runoff Class

Dissolved P is another important source of P that is transported in soil surface runoff. Dissolved P exists mainly in the form of ortho-phosphate, which is available immediately for uptake by algae and other aquatic plants. The first step in the movement of DP in runoff is desorption, dissolution, and extraction of P from soils, crop residues, and surface applied fertilizer and manure (Sharpley et al., 1994). These processes occur as rainfall or irrigation water interacts with a thin layer of surface soil (0.04 to 0.12 inches) before leaving the field as runoff or leaching downward in the soil profile (Sharpley, 1995). The soil test P content of surface soils is directly related to dissolved P concentrations in runoff. Field studies have shown that P losses by surface runoff are greater when soil test P values are above the agronomically optimum range (Beauchemin et al., 1998; Heckrath et al., 1995; Pote et al., 1996; Sims et al., 1998). Laboratory research has also shown that soils with high agronomic soil test P values are more likely to have high concentrations of soluble, desorbable, and bioavailable P (Pautler and Sims, 2000; Sibbesen and Sharpley, 1997; Sims, 1998b).

For the P Site Index, soil surface runoff class is based on the predominant soil type in each field as determined from a county soil survey. Runoff class is determined from soil permeability (Appendix; Tables A-1 and A-2) and percent slope (measured in the field or estimated from the web soil survey; Table 5).

Table 5. Soil characteristics used to determine soil surface runoff class for the Delaware P Site Index. Permeability classes as follows: Very rapid (>20.00 in/hr); rapid (6.00 – 20.00 in/hr); moderately rapid (2.00 – 6.00 in/hr); moderate (0.60 – 2.00 in/hr); moderately slow (0.20 – 0.60 in/hr); slow (0.06 – 0.20 in/hr); and very slow (<0.06 in/hr). Ratings for surface runoff class include: VL = very low; L = low; M = medium; H = high; and VH = very high.

Slope (%)	Soil Permeability Class*				
	Very Rid	Rapi to Moderatel Rapid	Moderae to Moderaty Slow	Slo	Very Slow
Concave**	VL	VL	VL	VL	
<1	VL	VL	VL	L	
1 – 5	VL	VL	L	M	
6 – 10	VL	L	M	H	
11 – 20	VL	L	M	H	
>20	L	M	H	VH	

*Permeability class of the least permeable layer within the upper 39 inches (one meter) of the soil profile. Permeability classes for specific soils can be obtained in the Appendix.
**Area from which no or very little water escapes by overland flow.

Determination of Surface Runoff Class for the P Site Index: Move down the left-hand column to the slope that was determined in the field. Move across the top row to find the soil permeability class found in the Appendix. The intersection of the columns for slope and permeability class determines soil runoff class value for the P Site Index.

Subsurface Drainage Class and Leaching Potential

While surface transport processes are the major contributing factors to P transport from soil to water in most cases, subsurface movement and leaching of P can contribute significant amounts of P to surface waters in some situations, such as in areas where there is relatively flat topography, high water tables, and artificial drainage systems (e.g., ditches, subsurface tile drains). Ryden et al. (1973) noted that "…losses of P to subsurface and ground water runoff, although of little significance from an agricultural standpoint, may under certain conditions constitute a significant loss of P from agricultural watersheds in terms of the P enrichment of surface waters." While P leaching is typically considered to be small there is potential for significant movement of P through the soil profile when soil P values increase to very high or excessive values due to long-term over-fertilization or manuring (Sims et al., 1998). Whether this leached P will reach surface waters depends on the depth to which it has leached and the hydrology of the site. Soils that are poorly drained with high water tables have a higher possibility of P loss than soils that are well drained with deep water tables. It is common in poorly drained soils to have water tables rise to the soil surface during the winter and spring months, thus during this time of year there is the potential for release of P into these drainage waters and P transport to nearby streams and drainage ditches via subsurface flow.

Subsurface drainage class

For the P Site Index, this is determined from the depth to the seasonal high water table and the soil drainage class of the predominant soil type in each field as determined from a county soil survey (Table 6). See the Appendix in this manual for information on the water features of Delaware soils.

Determination of subsurface drainage class for the P Site Index: Move down the left-hand column to the seasonal high water table depth found in Tables A-1 and A-2. Then move across the top row to the soil drainage class found in the Appendix. The intersection of these columns and rows determines the subsurface drainage class value. **NOTE**: any artificial subsurface drainage system (field ditches, tile drains, French drains, mole drains) will automatically give the field a HIGH subsurface drainage class value (bottom row of chart).

Leaching Potential

The leaching potential at a site is based on a USDA-NRCS categorization scheme that assigns a leaching potential value (low, medium, high) to soils in each county based on soil physical and chemical properties and the depth to the seasonal high water table.

Determination of leaching potential for the P Site Index: To find the leaching potential value, determine the predominant soil type in the field from the web soil survey. The leaching index values are available in the Appendix (Tables A-1 and A-2). Find the correct soil type, as determined earlier from the soil survey, and move across the table to find the leaching value, listed as 1, 2, or 3. Next, move down the left-hand column in Table 7 above to the seasonal high water table depth found in the Appendix (Tables A-1 and A-2). Then move across the top row to the Delaware NRCS Leaching Value from the Appendix. The intersection of these columns and rows determines the leaching potential value to be used in P Site Index computations.

Table 6. Soil characteristics used to determine subsurface drainage class for the Delaware P Site Index. Subsurface drainage class categories include: VL = very low; L = low; M = medium; H = high; and VH = very high.

Depth to Seasonal High Water Table (feet)	Soil Drainage Class						
	Very poorly drained	Poorly drained	Somewhat poorly drained	Moderately well drained	Well drained	Somewhat excessively drained	Excessively drained
0 – 1	VH	VH	VH	VH	VH		
>1 – 4	M	M	M	M	H	H	
>4 – 6		L	L	L	M	M	M
>6			VL	L	L	L	L
Artificial Drainage (any depth)	H	H	H	H	H	H	H

Table 7. Soil characteristics used to determine leaching potential for the Delaware P Site Index. Leaching potential classes include: L = low; M = medium; and H = high.

Depth to Seasonal High Water Table (feet)	Delaware NRCS Leaching Index for Soil Series		
	1	2	3
0 – 1	M	H	H
>1 – 4	L	M	H
>4 – 6	L	M	H
>6	L	L	M

Distance from Edge of Field to Surface Water

Another factor that affects the risk of P transport from soils to surface waters is the distance between the P source (i.e., the edge of the field) and the receiving waters. In some areas, the nearest waterbody may be a mile or more from the field being evaluated; in these cases, even high levels of soil P may have low risk for nonpoint source pollution in the near term since the potential for transport to the waterbody is low. In addition, many studies have shown that vegetated filter strips can remove P (especially particulate P) from water running off agricultural fields (Mikkelsen and Gilliam, 1995). Therefore, fields that have grassed filter strips or riparian buffers between a cultivated field and a nearby water source may be less of a threat to water quality than fields with no buffer present.

Vegetated filter strips consist of natural, unmanaged riparian vegetation or forest surrounding cleared lands, or can be established by the planting of grass or other vegetation on the downhill slope of the field and along ditches and streams. Studies have indicated that, depending on parameters such as type of vegetation, nature of pollutant source, buffer length, and time since buffer installation, over 90% of incoming runoff nutrients may be retained by buffer strips (Dillaha et al., 1988, 1989; Doyle et al., 1977). Although buffer strips can be very effective at reducing sediment and nutrient transport, their effectiveness decreases when concentrated flow patterns develop within the buffer or when the buffer becomes inundated with sediment. A field study of buffer strip effectiveness was performed by Chaubey et al. (1993) on a fescue pasture grown on a Captina silt loam soil. Poultry litter was applied to plots that were then subjected to simulated rainfall. Runoff was collected in gutters at 0, 10, 20, 35, 55, and 75 feet past the area of application. Untreated fescue pasture adjacent to plots served as the buffer. These results showed that even the 10-foot wide buffer decreased the dissolved P and total P in runoff by 68 and 70% respectively. Cooper and Gilliam (1987) estimated that riparian areas trapped ~50% of the P entering from cropland. Parsons et al. (1995) evaluated the effectiveness of grass filter strips (15 and 30 feet) and riparian buffers (15 and 30 feet) in the Coastal Plain region of North Carolina for removal of sediment and nutrients. The sediment yields from the grass buffers were 50 – 60% less than the sediment loads from direct field runoff. In most cases, there was greater than 50% reduction in dissolved P from the 15-foot wide grass filter strip and the reduction of total P was even greater. This study showed that even a poorly vegetated, relatively short filter can be valuable for water quality protection.

The P Site Index takes into account the distance from the edge of the field to nearby waterbodies or other permanent conduits that connect the field to surface waters (as measured in the field) and the type of buffer present. A waterbody is defined as any permanent conduit for transporting surface water, including permanent streams and ditches that flow intermittently through the year. This distance, along with vegetation present and fertilizer or manure application practices, is then used to determine risk of possible P transport from the edge of the field (Table 8). Note that the risk of P loss, and thus the overall P Site Index value for the field, is reduced when a “no P application zone” (a strip of land adjacent to a waterbody where no fertilizer or manure P is applied) is adopted as a best management practice.

Determination of Distance from Edge of Field to Surface Water for the P Site Index: Measure the following distances needed for Table 8 by any standard approach, such as measuring tapes or accurate pacing of the distance:

(i) the distance from the edge of the field to any surface waterbodies, including ditches or streams that go through the interior of a field (a waterbody is defined as any permanent conduit for transporting surface water, including permanent streams and drainage ditches that flow intermittently through the year).
(ii) the distance from the edge of the field to any other permanent conduits that connect the field to surface waters, such as tile inlet wells.

Table 8. Use of distance from edge of field to surface water, width of buffer strips, and the width of "no fertilizer or manure P application zones" in the Delaware P Site Index.

Information on Distance from Edge of Field to Water, Buffer Width, and Width of a "No P Application Zone"	Value
Greater than 100 feet to surface water	0
Less than 100 feet to surface water AND greater than 50 feet permanent vegetative buffer **OR** Less than 100 feet to surface water AND greater than 25 feet permanent vegetative buffer AND greater than 25 feet additional "No P Application Zone" beyond permanent vegetative buffer	2
Less than 100 feet to surface water AND greater than 25 feet permanent vegetative buffer AND less than 25 feet additional "No P Application Zone" beyond permanent vegetative buffer	4
Less than 100 feet to surface water AND less than 25 feet permanent vegetative buffer AND greater than 25 feet "No P Application Zone"	6
Less than 100 feet to surface water AND less than 25 feet permanent vegetative buffer AND less than 25 feet "No P Application Zone"	8

Priority of Receiving Water

The priority of the receiving waterbody is used as a determinant of relative risk of nonpoint source nutrient pollution based on the presumption that some waters require a greater degree of protection than others. Surface waters that already suffer from nutrient enrichment usually require intensive efforts to restore them to good environmental health, including proportionally more protection from additional nutrient inputs than do comparable waters that do not suffer from such impacts. Surface waters having high water quality may require the implementation of policies and management practices to protect them from deterioration due to excess inputs of nutrients.

For example, the Delaware Department of Natural Resources and Environmental Control's (DNREC) Watershed Assessment Section established Nutrient Management Critical Area Priorities (Figure 1) to help the Delaware Nutrient Management Commission decide where to focus their efforts with respect to their Nutrient Management Planning and Nutrient Relocation programs. These priorities were based on water quality data and Total Maximum Daily Load (TMDL) required nutrient reductions.

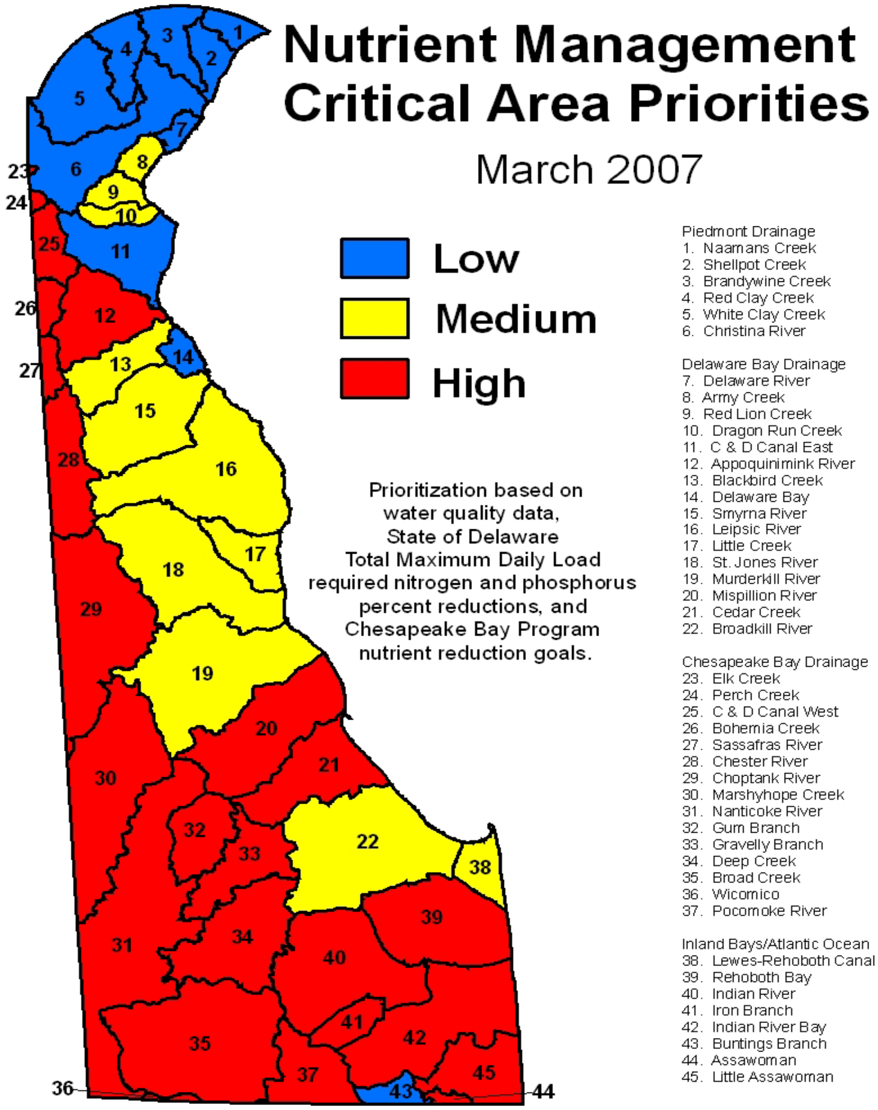

Figure 1. Delaware Nutrient Management Critical Area Priorities as developed by the DNREC Watershed Assessment Section.

Determination of Priority of Receiving Water for the P Site Index: For the Delaware P Site Index, all watersheds are given equal priority because edge of field P losses that reach water bodies can negatively impact water quality. Therefore, all fields in Delaware are assigned a "Priority of Receiving Water" score of 4 (Table 3).

Part B: Phosphorus Loss Potential due to Management Practices and P Source Characteristics

Soil Test Phosphorus

Phosphorus exists in many forms in the soil, both inorganic and organic. Major inorganic forms are soluble, adsorbed, precipitated, and minerals containing Al, Ca, and Fe. Each "pool" of soil P has a characteristic reactivity and potential for movement in either soluble or particulate forms. Iron and aluminum oxides, prevalent in most soils, strongly adsorb P under acid conditions; under alkaline conditions adsorption and precipitation are enhanced by the presence of free calcium ions and calcium carbonate (Pierzynski et al., 2000). Microorganisms and plant uptake can immobilize inorganic P by incorporation into biomass. Conversely, as organic materials decompose, soluble P can be released and become available for transport. Soil type, mineralogy, microbial activity, and cropping and fertilization practices (with both inorganic and organic sources of P) determine how much P exists in each of these pools.

Past research demonstrated that as soil test P increases, dissolved P in runoff increases (Daniel et al. 1993; Pote et al. 1996; Romkens and Nelson, 1974; Sharpley, 1995; Sibbesen and Sharpley, 1997; Vaithiyanathan and Correl, 1992). However, this relationship varies with soil type, cropping system, and nature of the runoff episode. In addition to impacting P levels in surface waters, soil test P also affects P loss in drainage waters (Heckrath et al., 1995; Sims et al., 1998). Thus, as soils are fertilized to levels exceeding those considered optimum for plant growth, the potential for P to be transported by surface runoff, leaching, subsurface movement and even groundwater increases. Therefore, it is important to include a measure of the current soil test P values in any risk assessment tool for P.

Determination of Soil Test P for the P Site Index: Soil test P values are expressed as fertility index values (FIV), the current rating system used by the University of Delaware (Sims and Gartley, 1996). Fertility index value is a unitless value that is proportional to soil test P concentration. The FIV system uses four categories (Low, Medium, Optimum, and Excessive) and is based on the probability of obtaining a profitable plant response to addition of P in fertilizers or other soil amendments. It is imperative that soil test P be expressed in University of Delaware FIV when calculating P Site Index values. Soil test P values from other labs must be converted to UD-FIV prior to use in the P Site Index. Equations to convert results from other soil testing labs and University of Delaware FIV are available in Table 9. To obtain the P Site Index value, multiply UD-FIV units by 0.2.

P Site Index Value = FIV × 0.2

Table 9. Conversion equations for soil test P results from laboratories using the ammonium acetate (NaOAc), Bray 1, Mehlich 1, and Mehlich 3 to University of Delaware Fertility Index Value (FIV).

Soil Test	Reporting Units	
	Ppm	lb/A
Ammonium acetate (NaOAc)	(1.23 × NaOAc-P) + 6.07	0.61 × NaOAc-P) + 6.07
Bray 1	(1.23 × Bray 1-P) + 6.07	0.61 × Bray 1-P) + 6.07
Mehlich 1	2.00 × Mehlich 1-P	00 × Mehlich 1- P
Mehlich 3	1.00 × Mehlich 3-P	50 × Mehlich 3- P

Phosphorus Fertilizer Application Rate and Organic P Application Rate

The addition of fertilizer P or organic P to a field will usually increase the amount of P available for transport to surface waters. The potential for P loss when fertilizers, manures, or other P sources are applied is influenced by the rate, timing, and method of application and by the form of the P source (i.e., organic vs. inorganic). These factors also interact with others, such as the timing and duration of subsequent rainfall, snowmelt, or irrigation and the type of soil cover present (vegetation, crop residues, etc.; Sharpley et al., 1993). Past research established a clear relationship between the rate of fertilizer P applied and the amount of P transported in runoff (Baker and Laflen, 1982; Romkens and Nelson, 1974). These studies showed a linear relationship between the amount of P added as superphosphate fertilizer and P loss in runoff. Using manure as the source of P, Westerman et al. (1983) also demonstrated a direct relationship between the quality of runoff water and the application rate of poultry litter. Therefore, it is important that the amount of P added to a site is accounted for in any risk assessment for nonpoint source pollution by P.

The P fertilizer application rate is the amount of inorganic P in pounds P_2O_5 per acre that is applied to the crop. Similarly, the organic P source application rate is the amount of P, in pounds P_2O_5 per acre that is applied to the soil when manures, biosolids, composts or other organic P sources are used (NOTE: Most organic P sources contain a substantial amount of inorganic P in addition to organic forms of P). The recommended way to determine the amount of P added in an organic source is to have the P source tested for total P by approved methods. The Delaware Department of Agriculture (DDA) Ag Compliance Lab will analyze DE manure samples for no charge; there is a nominal fee for manure from other states. Samples can be submitted in person to DDA Ag Compliance Lab or at Sussex Conservation District in Georgetown. In the absence of a manure analysis, standard nutrient content values are available in university or USDA-NRCS publications that have information on the P content of various organic P sources.

Determination of P Fertilizer Rate for the P Site Index: The P Site Index value for P fertilizer application rate is obtained by multiplying the planned P fertilizer application rate in pounds P_2O_5 per acre by 0.6.

P Site Index Value = [Planned rate of fertilizer P (lb P_2O_5/A)] × 0.6

Determination of Organic P Rate for the P Site Index: The P Site Index value for organic P application rate is obtained by multiplying the planned organic P source application rate in pounds P_2O_5 per acre by a Phosphorus Solubility Coefficient (PSC). A PSC value is used because it is known that organic P sources differ in P solubility and plant availability. Current PSC values are based on research conducted at the University of Delaware and other regional institutions (Elliott et al. 2006; Shober and Sims, 2007); these values are available in Table 10. The default PSC is 0.6, a value that is also used for inorganic fertilizer P.

P Site Index Value = [Planned rate of organic P (lbs P_2O_5 /acre)] × PSC

Table 10. Standard phosphorus source coefficients (PSCs), which are used in the Delaware P Site Index to account for differences in the solubility of phosphorus in different organic amendments.

Organic P Source	Phosphorus Source Coefficient
Default	0.6
Swine manure	0.6
Other manures (beef, dairy, poultry, horse, etc.)	0.5
Biological phosphorus removal (BPR) biosolids	0.5
Biological nutrient removal (BNR) biosolids	0.5
Biosolids (all except BPR and BNR)	0.2

Phosphorus Fertilizer and Organic P Source Application Method and Timing

Directly related to the amount of fertilizer and organic P source applied to a field is the method and timing of the application. Baker and Laflen (1982) determined that the dissolved P concentrations in runoff from areas receiving surface applications of broadcast fertilizer P averaged 100 times more than from areas where comparable rates were applied 5 cm below the soil surface. Mueller et al. (1984) showed that incorporation of dairy manure reduced total P losses in runoff five-fold compared with areas receiving broadcast applications. A surface application of fertilizers and manures decreases the potential interaction of P with the soil, and therefore increases the availability of P for runoff from the site. When fertilizers and manures are incorporated, the soil is better able to sorb the added P and thus decrease the likelihood of P loss (Shober and Sims, 2007). It is particularly important that fertilizers and manures are not surface applied during times when there is no plant growth, when the soil is frozen, during or shortly before periods of intense storms, or during times of the year when fields are generally flooded due to snowmelt or recharge periods. The major portion of annual P loss in runoff generally results from one or two intense storms (Sharpley et al., 1994). If P applications are made during periods of the year when intense storms are likely, then the percentage of applied P lost would be higher than if applications are made when runoff probabilities are lower (Edwards et al., 1992). In addition, the time between application of P and the first runoff event is important. Westerman and Overcash (1980) applied both swine and poultry manures to plots and simulated rainfall at intervals ranging from one to three days following manure application. Total P concentrations in the runoff were reduced by 90% by delaying the first runoff event for three days. To best manage manures and fertilizers to decrease potential for P transport off site, they should be either applied below the surface, or incorporated into the soil within a short period of time and should be applied shortly before the growing season when available P can be utilized by the plant.

Determination of P Application Method and Timing for the P Site Index: To determine the field value for application methods of fertilizer and organic P, information about the time of year and method of application must be obtained from the nutrient user. Once this information is collected, find the correct category and assign the value (Table 11).

Table 11. Values for fertilizer P and organic P application methods and timings of P applications for use in the Delaware P Site Index.

Phosphorus Application Method and Timing	Value
None applied	0
Injected/banded below surface at least 2”	15
Incorporated within 5 days of application	30
Surface applied March through November OR incorporated more than 5 days after application	45
Surface applied December through February	60

Calculating the P Site Index Score

Calculating the Total Site and Transport Value (Part A)

Once the values for soil erosion, soil surface runoff class, subsurface drainage, leaching potential, distance from edge of field to surface water, and priority of the receiving waterbody are determined, these values are added together to obtain an overall sum of the site and transport characteristics value for the site (i.e., the sum for Part A). This is then multiplied by a scaling factor to obtain the Total Site and Transport Value for the site.

EXAMPLE: A field located in the Choptank watershed in Kent County, Delaware with a predominant soil map unit of MkB (Matapeake soils, which are well drained with moderate permeability and a seasonal high water table of >6 feet) and has slopes of 7% leading to a stream. Slope length is 100 ft. There is a riparian buffer between the field and the stream that varies between 8 and 12 feet from the edge of the cultivated field to the water and either a gully or steep grade leading down to the stream. The crop rotation is corn (no-till)/wheat (conventional till)/double cropped soybeans (no-till).

Soil Erosion P Loss Rating = 9.9

RUSLE factor = 4.9 tons soil loss/acre, which is multiplied by 2. (4.9 × 2 = 9.9). See the Appendix for a detailed explanation of the RUSLE calculation.

Soil Surface Runoff Class P Loss Rating = 4

Use Table 5 to determine surface runoff class: A soil with a 7% slope and moderate permeability is a MEDIUM risk, which equates to a field value of 4.

Subsurface Drainage P Loss Rating = 2

Use Table 6 to determine subsurface drainage class: A well-drained soil with a water table >6 feet is a LOW risk, which equates to a field value of 2.

Leaching Potential P Loss Rating = 2

Determine P leaching potential from Table 7 and the USDA-NRCS leaching index in table A-2 in the Appendix. A Matapeake soil with a depth to seasonal high water table > 6 feet has a MEDIUM risk of P leaching and thus a field value of 2.

Distance to Water P Loss Rating = 8

Using Table 8 and field measurement data (buffer width of 8 to 12 feet) and the fact that obvious gully erosion was present, a field value of 8 was assigned.

Priority of Receiving Water P Loss Rating = 4

The Choptank is listed as a "high" priority watershed for protecting nearby waterbodies (Figure 1). A value of 4 was assigned to this field because of the "high" priority rating.

All of the field values in Part A are then summed to obtain the Total Site and Transport Value.

Sum of Part A = (9.9 + 4 + 2 + 2 + 8 + 4) = 29.9

Next, multiply the sum by the scaling factor:

29.9 × 0.02 = 0.60

Therefore, Part A – Total Site and Transport Value = 0.60

<u>Calculating the Total P Management Practice and P Source Value (Part B)</u>

Once values for soil test P, P fertilizer application rate, P fertilizer application method, organic P source application rate and organic P source application method are obtained, these values are added together to obtain a total management practice and P source value (i.e., the sum for Part B).

EXAMPLE: The field described in the example calculation for Part A has a crop rotation of corn (no-till)/wheat (conventional till)/double cropped soybeans (no-till), a soil test P value of 150 UD-FIV (Fertility Index Value or FIV), starter fertilizer is applied to the corn at a rate of 25 lbs P_2O_5/acre, and 3 tons/acre of broiler litter are surface applied for the corn in March (the litter is not incorporated by tillage).

Soil Test P Rating = 30

FIV = 150 which is multiplied by 0.2 to get the field value (150 × 0.2 = 30)

P Fertilizer Application Rate Rating = 15

25 lbs P_2O_5/acre is banded as starter fertilizer, which is multiplied by 0.6 (25 × 0.6 = 15)

P Fertilizer Application Method Rating = 15

Starter fertilizer is banded, see Table 11.

Organic P Source Application Rate Rating = 90

Broiler litter contains ~ 60 lbs P_2O_5/ton, therefore 180 lbs P_2O_5/acre are applied. Multiply this by the PSC for manure found in table 10 (0.5) to obtain the field value for the P Site Index: (180 × 0.5 = 108)

Organic P Source Application Method Rating = 45

Application of broiler litter in March, without incorporation by tillage results in a P Site Index field value of 45 (Table 11).

All of the field values in Part B are then summed to obtain the Total P Management Practices and P Source Value.

Sum of Part B = (30 + 15 + 15 + 90 + 45) = 195

Therefore, Part B – Total P Management Practice and P Source Value = 195

Calculation and Interpretation of the Phosphorus Site Index

To calculate the P Site Index, multiply the total site and transport value determined in Part A by the total P management practice and P source value determined in Part B. The product is the final P Site Index for the field of interest.

P Site Index = [Final Value for Part A] × [Final Value for Part B]

To calculate the P Site Index for the example shown in Parts A and B:

Part A Value = 0.60

Part B Value = 195

Phosphorus Site Index = 0.60 × 195 = 117

Interpretation of the P Site Index Value

Compare the P Site Index value calculated as described above with the ranges given in Table 12 for Low, Medium, High, or Very High risk of P loss from soil to water. It is important to remember that the P Site Index is an indication of the relative degree of risk of P loss, not a quantitative prediction of the actual amount of P lost from a given field. Fields in the “Low” P Site Index category are expected to have a lower potential for P losses to waters than fields in the “Medium” P Site Index category, while fields in the “Medium” P Site Index category are expected to have a relatively lower potential for P loss than fields in the “High” P Site Index category, and so on. The numeric values used in Table 12 to separate the various P loss categories are based on the best professional judgment of the individuals involved in the development of the P Site Index, using data from fields and farms in Delaware and Maryland where field evaluations were conducted in 1999 and 2001.

A P Site Index of 117 is classified as “VERY HIGH”

Table 12. Generalized Interpretation of the Delaware Phosphorus Site Index.

P Site Index	Generalized Interpretation of P Site Index
<50	**LOW** potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from this site. 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.
51 – 75	**MEDIUM** potential for P movement from this site given current management practices and site characteristics. Practices should be implemented to reduce P losses by surface runoff, subsurface flow, and erosion. Nitrogen-based nutrient management should be implemented no more than one year out of three. Phosphorus-based nutrient management should be implemented two years out of three during which time P applications should be limited to the amount expected to be removed from the field by crop harvest or soil test based P application recommendations, whichever is greater.
76 – 100	**HIGH** potential for P movement from this site given current management practices and site characteristics. Phosphorus-based nutrient management should be used for this site. Phosphorus applications should be limited to the amount expected to be removed from the field by crop harvest or soil test based P application recommendations. All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion should be implemented.
>100	**VERY HIGH** potential for P movement from this site given current management practices and site characteristics. No P should be applied to this site. Active remediation techniques should be implemented in an effort to reduce the P loss potential from this site.

Preparations for Conducting a Field Risk Assessment Using the Delaware Phosphorus Site Index

<u>Gather all appropriate information</u>

The following is a list of the information needed to determine P Site Index values, along with descriptions of where that information is usually obtained.

Information Source #1: Farm Operator

1. Soil-test P (from soil-test report – also obtain soil test P method and units for soil test P)
2. Amount, analysis and type of P fertilizer applied
3. Application method and timing of P fertilizer application
4. Amount and type of manure, compost, or biosolids applied
5. Application method and timing for manure, compost, or biosolids application
6. Manure, compost, or biosolids analysis
7. Width of any "no P application zone" buffer strips
8. Crop rotation sequence
9. Tillage methods
10. Conservation practices such as strip or contour cropping, buffer strips, etc.
11. Artificial drainage areas (tax ditches, French drains, tile drains, mole drains, or surface inlets)

Information Source #2: County Soil Survey

1. Predominant soil mapping unit in the field

Information Source #3: Delaware P Site Index Technical Guidance Manual (this document)

1. Appendix: Information for calculating the Revised Universal Soil Loss Equation (RUSLE); water features for Delaware soils (water table depths, leaching index values); soil permeability class; and soil drainage class.

Information Source #4: Field Visit

1. Distance to surface water
2. Type and width of vegetated field buffers
3. Slope of field (length and steepness)
4. RUSLE "P" practices: number of crop strips across slope, width of crop and/or buffer strips

The following resources and equipment are necessary to collect the data and information needed to determine a P Site Index for a field:

1. Delaware P Site Index Technical Guidance Manual (this document)
2. Nutrient Management Handbook for Delaware (Available online at: http://ag.udel.edu/dstp/UDNMHandbook%20Title.html)
3. Web Soil Survey (Available online at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm)
4. University of Delaware Nutrient Management Fact Sheets (Available online at: http://extension.udel.edu/factsheets/)

5. Clinometer or similar device for measuring the slope of a field
6. Measuring wheel or measuring tape

Information on Field Measurements Needed for the Phosphorus Site Index

Slope

Slope steepness should be measured using a standard clinometer (available through any forestry supply catalog). This technique should not be attempted without guidance from a trained professional. Although not difficult, it takes some practice to learn how to take this measurement. It helps to have another person in the field to properly aim the clinometer.

Slope steepness, measured as % slope, should be the average of the major slopes of the field of interest.

Slope length is defined as the distance from the origin of overland flow to the point that the overland flow enters a major concentrated flow channel.

Distance from Edge of Field to Surface Water

Distance from Edge of Field to surface water should be measured using a measuring tape or by accurately pacing. When determining this distance, one must also note the existence and width of any permanent vegetated buffer strips. Included in this category is the possibility that a farmer might adopt use of a “25 foot no P application zone” as a BMP. This is simply a 25 foot wide strip next to any surface waterbody or permanent conduit (stream, ditch, etc.) that has no fertilizer or manure P applied for a distance of 25 feet beyond the field edge or the edge of a permanent vegetative buffer. This is not measured in the field, but is determined by talking to the farm operator.

Tile Drainage

Tile drainage (or any other subsurface drainage system) should be noted if it exists in any field, as it affects the subsurface drainage potential factor.

Special Practices

Special practices are also important to note, as these will affect the “P” factor in the RUSLE calculation. To determine the P factor it is important to note hydrologic soil group, ridge height, furrow grade, and cover management condition in the field for the entire crop rotation.

Definitions

Soil Erosion – annual sheet and rill erosion, determined by the Revised Universal Soil Loss Equation (RUSLE) and measured in tons soil loss/acre/year.

Surface Runoff Class – potential for water to leave the field from overland or surface flow; determined from slope and soil permeability class.

Subsurface Drainage Potential – potential for water to move below ground in subsurface lateral flow; determined from depth to seasonal high water table, soil drainage class, and the existence of artificial subsurface drainage systems such as field ditches, tile, French, or mole drains.

Leaching Potential – potential for water to move vertically down through the soil towards groundwater; determined by use of a USDA-NRCS rating, which is calculated using inherent soil characteristics and depth to seasonal high water table.

Distance from Edge of Field to Surface Water – distance (feet) from the edge of the cropped area to the nearest surface water. Surface water includes any permanent conduit for transporting surface water, including permanent streams and ditches that flow intermittently through the year, as well as any surface inlets which discharge into surface water sources. This category also includes the width of a permanent vegetated buffer strip and the possible inclusion of a “no fertilizer or manure P application zone” along the field edge nearest the surface water (a conservation practice to keep application of P away from the water).

Priority of Receiving Water – a ranking of the relative importance of nearby waters in terms of the priority of their protection from nonpoint source pollution by P. Determined state-by-state; the approach to set waterbody priorities. The Delaware Department of Natural Resources and Environmental Control’s (DNREC) Watershed Assessment Section established Nutrient Management Critical Area Priorities based on water quality data and Total Maximum Daily Load (TMDL) required nutrient reductions.

Soil Test P – the amount of plant available P in the soil determined by a soil test and reported as a University of Delaware Fertility Index Value (UD-FIV). If soil tests are conducted by different methods or reported in different units than used by the University of Delaware, they must be converted to UD-FIV units prior to calculating the P Site Index for a field.

P Fertilizer Application Rate – amount of fertilizer P added, in P_2O_5 lb/acre.

P Fertilizer Application Method – injected, surface applied (including date of surface application), or incorporated (including how long after application it was incorporated).

Organic P Application Rate – amount of P added in an organic source, in P_2O_5 lb/acre.

Organic P Application Method – injected, surface applied (including date of surface application), or incorporated (including how long after application it was incorporated).

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The Delaware Phosphorus Site Index Technical Guidance Manual: Appendix

The Revised Universal Soil Loss Equation

Calculating Soil Loss by Water Erosion in Delaware

The *Revised Universal Soil Loss Equation (RUSLE)* is an empirical soil water erosion prediction tool developed in the early 1990s by the USDA Natural Resources Conservation Service. It is a modification and update of the *Universal Soil Loss Equation* originally developed in the 1970s.The RUSLE model predicts soil loss due to water erosion from the following equation:

$$A = [R \times K \times LS \times C \times P]$$

where:

A = Computed spatial average soil loss and temporal average soil loss per unit of area, expressed in the units selected for **K** and for the period selected for **R.** In practice, the values for **K** and **R** are usually selected so that A is expressed in tons/acre.

R = Rainfall erosivity factor – the rainfall erosion index plus a factor for any significant runoff from snowmelt. It takes into consideration the total rainfall and the intensity and seasonal distribution of rainfall. The **R** factor varies with geographic location in the U.S. For Delaware, the **R** factor varies between counties, as follows:

New Castle: R = 180 Kent: R = 185 Sussex: R = 190

K = Soil erodibility factor – the soil loss rate per erosion index unit for a specified soil as measured on a standard plot, which is defined as 72.6 ft (22 m) length of uniform 9 percent slope in continuous clean-tilled fallow. The **K** factor is essentially a measure of each soil types = inherent susceptibility to erosion. The **K** factor values for Delaware soils are summarized by county in Tables A-1 to A-2. These tables also include the **T** value (erosion tolerance level, defined as "...the maximum rate of annual soil loss that will permit crop productivity to be maintained indefinitely") for each soil series in Delaware.

LS = Field length and slope factor – the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow. The **LS** factor quantifies the increases in erosion that occur as a function of slope length and steepness. These values (length and steepness of slope) are usually measured directly in the field. Table A-3 provides a summary of LS values for use in RUSLE calculations for Delaware.

C = Cover-management factor – the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow. The **C** factor accounts for differences in soil loss due to the type of vegetation present and the nature of the cropping system used (e.g., effects of tillage, amount of residue, cover crops, etc.). Table A-4 summarizes the **C** factors for the major cropping systems in Delaware.

P = Support practice factor – the ratio of soil loss with a support practice such as contouring, strip cropping, or terracing to soil loss with straight-row farming up and down the slope. Table A-5 summarizes the **P** values for some support practices that are used in Delaware. Additional information on support practices is available from USDA-NRCS.

Table A-1. Soil erodibility (K) factors, water features, and leaching index values for New Castle County, Delaware.

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
Ba	Broadkill Series (55% of map unit)	0.02	3	Moderately slow	Very poorly drained	0.00	1	D
BbB	Baile Series (55% of map unit)	0.37	5	Moderately slow	Poorly drained	0.43	1	D
BbB	Glenville Series (40% of map unit)	0.32	3	Slow	Moderately well drained	2.49	1	C
BkD	Brinklow Series (70% of map unit)	0.32	2	Moderately slow	Well drained	6.00	2	B
BnF	Blocktown Series (45% of map unit)	0.32	2	Moderate	Well drained	6.00	2	B
BnF	Brinklow Series (55% of map unit)	0.32	2	Moderately slow	Well drained	6.00	2	B
Br	Broadkill Series (70% of map unit)	0.02	3	Moderately slow	Very poorly drained	0.00	1	D
BrvF	Brinklow Series (70% of map unit)	0.32	2	Moderately slow	Well drained	6.00	2	B
Ch	Codorus Series (80% of map unit)	0.37	5	Moderate	Moderately well drained	2.26	1	C
CnB	Collington Series (85% of map unit)	0.32	5	Moderate	Well drained	6.00	2	B
CnD	Collington Series (70% of map unit)	0.32	5	Moderate	Well drained	6.00	2	B
CoA	Corsica Series undrained (40% of map unit)	0.02	5	Moderate	Very poorly drained	0.16	1	D
Cp	Comus Series (85% of map unit)	0.37	5	Moderately rapid	Well drained	3.74	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
DaB	Delanco Series (90% of map unit)	0.37	5	Moderately slow	Moderately well drained	2.49	1	C
DcB	Codorus Series (35% of map unit)	0.37	5	Moderate	Moderately well drained	2.26	1	C
DcB	Delanco Series (40% of map unit)	0.37	5	Moderately slow	Moderately well drained	2.49	1	C
DcB	Hatboro Series (25% of map unit)	0.37	5	Moderately rapid	Poorly drained	0.26	1	D
EnB	Elsinboro Series (95% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
ErB	Delanco Series (30% of map unit)	0.37	5	Moderately slow	Moderately well drained	2.49	1	C
ErB	Elsinboro Series (45% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
ESA	Endoaquepts Series drained (45% of map unit)	0.43	2	Moderate	Poorly drained	1.18	1	D
ESA	Sulfaquepts Series drained (45% of map unit)	0.49	2	Moderate	Poorly drained	1.18	1	D
FadA	Fallsington Series undrained (40% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
FgdA	Fallsington Series undrained (40% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
FzB	Fallsington Series drained (40% of map unit)	0.20	5	Moderate	Poorly drained	1.18	1	C

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
FzB	Fallsington Series undrained (25% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
GaC	Gaila Series (85% of map unit)	0.28	5	Moderate	Well drained	6.00	3	B
GaD	Gaila Series (90% of map unit)	0.28	5	Moderate	Well drained	6.00	3	B
GaD(NC)	Gaila Series (90% of map unit)	0.28	5	Moderate	Well drained	6.00	3	B
GaE	Gaila Series (80% of map unit)	0.28	5	Moderate	Well drained	6.00	3	B
GeA	Glenelg Series (85% of map unit)	0.28	5	Moderate	Well drained	6.00	2	B
GeB	Glenelg Series (85% of map unit)	0.28	5	Moderate	Well drained	6.00	2	B
GeC	Glenelg Series (85% of map unit)	0.28	5	Moderate	Well drained	6.00	2	B
GgA	Glenelg Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GgB	Glenelg Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GgC	Glenelg Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GgD	Glenelg Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GhB	Glenelg Series (45% of map unit)	0.28	5	Moderate	Well drained	6.00	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
GhB	Wheaton Series (30% of map unit)	0.49	5	Moderate	Well drained	6.00	3	B
GhC	Glenelg Series (45% of map unit)	0.28	5	Moderate	Well drained	6.00	2	B
GhC	Wheaton Series (30% of map unit)	0.49	5	Moderate	Well drained	6.00	3	B
GnA	Glenville Series (85% of map unit)	0.32	3	Slow	Moderately well drained	2.49	1	C
GnB	Glenville Series (85% of map unit)	0.32	3	Slow	Moderately well drained	2.49	1	C
GnC	Glenville Series (85% of map unit)	0.32	3	Slow	Moderately well drained	2.49	1	C
HkB	Hambrook Series (45% of map unit)	0.24	5	Moderate	Well drained	3.74	3	B
HoA	Fallsington Series drained (10% of map unit)	0.20	5	Moderate	Poorly drained	1.18	1	C
HoA	Fallsington Series undrained (25% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
HoA	Mullica Series undrained (10% of map unit)	0.02	5	Moderately rapid	Very poorly drained	0.16	1	D
Ht	Hatboro Series (90% of map unit)	0.37	5	Moderately rapid	Poorly drained	0.26	1	D
Hw	Codorus Series (40% of map unit)	0.37	5	Moderate	Moderately well drained	2.26	1	C
Hw	Hatboro Series (50% of map unit)	0.37	5	Moderately rapid	Poorly drained	0.26	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
ImB	Fallsington Series drained (15% of map unit)	0.20	5	Moderate	Poorly drained	1.18	1	C
ImB	Fallsington Series undrained (10% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
KhC	Keyport Series (80% of map unit)	0.24	3	Very slow	Moderately well drained	2.49	1	C
KmE	Keyport Series (80% of map unit)	0.37	3	Very slow	Moderately well drained	2.49	1	C
KpA	Keyport Series (80% of map unit)	0.49	3	Very slow	Moderately well drained	2.49	1	C
LfA	Leipsic Series (45% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
LfA	Reybold Series (40% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
LfB	Leipsic Series (45% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
LfB	Reybold Series (40% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
LhA	Lenni Series undrained (30% of map unit)	0.02	3	Slow	Poorly drained	0.43	1	D
Lk	Lenape Series (85% of map unit)	0.02	2	Moderate	Very poorly drained	0.16	1	D
Ln	Lenape Series (45% of map unit)	0.02	2	Moderate	Very poorly drained	0.16	1	D
LO	Indiantown Series (40% of map unit)	0.02	5	Moderate	Very poorly drained	0.43	1	D
LO	Longmarsh Series (40% of map unit)	0.02	5	Moderate	Very poorly drained	0.43	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
MaC	Manor Series (85% of map unit)	0.28	5	Rapid	Well drained	6.00	3	B
MaD	Manor Series (90% of map unit)	0.28	5	Rapid	Well drained	6.00	3	B
MaE	Manor Series (90% of map unit)	0.28	5	Rapid	Well drained	6.00	3	B
MmA	Mullica Series undrained (30% of map unit)	0.02	5	Moderately rapid	Very poorly drained	0.16	2	D
MtA	Mattapex Series (80% of map unit)	0.43	5	Moderately slow	Moderately well drained	2.49	1	C
MtB	Mattapex Series (80% of map unit)	0.43	5	Moderately slow	Moderately well drained	2.49	1	C
MtC	Mattapex Series (75% of map unit)	0.43	5	Moderately slow	Moderately well drained	2.49	1	C
MuB	Mattapex Series (50% of map unit)	0.43	5	Moderately slow	Moderately well drained	2.49	1	C
MxB	Montalto Series (85% of map unit)	0.32	5	Moderately slow	Well drained	6.00	1	C
MxC	Montalto Series (90% of map unit)	0.32	5	Moderately slow	Well drained	6.00	1	C
MzA	Mount Lucas Series (90% of map unit)	0.37	5	Slow	Moderately well drained	1.74	1	C
MzB	Mount Lucas Series (90% of map unit)	0.37	5	Slow	Moderately well drained	1.74	1	C
MzuB	Mount Lucas Series (70% of map unit)	0.37	5	Slow	Moderately well drained	1.74	1	C

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
NtB	Neshaminy Series very deep over gabbro (85% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
NtC	Neshaminy Series very deep over gabbro (90% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
NvC	Montalto Series (45% of map unit)	0.32	5	Moderately slow	Well drained	6.00	1	C
NvC	Neshaminy Series very deep over gabbro (50%of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
NvD	Montalto Series (45% of map unit)	0.32	5	Moderately slow	Well drained	6.00	1	C
NvD	Neshaminy Series very deep over gabbro (55% of map unit)	0.32	5	Moderate	Well drained	6.00	2	B
NvE	Montalto Series (45% of map unit)	0.32	5	Moderately slow	Well drained	6.00	2	C
NvE	Neshaminy Series very deep over gabbro (55%of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
NxB	Neshaminy Series very deep over gabbro (55%of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
RdA	Queponco Series (40% of map unit)	0.37	5	Moderate	Well drained	3.74	2	B
ReC	Reybold Series (75% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
SaD	Sassafras Series (75% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SaE	Sassafras Series (75% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SuA	Sunken Series (80% of map unit)	0.02	5	Slow	Very poorly drained	0.43	1	D
TaB	Talleyville Series (80% of map unit)	0.49	5	Moderately slow	Well drained	6.00	2	B
TdB	Montalto Series (30% of map unit)	0.32	5	Moderately slow	Well drained	6.00	1	C
TdB	Talleyville Series (45% of map unit)	0.49	5	Moderately slow	Well drained	6.00	2	B
TeA	Tent Series drained (50% of map unit)	0.02	5	Moderately slow	Poorly drained	1.18	1	C
TeA	Tent Series undrained (35% of map unit)	0.49	5	Moderately slow	Poorly drained	0.43	1	D
TP	Mispillion Series (40% of map unit)	0.02	2	Moderately rapid	Very poorly drained	0.16	1	D
TP	Transquaking Series (40% of map unit)	0.02	3	Rapid	Very poorly drained	0.16	1	D
UaB	Udorthents Series schist and gneiss (95% of map unit)	0.43	4	Slow	Well drained	4.99	3	B
UbB	Udorthents Series (75% of map unit)	0.37	5	Moderately slow	Moderately well drained	2.49	3	B
UdrB	Udorthents Series (90% of map unit)	0.43	5	Slow	Well drained	6.00	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Soil Group
UsB	Udorthents Series (85% of map unit)	0.20	5	Moderately slow	Well drained	3.74	2	C
UwA	Udorthents Series (85% of map unit)	0.37	5	Moderately slow	Moderately well drained	2.49	3	B
UzF	Udorthents Series loamy (85% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
VoB	Othello Series drained (30% of map unit)	0.49	5	Moderately slow	Poorly drained	1.18	1	C
VwB	Wheaton Series (40% of map unit)	0.49	5	Moderate	Well drained	6.00	3	B
WaA	Watchung Series (90% of map unit)	0.32	5	Slow	Poorly drained	0.43	1	D
WaB	Watchung Series (90% of map unit)	0.32	5	Slow	Poorly drained	0.43	1	D
WcB	Watchung Series (85% of map unit)	0.32	5	Slow	Poorly drained	0.43	1	D
WdB	Woodstown Series (85% of map unit)	0.24	5	Moderate	Moderately well drained	2.49	1	C

Table A-2. Soil erodibility (K) factors, water features, and leaching index values for Kent and Sussex Counties, Delaware.

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
AbC	Acquango Series (50% of map unit)	0.02	5	Very rapid	Excessively drained	6.00	3	A
AbC	Beaches Series (45% of map unit)	0.02	5	Very rapid	Very poorly drained	0.43	3	D
AsA	Askecksy Series drained (30% of map unit)	0.10	5	Rapid	Poorly drained	1.18	1	B
AsA	Askecksy Series undrained (45% of map unit)	0.02	5	Rapid	Poorly drained	0.43	1	D
AuB	Acquango Series (45% of map unit)	0.02	5	Very rapid	Excessively drained	6.00	3	A
Ba	Appoquinimink Series (30% of map unit)	0.37	3	Moderately slow	Very poorly drained	0.00	1	D
Ba	Broadkill Series (55% of map unit)	0.02	3	Moderately slow	Very poorly drained	0.00	1	D
BhA	Berryland Series drained (50% of map unit)	0.10	5	Rapid	Very poorly drained	0.43	2	B
BhA	Berryland Series undrained (30% of map unit)	0.02	5	Rapid	Very poorly drained	0.16	2	D
Br	Broadkill Series (70% of map unit)	0.02	3	Moderately slow	Very poorly drained	0.00	1	D
BuA	Brockatonorton Series (45% of map unit)	0.02	5	Rapid	Moderately well drained	2.49	1	D
CaA	Carmichael Series drained (40% of map unit)	0.37	4	Moderately slow	Poorly drained	1.18	1	C
CaA	Carmichael Series undrained (40% of map unit)	0.02	4	Moderately slow	Poorly drained	0.43	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
CdB	Cedartown Series (75% of map unit)	0.10	5	Rapid	Somewhat excessively drained	3.74	3	A
CoA	Corsica Series drained (40% of map unit)	0.32	5	Moderate	Very poorly drained	0.43	1	C
CoA	Corsica Series undrained (40% of map unit)	0.02	5	Moderate	Very poorly drained	0.16	1	D
CsA	Crosiadore Series (75% of map unit)	0.49	5	Moderately slow	Somewhat poorly drained	1.18	1	C
DnA	Downer Series (80% of map unit)	0.15	5	Moderately rapid	Well drained	6.00	3	B
DnB	Downer Series (80% of map unit)	0.15	5	Moderately rapid	Well drained	6.00	3	B
DnC	Downer Series (80% of map unit)	0.15	5	Moderately rapid	Well drained	6.00	3	B
DoA	Downer Series (80% of map unit)	0.17	5	Moderately rapid	Well drained	6.00	2	B
DoB	Downer Series (80% of map unit)	0.17	5	Moderately rapid	Well drained	6.00	2	B
DoC	Downer Series (80% of map unit)	0.17	5	Moderately rapid	Well drained	6.00	2	B
DuB	Downer Series (60% of map unit)	0.15	5	Moderately rapid	Well drained	6.00	2	B
EmA	Elkton Series drained (35% of map unit)	0.43	4	Slow	Poorly drained	1.18	1	C
EmA	Elkton Series undrained (40% of map unit)	0.02	4	Slow	Poorly drained	0.43	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
EvB	Evesboro Series (75% of map unit)	0.10	5	Rapid	Excessively drained	6.00	3	A
EvD	Evesboro Series (75% of map unit)	0.10	5	Rapid	Excessively drained	6.00	3	A
FacA	Fallsington Series drained (40% of map unit)	0.20	5	Moderate	Poorly drained	1.18	1	C
FadA	Fallsington Series undrained (40% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
FgcA	Fallsington Series drained (40% of map unit)	0.37	5	Moderate	Poorly drained	1.18	1	C
FgdA	Fallsington Series undrained (40% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
FhA	Fort Mott Series (45% of map unit)	0.15	5	Moderate	Well drained	6.00	3	A
FhA	Henlopen Series (35% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
FhB	Fort Mott Series (45% of map unit)	0.15	5	Moderate	Well drained	6.00	3	A
FhB	Henlopen Series (35% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
FmA	Fort Mott Series (80% of map unit)	0.15	5	Moderate	Well drained	6.00	3	A
FmB	Fort Mott Series (80% of map unit)	0.15	5	Moderate	Well drained	6.00	3	A
FzB	Fallsington Series drained (40% of map unit)	0.24	5	Moderate	Poorly drained	1.18	1	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
FzB	Fallsington Series undrained (25% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
GaB	Galestown Series (80% of map unit)	0.10	5	Rapid	Somewhat excessively drained	6.00	3	A
GaD	Galestown Series (80% of map unit)	0.10	5	Rapid	Somewhat excessively drained	6.00	3	A
GoA	Glassboro Series (80% of map unit)	0.28	5	Moderately rapid	Somewhat poorly drained	1.25	1	C
GrA	Greenwich Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GrB	Greenwich Series (85% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
GuB	Greenwich Series (60% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
HbA	Hambrook Series (80% of map unit)	0.24	5	Moderate	Well drained	3.74	3	B
HbB	Hambrook Series (80% of map unit)	0.24	5	Moderate	Well drained	3.74	3	B
HkB	Hambrook Series (55% of map unit)	0.24	5	Moderate	Well drained	3.74	3	B
HmA	Hammonton Series (80% of map unit)	0.15	5	Moderately rapid	Moderately well drained	2.49	2	B
HnA	Hammonton Series (80% of map unit)	0.20	5	Moderately rapid	Moderately well drained	2.49	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
HnB	Hammonton Series (80% of map unit)	0.20	5	Moderately rapid	Moderately well drained	2.49	2	B
HoA	Fallsington Series drained (10% of map unit)	0.24	5	Moderate	Poorly drained	1.18	1	B
HoA	Fallsington Series undrained (25% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D
HoA	Hammonton Series (40% of map unit)	0.20	5	Moderately rapid	Moderately well drained	2.49	2	B
HoA	Mullica Series drained (5% of map unit)	0.15	5	Moderately rapid	Very poorly drained	0.43	1	B
HoA	Mullica Series undrained (10% of map unit)	0.02	5	Moderately rapid	Very poorly drained	0.16	1	D
HpA	Henlopen Series (80% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
HpB	Henlopen Series (80% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
HrA	Henlopen Series (50% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
HrA	Rosedale Series (40% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A
HrB	Henlopen Series (45% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
HrB	Rosedale Series (40% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
HsA	Henlopen Series (40% of map unit)	0.15	5	Rapid	Somewhat excessively drained	6.00	3	A
HsA	Rosedale Series (30% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A
HuA	Hurlock Series drained (40% of map unit)	0.15	5	Moderately rapid	Poorly drained	1.18	1	B
HuA	Hurlock Series undrained (40% of map unit)	0.02	5	Moderately rapid	Poorly drained	0.43	1	D
HvA	Hurlock Series drained (40% of map unit)	0.20	5	Moderately rapid	Poorly drained	1.18	1	B
HvA	Hurlock Series undrained (40% of map unit)	0.02	5	Moderately rapid	Poorly drained	0.43	1	D
IeA	Ingleside Series (75% of map unit)	0.15	5	Moderately rapid	Well drained	3.74	3	B
IeB	Ingleside Series (75% of map unit)	0.15	5	Moderately rapid	Well drained	3.74	3	B
IgA	Ingleside Series (75% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
IgB	Ingleside Series (75% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
IgC	Ingleside Series (75% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
ImB	Fallsington Series drained (15% of map unit)	0.24	5	Moderate	Poorly drained	1.18	1	B
ImB	Fallsington Series undrained (10% of map unit)	0.02	5	Moderate	Poorly drained	0.43	1	D

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
ImB	Hammonton Series (30% of map unit)	0.20	5	Moderately rapid	Moderately well drained	2.49	2	B
ImB	Ingleside Series (35% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
IuB	Ingleside Series (50% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
KfA	Keyport Series (85% of map unit)	0.37	3	Very slow	Moderately well drained	2.49	1	C
KgB	Galloway Series (35% of map unit)	0.10	5	Rapid	Moderately well drained	2.49	2	B
KgB	Klej Series (45% of map unit)	0.10	5	Rapid	Somewhat poorly drained	1.18	2	C
KnA	Kentuck Series drained (20% of map unit)	0.32	5	Slow	Very poorly drained	0.43	1	C
KnA	Kentuck Series undrained (50% of map unit)	0.02	5	Slow	Very poorly drained	0.16	1	D
KpA	Keyport Series (80% of map unit)	0.43	3	Very slow	Moderately well drained	2.49	1	C
KpB	Keyport Series (80% of map unit)	0.49	3	Very slow	Moderately well drained	2.49	1	C
KsA	Klej Series (70% of map unit)	0.10	5	Rapid	Somewhat poorly drained	1.18	2	C
LeA	Leipsic Series (75% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
LeB	Leipsic Series (75% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
LfA	Lenni Series drained (35% of map unit)	0.28	3	Slow	Poorly drained	1.18	1	D
LfA	Lenni Series undrained (50% of map unit)	0.02	3	Slow	Poorly drained	0.43	1	D
LhA	Lenni Series drained (50% of map unit)	0.43	3	Slow	Poorly drained	1.18	1	D
LhA	Lenni Series undrained (30% of map unit)	0.02	3	Slow	Poorly drained	0.43	1	D
Lk	Lenape Series (85% of map unit)	0.02	2	Moderate	Very poorly drained	0.16	1	D
Ln	Lenape Series (45% of map unit)	0.02	2	Moderate	Very poorly drained	0.16	1	D
Ln	Nanticoke Series (40% of map unit)	0.37	5	Moderate	Very poorly drained	0.16	1	D
LO	Indiantown Series (40% of map unit)	0.37	5	Moderate	Very poorly drained	0.43	1	D
LO	Longmarsh Series (40% of map unit)	0.02	5	Moderate	Very poorly drained	0.43	1	D
Ma	Manahawkin Series (85% of map unit)	0.02	2	Moderate	Very poorly drained	0.16	1	D
McA	Marshyhope Series (85% of map unit)	0.37	5	Moderate	Somewhat poorly drained	1.18	1	C
MdA	Marshyhope Series (85% of map unit)	0.17	5	Moderate	Somewhat poorly drained	1.18	1	C
MkA	Matapeake Series (80% of map unit)	0.49	5	Moderately slow	Well drained	6.00	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
MkB	Matapeake Series (80% of map unit)	0.49	5	Moderately slow	Well drained	6.00	2	B
MmA	Mullica Series drained (50% of map unit)	0.15	5	Moderately rapid	Very poorly drained	0.43	1	B
MmA	Mullica Series undrained (30% of map unit)	0.02	5	Moderately rapid	Very poorly drained	0.16	1	D
MtA	Mattapex Series (80% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
MtB	Mattapex Series (80% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
MtC	Mattapex Series (75% of map unit)	0.49	5	Moderately slow	Moderately well drained	2.49	1	C
MuA	Berryland Series drained (25% of map unit)	0.10	5	Rapid	Very poorly drained	0.43	2	B
MuA	Berryland Series undrained (15% of map unit)	0.02	5	Rapid	Very poorly drained	0.16	2	D
MuA	Mullica Series drained (25% of map unit)	0.15	5	Moderately rapid	Very poorly drained	0.43	1	B
MuA	Mullica Series undrained (15% of map unit)	0.02	5	Moderately rapid	Very poorly drained	0.16	1	D
NM	Mannington Series (45% of map unit)	0.37	5	Moderate	Very poorly drained	0.16	1	D
NM	Nanticoke Series (45% of map unit)	0.37	5	Moderate	Very poorly drained	0.16	1	D
NsA	Nassawango Series (80% of map unit)	0.49	5	Moderately slow	Well drained	3.74	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
NsB	Nassawango Series (80% of map unit)	0.49	5	Moderately slow	Well drained	3.74	2	B
OtA	Othello Series drained (35% of map unit)	0.49	5	Moderately slow	Poorly drained	1.18	1	C
OtA	Othello Series undrained (40% of map unit)	0.02	5	Moderately slow	Poorly drained	0.43	1	D
Pa	Pawcatuck Series (80% of map unit)	0.02	5	Moderate	Very poorly drained	0.00	1	D
Pk	Puckum Series (85% of map unit)	0.02	3	Moderately rapid	Very poorly drained	0.16	1	D
PpA	Pepperbox Series (80% of map unit)	0.15	5	Moderate	Moderately well drained	2.49	1	C
PpB	Pepperbox Series (80% of map unit)	0.15	5	Moderate	Moderately well drained	2.49	1	C
PrA	Pepperbox Series (50% of map unit)	0.15	5	Moderate	Moderately well drained	2.49	1	C
PrA	Rockawalkin Series (30% of map unit)	0.15	5	Moderately rapid	Moderately well drained	2.49	3	B
PrB	Pepperbox Series (50% of map unit)	0.15	5	Moderate	Moderately well drained	2.49	1	C
PrB	Rockawalkin Series (30% of map unit)	0.15	5	Moderately rapid	Moderately well drained	2.49	3	B
PsA	Pepperbox Series (45% of map unit)	0.15	5	Moderate	Moderately well drained	2.49	1	C
PsA	Rosedale Series (45% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
PsB	Pepperbox Series (45% of map unit)	0.10	5	Moderate	Moderately well drained	2.49	1	C
PsB	Rosedale Series (45% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A
Pu	Purnell Series (85% of map unit)	0.02	3	Rapid	Very poorly drained	0.00	1	D
PyA	Pineyneck Series (80% of map unit)	0.37	5	Moderate	Moderately well drained	2.49	2	B
PyB	Pineyneck Series (80% of map unit)	0.37	5	Moderate	Moderately well drained	2.49	2	B
RdA	Queponco Series (40% of map unit)	0.43	5	Moderate	Well drained	3.74	2	B
RdA	Reybold Series (45% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
ReA	Reybold Series (75% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
ReB	Reybold Series (75% of map unit)	0.43	5	Moderate	Well drained	6.00	2	B
RkA	Rockawalkin Series (75% of map unit)	0.15	5	Moderately rapid	Moderately well drained	2.49	3	B
RkB	Rockawalkin Series (75% of map unit)	0.15	5	Moderately rapid	Moderately well drained	2.49	3	B
RoA	Rosedale Series (75% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A
RoB	Rosedale Series (75% of map unit)	0.10	5	Moderately rapid	Well drained	3.74	3	A

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
RsA	Runclint Series (75% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
RsB	Runclint Series (75% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
RuA	Runclint Series (75% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
RuB	Runclint Series (75% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
RwA	Cedartown Series (40% of map unit)	0.10	5	Rapid	Somewhat excessively drained	3.74	3	A
RwA	Runclint Series (45% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
RwB	Cedartown Series (40% of map unit)	0.10	5	Rapid	Somewhat excessively drained	3.74	3	A
RwB	Runclint Series (45% of map unit)	0.10	5	Rapid	Excessively drained	3.74	3	A
SaA	Sassafras Series (80% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SaB	Sassafras Series (80% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SaC	Sassafras Series (75% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SlA	Sassafras Series (80% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B
SlB	Sassafras Series (80% of map unit)	0.37	5	Moderate	Well drained	6.00	2	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
Sp	Saltpond Series (85% of map unit)	0.02	5	Very rapid	Poorly drained	0.43	1	D
SSD	Sassafras Series (75% of map unit)	0.24	5	Moderate	Well drained	6.00	3	B
SuA	Sunken Series (80% of map unit)	0.02	5	Slow	Very poorly drained	0.43	1	D
TeA	Tent Series drained (50% of map unit)	0.49	5	Moderately slow	Poorly drained	1.18	1	C
TeA	Tent Series undrained (35% of map unit)	0.02	5	Moderately slow	Poorly drained	0.43	1	D
TP	Mispillion Series (40% of map unit)	0.02	2	Moderately rapid	Very poorly drained	0.16	1	D
TP	Transquaking Series (40% of map unit)	0.02	3	Rapid	Very poorly drained	0.16	1	D
UbB	Udorthents Series (75% of map unit)	0.28	5	Moderately slow	Moderately well drained	2.49	3	B
UfB	Udorthents Series (85% of map unit)	0.20	2	Moderately rapid	Well drained	3.74	3	C
UlA	Unicorn Series (85% of map unit)	0.37	5	Moderate	Well drained	3.74	2	B
UlB	Unicorn Series (85% of map unit)	0.37	5	Moderate	Well drained	3.74	2	B
UzC	Udorthents Series loamy (90% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B
UzD	Udorthents Series loamy (90% of map unit)	0.20	5	Moderately rapid	Well drained	3.74	3	B

Map Symbol	Soil Name	K	T	Permeability	Drainage	Average High Water Table (ft)	Leaching Index	Hydrologic Group
WdA	Woodstown Series (80% of map unit)	0.24	5	Moderate	Moderately well drained	2.49	1	C
WdB	Woodstown Series (85% of map unit)	0.17	5	Moderate	Moderately well drained	2.49	1	C
WhA	Whitemarsh Series drained (35% of map unit)	0.49	3	Slow	Poorly drained	1.18	1	C
WhA	Whitemarsh Series undrained (40% of map unit)	0.02	3	Slow	Poorly drained	0.43	1	D
WoA	Woodstown Series (80% of map unit)	0.37	5	Moderate	Moderately well drained	2.49	1	C
WoB	Woodstown Series (80% of map unit)	0.37	5	Moderate	Moderately well drained	2.49	1	C
Za	Zekiah Series (75% of map unit)	0.37	5	Moderate	Poorly drained	0.43	1	D

Table A-3. Length and slope (LS) factors for use in RUSLE calculations for Delaware.

Slope %	25	50	75	100	150	200	250	300	400	600
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
0.5	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10
1	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.17	0.18	0.19
2	0.19	0.22	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.41
3	0.25	0.32	0.36	0.39	0.44	0.48	0.52	0.55	0.6	0.68
4	0.31	0.40	0.47	0.52	0.6	0.67	0.72	0.77	0.86	0.99
5	0.37	0.49	0.58	0.65	0.76	0.85	0.93	1.01	1.13	1.33
6	0.43	0.58	0.69	0.78	0.93	1.05	1.16	1.20	1.42	1.69
8	0.53	0.74	0.91	1.04	1.26	1.45	1.62	1.77	2.03	2.47
10	0.67	0.97	1.19	1.38	1.71	1.98	2.22	2.44	2.84	3.5
12	0.84	1.23	1.53	1.79	2.23	2.61	2.95	3.26	3.81	4.75
14	1.00	1.48	1.86	2.19	2.76	3.25	3.69	4.09	4.82	6.07
16	1.15	1.73	2.2	2.60	3.30	3.90	4.45	4.95	5.86	7.43
20	1.45	2.22	2.85	3.40	4.36	5.21	5.97	6.68	7.97	10.23
25	1.81	2.82	3.65	4.39	5.69	6.83	7.88	8.86	10.65	13.80

Table A-4. Cover management (C) factors and crop codes that describe various cropping systems for use in RUSLE calculations for Delaware. (C = Corn; W = Wheat [in rotations]; S = Soybeans; W = Wide [for continuous soybeans only]; N = Narrow [for continuous soybeans only]; NT = No-till; N = No-till [in rotations])

Cropping System	C Factor	Crop Code
Continuous Corn		
no-till	0.01	CNT
conservation tillage	0.08	CCT
clean tillage	0.18	CCV
Continuous Soybeans		
no-till - narrow row	0.14	SNTN
no-till - wide row	0.11	SNTW
conservation tillage - narrow row	0.24	SCTN
conservation tillage - wide row	0.26	SCTW
clean tillage - narrow row	0.27	SCVN
clean tillage - wide row	0.28	SCVW
Corn, Full Season Soybeans		
no-till corn, no-till soybeans	0.04	CNTSNT
no-till corn, conservation tillage soybeans	0.13	CNTSCT
no-till corn, clean tillage soybeans	0.18	CNTSCV
conservation tillage corn, no-till soybeans	0.10	CCTSNT
conservation tillage corn, conservation tillage soybeans	0.14	CCTSCT
conservation tillage corn, clean tillage soybeans	0.20	CCTSCV
clean tillage corn, no-till soybeans	0.14	CCVSNT
clean tillage corn, conservation tillage soybeans	0.17	CCVSCT
clean tillage corn, conventional soybeans	0.22	CCVSCV
Corn, Wheat, Double Cropped Soybeans		
no-till corn, clean tillage wheat, no-till soybeans	0.06	CNTWCVSN
no-till corn, conservation tillage wheat, no-till soybeans	0.03	CNTWCTSN
conservation tillage corn, clean tillage wheat, no-till soybeans	0.11	CCTWCVSN
conservation tillage corn, conservation tillage wheat, no-till soybeans	0.08	CCTWCTSN
clean tillage corn, clean tillage wheat, no-till soybeans	0.12	CCVWCVSN
clean tillage corn, conservation tillage wheat, no-till soybeans	0.10	CCVWCTSNT

Cropping System	C Factor	Crop Code
Corn, Corn, Wheat, Soybeans		
2 years no-till corn, clean tillage wheat, no-till soybeans	0.04	CCNTWVSN
2 years no-till corn, conservation tillage wheat, no-till soybeans	0.03	CCNTWTSN
2 years conservation tillage corn, clean tillage wheat, no-till soybeans	0.08	CCTWVSNT
2 years conservation tillage corn, conservation tillage wheat, no-till soybeans	0.06	CCTWTSNT
2 years clean tillage corn, clean tillage wheat, no-till soybeans	0.14	CCVWSNT
2 years clean tillage corn, conservation tillage wheat, no-till soybeans	0.13	CCVWTSNT
Miscellaneous vegetable crops – clean tillage		
cabbage	0.33	no file
sweet corn	0.22	no file
sweet corn, winter small grain cover	0.19	no file
tomatoes	0.45	no file
tomatoes, winter small grain cover	0.34	no file
cucumbers	0.55	no file
cucumbers, winter small grain cover	0.38	no file
peppers	0.52	no file
peppers, winter small grain cover	0.36	no file
snap beans	0.43	no file
snap beans, winter small grain cover	0.30	no file

Table A-5. Support Practice (P) factors for use in RUSLE calculations for Delaware.

Furrow Gradient (%)	Hydrologic Soil Group	Field Slope			
		3%	5%	7%	10%
Support Practice: Contour Farming with Very Low Ridge Height					
0.5	A	0.60	0.53	0.51	0.53
1.0	A	0.72	0.67	0.59	0.59
2.0	A	0.88	0.75	0.69	0.67
0.5	B	0.79	0.75	0.46	0.83
1.0	B	0.85	0.80	0.80	0.85
2.0	B	0.94	0.97	0.85	0.88
0.5	C	0.90	0.89	0.90	0.96
1.0	C	0.93	0.91	0.91	0.97
2.0	C	0.97	0.94	0.94	0.97
Support Practice: Contour Farming with Low Ridge Height*					
1.0	A	0.72	0.67	0.59	0.51
2.0	A	0.88	0.75	0.69	0.60
0.5	B	0.79	0.75	0.63	0.67
1.0	B	0.85	0.80	0.80	0.71
2.0	B	0.94	0.97	0.85	0.76
0.5	C	0.90	0.89	0.74	0.80
1.0	C	0.93	0.91	0.78	0.82
2.0	C	0.97	0.94	0.84	0.87
Support Practice: Contour Stripcropping with Very Low Ridge Height					
1.0	A	0.68	0.64	0.56	0.56
2.0	A	0.83	0.71	0.66	0.63
0.5	B	0.75	0.71	0.44	0.79
1.0	B	0.81	0.76	0.76	0.81
2.0	B	0.89	0.92	0.80	0.84
0.5	C	0.86	0.84	0.85	0.92
1.0	C	0.88	0.86	0.87	0.92
2.0	C	0.92	0.89	0.89	0.93

Furrow Gradient (%)	Hydrologic Soil Group	Field Slope			
		3%	5%	7%	10%
Support Practice: Contour Stripcropping with Low Ridge Height**					
1.0	A	0.681	0.589	0.56	0.48
2.0	A	0.833	0.709	0.66	0.57
0.5	B	0.749	0.713	0.60	0.63
2.0	B	0.874	0.822	0.80	0.72
0.5	C	0.857	0.841	0.71	0.76
1.0	C	0.884	0.862	0.74	0.78
2.0	C	0.922	0.891	0.80	0.82

* Figures based on moderate ground cover, 100 foot slope length.
** Figures based on moderate ground cover, 300 foot slope length, and 100 food wide strips.
Factor for strips is 0.95 of that for contours.

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