Draft BMP Panel Report

Definitions and Recommended Nutrient and Sediment Reduction Efficiencies of

Conservation Tillage Practices

For Use in Phase 6.0 of the Chesapeake Bay Program Watershed Model

Recommendations for Approval by the Water Quality Goal Implementation Team's Watershed Technical and Agricultural Workgroups

Submitted by the Phase 6.0 Conservation tillage BMP Expert Panel

Submitted to:
Agriculture Workgroup
Chesapeake Bay Program

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Acronyms and Abbreviations

ac	Acre
APLE	Annual Phosphorus Loss Estimator
BMP	Best Management Practice
CBP	Chesapeake Bay Program
CBPO	Chesapeake Bay Program Office
CDL	Cropland Data Layer
CRC	Chesapeake Research Consortium
CTIC	Conservation Technology Information Center
ha	Hectare
HGM	Hydrogeomorphic Region
HRMSD	High Residue, Minimum Soil Disturbance
kg	Kilograms
N	Nitrogen
NEIEN	National Environmental Information Exchange Network
NRCS	Natural Resources Conservation Service
P	Phosphorus
Panel	Phase 6.0 Conservation Tillage Expert Panel
QA/QC	Quality Assurance and Quality Control
QAPP	Quality Assurance Project Plan
RUSLE2	Revised Universal Soil Loss Equation 2
SCI	Soil Conditioning Index
SSURGO	Soil Survey Geographic Database
STIR	Soil Tillage Intensity Rating
t	Tons
USDA	U.S. Department of Agriculture

Summary of Recommendations

1 Introduction

This document summarizes the recommendations of the Phase 6.0 Conservation Tillage Expert Panel (the Panel) for revised definitions and efficiency estimates for Conservation Tillage. The Panel, whose members are identified in Table 1, proposes that the Chesapeake Bay Program's (CBP) existing definitions and credits associated with implementation of Conservation Tillage be replaced by four new categories of conservation tillage best management practices (BMPs) that are defined primarily by soil residue cover and soil disturbance.

Table 1. CBP Phase 6.0 Conservation Tillage Expert Panel membership

Name	Jurisdiction	Affiliation	Role
Wade Thomason	Virginia	Virginia Tech	Panel Chair
Sjoerd Duiker	Pennsylvania	Penn State University	Panel Member
Kevin Ganoe	New York	Cornell University	Panel Member
Dale Gates	New York	USDA-Natural Resources Conservation Service	Panel Member
Bill McCollum	Delaware	DuPont Pioneer	Panel Member
Mark Reiter	Virginia	Virginia Tech	Panel Member
Bill Keeling	Virginia	Virginia Department of Environmental Quality	Watershed Technical Workgroup Representative
Jeff Sweeney	Maryland	University of Maryland, CBPO	Modeling Team Representative
Technical support provided by Mark Dubin (University of Maryland, CBPO), Lindsey Gordon (CRC Staffer), and Jennifer Ferrando (Tetra Tech).			

CBPO – Chesapeake Bay Program Office; CRC – Chesapeake Research Consortium; USDA – U.S. Department of Agriculture

2 Practice Definition

Conservation tillage involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface through the use of minimum tillage, mulch tillage, ridge tillage, or no-till. The current version of the CBP partnership's Watershed Model (Phase 5.3.2) includes three management levels for crop residue management. High till (0-29 percent crop residue) otherwise known as conventional tillage, and low till (30+ percent crop residue) known as conservation tillage, are both simulated as land uses and not as BMPs. A subset of the low till acreage is eligible for the high residue, minimum soil disturbance tillage management (HRMSD[1]) BMP, which is defined as "a crop planting and residue management practice in which soil disturbance by plows and implements intended to invert residue is eliminated. Any disturbance must leave a minimum of 60 percent crop residue cover on the soil surface as measured after planting. This annual practice involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living and dead material) is to be met immediately after planting of each crop." The existing HRMSD practice can be combined with other associated, applicable BMPs for additional reductions, including nutrient management and cover crops.

Tillage practices for the Phase 6 Model are proposed to include four categories, characterized primarily by residue cover and soil disturbance. Three of these categories represent reductions in tillage compared to conventional/high tillage, which is considered the baseline (Table 2). Each should be represented as an annual BMP. Each tillage category can be combined with other associated, applicable BMPs.

Table 2. Tillage categories, brief definitions and other relevant standards

Category	Residue cover and soil disturbance	Corollary Phase 5.3.2 practice	Other relevant standard
1. Conventional/high tillage	< 15% cover OR 15 – 29% cover with full width tillage.	High till/conventional tillage	
2. Low residue, strip till/no-till	15 – 29% cover, strip till or no-till, and less than 40% soil disturbance	N/A - This is a new category for the conservation tillage practice.	NRCS Conservation Practice Standard Code 329
3. Conservation tillage	30 – 59% cover	Low till/conservation tillage	NRCS Conservation Practice Standard Code 345
4. High residue, minimum soil disturbance tillage	≥60% cover, minimum disturbance	HRMSD	

NRCS – Natural Resources Conservation Service

The use of soil residue cover and disturbance as the primary criteria for tillage category determination facilitates simple divisions based on field characterization and allows the use of historical data collected in previous years. The Phase 5.3.2 Conservation Tillage Expert Panel recognized the potential for including additional management levels for crop residue management in the Phase 6 modeling tools, which have been documented by USDA-NRCS, and implementation data captured by the Conservation Technology Information Center (CTIC). Current and historical crop residue implementation data are represented in the CTIC database for the following categories:

[1] Note that this practice is designated "HR Till" for the Phase 5.3.2 model.

- Conventional Tillage 0 - 15% Residue
- Reduced Tillage 15 - 30% Residue
- Mulch Tillage >30 % Residue
- Ridge Tillage >30 % Residue

The Phase 6.0 modeling tools will replace the existing Phase 5.3.2 agricultural land uses with new crop-focused land uses. As part of this transition, the former high till and low till land uses will be replaced by the new tillage BMPs applied to the new crop-focused land uses. The CTIC data can provide an important historical implementation record for supplementing past jurisdictional BMP reporting, as well as support model calibration starting in 1989 as the initial year for the national dataset. The CTIC data exist for all counties through 2005 when the nationally funded program ended, and are available post-2005 for those counties and states that continued to collect data.

The development of the new low residue, strip till/no-till category reflects the Panel's investigation into the infiltration and soil aggregation benefits associated with greatly reduced soil disturbance under low residue conditions. Field evaluation of management practices that fit this category could be based on residue coverage and tillage practice details listed in NRCS Conservation Practice Standard Code 329. Soil disturbance and residue management criteria for the low residue, strip till/no-till category should be consistent with the USDA-NRCS practice standard for no-till/strip-till (329), and the conservation tillage category should be consistent with the reduced tillage standard (345).

As charged by the Expert Panel Establishment Group, the Panel considered development of a relationship matrix to associate tillage categories with both visual assessments of residue cover and residue levels estimated by USDA-NRCS index tools used to predict residue levels (e.g. RUSLE2 Soil Tillage Intensity Rating [STIR] and Soil Conditioning Index [SCI]) to allow cross-referencing between assessment methods and provide examples of seeding/tillage activities that typically result in the prescribed residue levels. RUSLE2 runs were instructive for verifying that the tillage categories defined for this practice are consistent with the expected SCI and STIR values for relevant NRCS practice standards. Table 3 below provides examples of practices and associated SCI and STIR values that would be representative of each category as modeled for cropping systems in New York. The Panel recommends that thresholds for SCI and STIR not be used for verification of tillage practices, but instead provides these as representative farming systems for the four tillage categories. Note that Conservation Practice Standard Code 329 requires a STIR of 20 or less and Code 345 requires a STIR of 80 or less. Both practices require an SCI of 0 or greater. Table 3 provides examples of soil loss, SCI, and STIR under various tillage scenarios. Scenarios where a single value for residue after planting is presented represent single-year examples while those with a value for both corn and soy represent a two-crop, two year rotation.

Table 3. RUSLE2 results for crop and tillage scenarios corresponding to Phase 6 tillage categories

Location	*Soil*	*T value, t/ac/yr*	*Slope length (horiz), ft*	*Avg. slope steepness, %*
USA\New York\Chenango County	Chenango County, New York\BaB Bath channery silt loam, 3 to 8 percent slopes\Bath Channery silt loam 85%	3.0	200	5.0

Description	Residue after planting	Soil loss (RUSLE2) (t/ac)	SCI	STIR
1. Conventional/high tillage				
Conventional Till Corn Silage. Full inversion primary tillage with two pass secondary tillage.	<1%	5.1	-0.44	117
Reduced Till Corn Silage. One pass full width tillage with field cultivator.	24%	3.9	-0.0076	29.7
Reduced Till Corn Grain 1/Soy 1. Full width chisel primary tillage with two pass secondary tillage.	After corn: 9% After soy: 15%	2.5	-0.13	140
Corn Grain Reduced Till. Primary tillage with twisted shank chisel plow, followed by secondary disk tillage.	13%	2.1	0.19	114
Reduced Till Corn Silage. One pass full width tillage with turbo till like implement then plant 100% surface disturbance.	17%	4.1	-0.063	41.1
Reduced Till Corn Silage. Aerway, double gang set at 5 degrees for manure incorporation. One pass plant in spring. 80% surface disturbance.	29%	3.3	0.030	31.9
2. Low residue, strip till/no-till				
Strip Till Corn Silage. In-row subsoiler/zone builder disturbing no more than 40% of soil surface, followed by planter in strips/zones.	26%	3.1	0.11	15.6
Strip Till Corn Silage. In-row subsoiler/zone builder disturbing no more than 40% of soil surface, followed by planter in strips/zones.	26%	3.1	0.11	15.6
No-Till Corn Silage. Low disturbance manure injection followed by one pass no- till planter. 30% surface disturbance.	29%	2.7	0.20	8.53
3. Conservation tillage				
Reduced Till Corn Grain. One pass full width disk tillage prior to corn grain and prior to soybean planting.	After corn: 30% After soy: 49%	2.1	0.33	33.6
Reduced Till Corn Grain followed by reduced Till Soybeans. One pass full width tillage with field cultivator.	After corn: 46% After soy: 61%	1.9	0.35	31.8
Corn Grain reduced till. Two pass disk operation	34%	1.6	0.41	68.9
4. High residue, minimum soil disturbance				
No-Till Corn Grain and reduced Till Soybeans. One pass no-till corn grain followed by soybeans with full width one pass field cultivator.	After corn: 71% After soy: 67%	1.6	0.44	16.5
Zone Till Corn Grain, followed by Zone Till Soybeans. One pass with strip till planter.	After corn: 56% After soy: 77%	0.71	0.53	5.55
No-Till Corn Silage 1, followed by No-Till soybeans, One pass with no- till planter.	After corn: 73% After soy: 80%	0.23	0.63	3.44

3 Effectiveness Estimates

Table 4 below represents the recommended efficiency values for sediment and surface nitrogen (N) reductions due to low residue strip-till/no-till, conservation tillage, and HRMSD, expressed as load reductions relative to conventional/high tillage practices.

Table 4. Recommended efficiency values for sediment and surface N reductions due to low residue strip-till/no-till, conservation tillage, and HRMSD practices, relative to conventional/high tillage practices

Low residue, strip till/no-till 16-29% residue	Conservation tillage 30-59% residue	HRMSD ≥60% residue
Sediment Losses (relative to conventional/high tillage)		
-18%	-41%	-79%
Surface N Losses (relative to conventional/high tillage)		
Uplands: -5%	Uplands: -10%	Uplands: -14%
Coastal Plain: -2%	Coastal Plain: -4%	Coastal Plain: -12%

Nitrogen efficiencies vary according to region, as shown in the table. Sediment efficiencies apply consistently throughout the watershed.

Table 5 presents surface phosphorus (P) loss reductions due to reduced tillage practice compared to conventional tillage, by hydrogeomorphic region.

Table 5. Recommended surface P loss reductions due to reduced tillage practice compared to conventional/high tillage practices, by hydrogeomorphic region

	Surface P Losses		
HGM Region	Low residue, strip till/no-till 16-29% residue	Conservation tillage 30-59% residue	HRMSD ≥60% residue
Appalachian Plateau, Siliciclastic	-7%	-17%	-27%
Appalachian Plateau, Carbonate	-7%	-27%	-38%
Blue Ridge	-8%	-50%	-63%
Coastal Plain Dissected Upland	-8%	-35%	-47%
Coastal Plain Lowland	-6%	-2%	-11%
Coastal Plain Upland	-7%	-16%	-26%
Mesozoic Lowland	-7%	-21%	-32%
Piedmont Carbonate	-9%	-60%	-74%
Piedmont Crystalline	-9%	-58%	-71%
Valley and Ridge Carbonate	-9%	-57%	-71%
Valley and Ridge Siliciclastic	-8%	-49%	-62%

3.1 Justification for Recommended Effectiveness Estimates

3.1.1 Nitrogen

The Panel reviewed literature (detailed in Section 7 and in Section 3.2 below) that reported runoff N relative to surface residue cover achieved with various tillage practices. Based on information in the literature (Dickey and Siemens 1992) and professional experience, the Panel estimated the percent residue after tillage for each study treatment and calculated the surface N loss for each treatment relative to that reported for conventional tillage. The Panel then conducted a linear regression analysis to describe the relationship between surface residue cover and surface N losses (Figure 1).

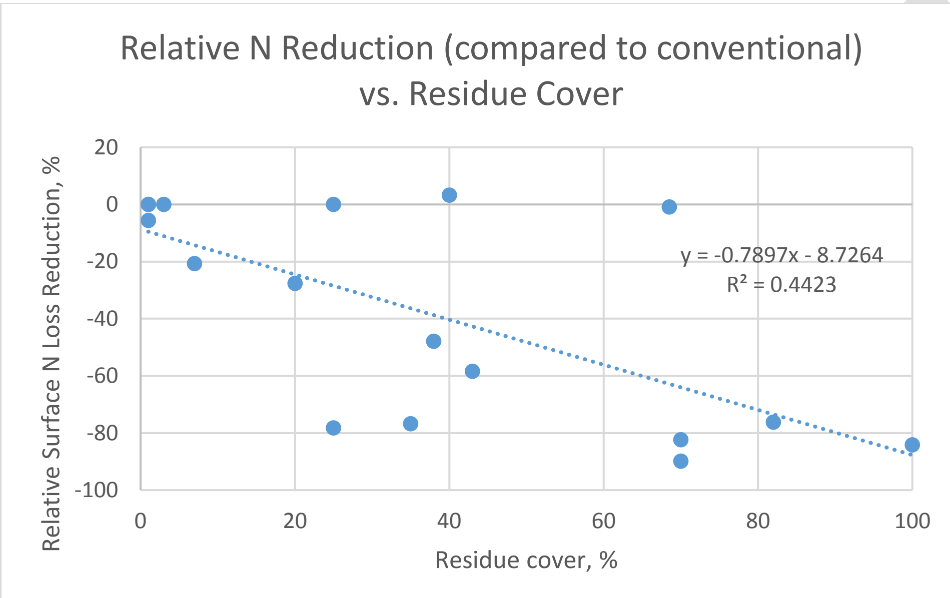

Figure 1. Relative surface N loss by surface residue cover.

Predicted surface N losses were multiplied by previously assumed water loss partitioning coefficients to describe differences due to landscape between uplands and Coastal Plains regions. The Panel assumed 85 percent infiltration for Coastal Plains regions and 70 percent infiltration for uplands regions. Acknowledging a commonly-held perception that implementing no-till can increase subsurface losses of dissolved nutrients, the Panel evaluated literature that reported N leaching under various tillage practices as well as studies reporting N remaining in the soil profile under no-till versus conventional tillage. Based on those studies, which are identified in Section 7 (References) and discussed further in Section 3.2 (Reference Summary), the Panel members agreed that for most cropland soils there is inconsistent evidence for differences for N leaching between no-till and conventional tillage systems. Therefore, the recommended effectiveness estimates for all tillage types assume that N leaches at a similar rate relative to N application regardless of tillage type. The efficiencies reflect reductions only in surface losses for all N forms.

3.1.2 Phosphorus

An initial review of relevant literature reporting surface P losses under various tillage practices revealed a wide range in surface P losses, even within the Chesapeake Bay watershed, with soil drainage class an apparent controlling factor. In general, on well-drained soils, adoption of reduced tillage practices resulted in significant reduction in surface P losses while P losses were frequently increased on poorly drained soils. The Panel expanded the literature review and regrouped literature citations by soil drainage to derive the effectiveness estimates described below. The Panel judged that only one study provided relevant data for the low-residue no-till practice and that study had large relative sediment loads so P loss reduction estimates were proportionally decreased to match expected sediment loads in this region. Professional judgement was applied to the final estimate and the Panel felt it appropriate to advance. Table 6 presents a summary of mean surface P loss reductions for studies conducted on well-drained sites and associated variation in the data reports.

Table 6. Surface P loss reduction means and simple statistics from relevant literature, by tillage category

Category	Residue	Estimated Surface P Loss Reduction	Number of Publications	Average Standard Deviation	Average Variance	Pooled Sum of Squares
Low residue, strip till/no-till	16-29%	-9%	1	0.56†	0.46	5.23
Conservation tillage	30-59%	-64%	5	0.7‡	0.5	2.6
HRMSD	≥60%	-78%	6	1.2‡	1.5	10.3

† over years of the same study
‡ over listed number of publications

Five peer-reviewed studies were conducted on poorly drained soils, one with treatments comparing high-till and conservation tillage treatment and four comparing the effects of moving from conservation tillage to no-till. The Panel grouped the papers together and derived a mean increase in P losses of 130 percent, with standard deviation of 0.89, variance of 0.8 and pooled sum of squares of 4. There were no studies reporting on low-residue no-till effects on poorly drained soils.

The Panel felt any effectiveness attributed to tillage practices should include both reductions and increases in P losses due to reduced tillage practices. In order to apply the estimates of P loss the Panel followed the methodology illustrated in Figure 2, as described below. The soil survey geographic database, containing agricultural drainage class was downloaded for each county in the watershed, then merged by state. The resulting state-level soils data layer was clipped over the USDA cropland data layer (CDL) from 2015. Only those crops which would be eligible for reduced tillage practices were included. This allowed determination of the proportion of eligible cropland by drainage category at the state level. Then, within a state, the merged drainage/CDL data were extracted over the hydrogeomorphic (HGM) regions allowing a summarization of cropland soils by drainage. Individual state data were then aggregated to the HGM region to give a single value for each in the watershed.

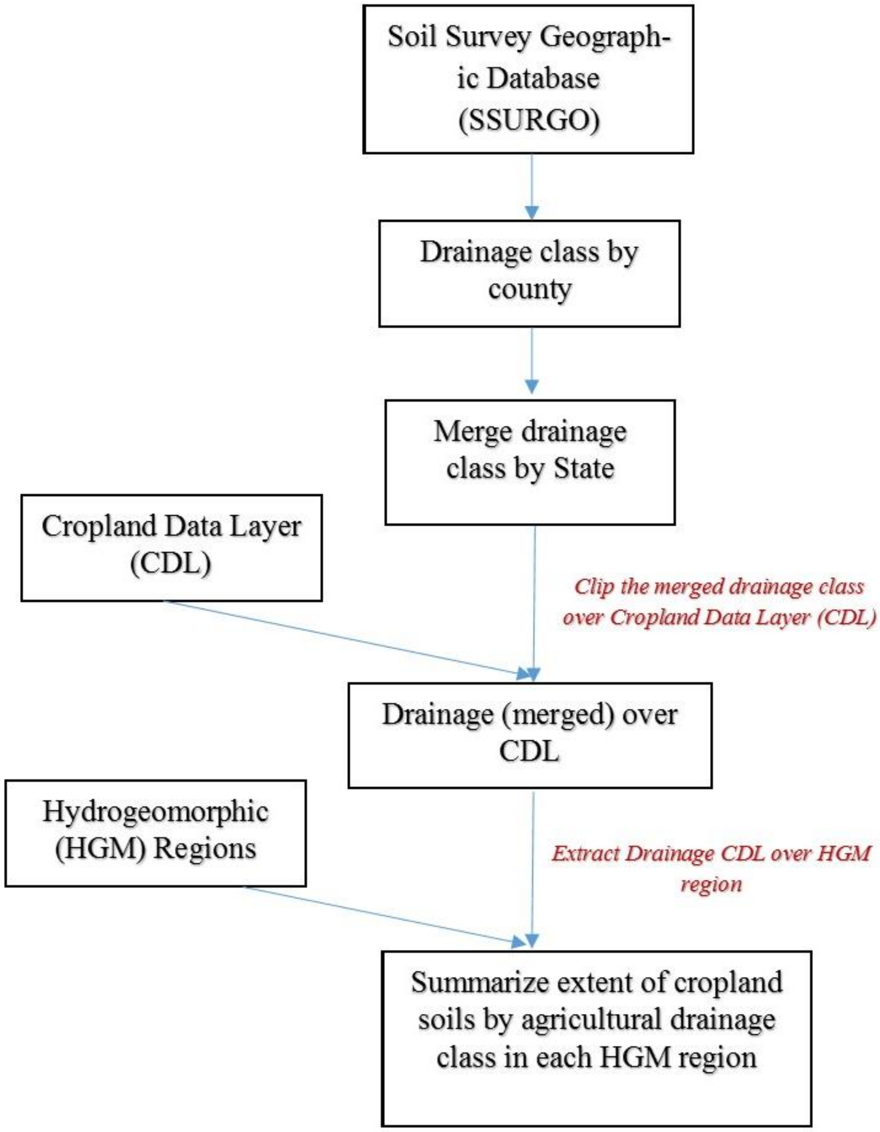

Figure 2. Methodology for estimating distribution of cropland soils by soil drainage class for HGM regions.

Literature values for P losses for the HRMSD and conservation tillage practices were then applied to the appropriate proportion of cropland by drainage as follows:

(% well drained cropland)(literature reduction value) + (% poorly drained cropland)*(literature increase value) = P loss value for HGM region*

Because of the absence of data on the effect of the low residue, strip-till/no-till practice on poorly drained soils estimates of P losses are presented as the literature value for the study conducted on well-drained soils but do vary based on the proportion of cropland drainage by category. The calculation used for the low residue, strip-till/no-till practice was:

(% well drained cropland)(literature reduction value) = P loss value for HGM region*

The results of these calculations and estimates are presented above in Table 6.

3.1.3 Sediment

Low residue, strip-till/no-till
The Panel compiled literature that reported relevant comparisons of sediment losses between the proposed new low residue no-till/strip-till practice and both conventional/high tillage and conservation tillage practices with varying levels of associated crop residue cover.

Over a total of three studies (references provided in Section 7) a relative decrease in sediment loss of 18 percent was noted between conventional/high tillage management and low residue, strip-till/no-till management (15-29 percent residue cover and less than 40 percent soil surface disturbance). Table 7 presents a summary of mean sediment loss reductions and associated variation in the data reports.

Table 7. Sediment loss reduction means and simple statistics from relevant literature for low residue, strip-till/no-till

n=3	Residue Cover %	Sediment Loss kg/ha	Relative Change %	Average Standard Deviation %	Average Variance	Pooled Sum of Squares
Conventional/high tillage	8	7341				
Low residue, strip-till/ no-till	23	6018	-18	1.55	2.40	7.20

Conservation tillage
The Panel relied on the work of the previous Phase 5.3.2 Conservation Tillage Panel (2014) and on previous iterations of reductions in sediment loss between conventional tillage and conservation tillage used. The earlier values and literature were scrutinized. After deliberation the Panel agreed to carry forward the previously credited sediment reductions for situations meeting the conservation tillage criterion (30 – 59 percent residue cover).

High residue, minimum soil disturbance
The Phase 5.3.2 Conservation Tillage Panel report (2014) summarized a body of recent literature and reported sediment reduction efficiencies compared to the existing conservation tillage category. The Phase 6.0 Panel also reviewed and accepted those values/recommendations. However, the previous reduction for this category was reported relative to conservation tillage. This Panel chose to define the reduction relative to conventional/high tillage instead and therefore used the product of the two earlier reductions as the value for their recommendation.

3.1.4 Additional Discussion

The Panel found no indication of increased sediment or N losses with greater surface residue. The Panel consistently found evidence for decreased surface P losses on well-drained soils and increased total surface P losses on poorly drain soils. In almost all cases, an increase in water soluble P was responsible for the greater load. The recommended efficiencies for HRMSD and Conservation tillage include the increase in P losses from poorly drained soils; the method for incorporating that finding is described above.

The Panel found no evidence that sediment losses could be relocated to a different place or loss pathway. The Panel reviewed several studies on the impact of surface residue and/or tillage practice on N losses and found no consistent evidence of either greater or reduced subsurface N losses.

3.1.5 Relationship to Other Practices

Other practices that likely interact with tillage include: cover crops, nutrient management and manure injection/incorporation. Cover crops provide surface cover other than that provided by crop residue so their inclusion could result in changes in soil cover for the various example cropping systems. Nutrient source, rate, timing and placement can all affect nutrient losses, regardless of tillage system. In particular, soil test P level, stratification of P level by soil depth, slope, and surface application of manure and fertilizer all interact and ultimately affect losses. Manure injection or incorporation, by definition, causes soil disturbance but because nutrients re placed below the surface, P losses may be reduced in many instances. Because this Panel compared the effect of tillage on surface-placed nutrients, differences could be observed.

3.1.6 Other Potential Benefits

Reduced tillage practices are widely recognized as potentially improving many of the individual physical, chemical and biological factors that influence soil quality. In addition to potentially improving infiltration, reduced tillage often results in greater aggregate stability, increased soil organic matter, increased water retention, and increased nutrient cycling.

3.2 Reference Summary

3.2.1 Surface Nitrogen Losses

The Panel conducted a regression analysis using data from the sources listed below to develop a relationship between surface residue cover and surface N losses (full citations are provided in Section 7).

- Chichester 1977
- McDowell and McGregor 1984
- Romkens et al. 1973
- Shipitalo et al. 2013

These studies were considered to be applicable, having been conducted within the watershed or on soils similar to those found in the watershed. The Panel evaluated and rejected numerous other studies based on lack of similar soils, lack of appropriate tillage treatments (residue cover), no reporting of surface residue values, or because experimental practices were not described sufficiently for the Panel to estimate cover using professional judgement.

The Panel considered five studies in evaluating the necessity of addressing changes in subsurface N loss under different tillage systems. Three of the studies (Angle et al. 1989, Angle et al. 1993, Zhu and Fox 2003) reported no difference or interaction in N leaching between conventional tillage and no-till systems. A fourth study (Owens 1987) reported a small (3 percent) increase in leaching for no-till systems compared to conventional tillage. On the contrary, Menelik et al. (1990) found less N loss from the soil profile under no-till versus conventional tillage. On the whole, the Panel members agreed that the results reported in the literature support an assumption that the rate of N leaching does not vary based on tillage practices.

3.2.2 Surface Phosphorus Losses

The Panel used data from each of the following studies conducted on well-drained to moderately well-drained soils to calculate the change in surface P loss with a change in tillage from conventional/high tillage to conservation tillage (full citations are provided in Section 7).

- Angle et al. 1984
- Benham et al. 2007
- Butler and Coale 2005

- Mostaghimi et al. 1988
- Ross et al. 2001

The surface P loss reduction was averaged across all of the studies. Each of the studies included in the average was conducted in the Chesapeake Bay watershed. Means and simple statistics describing the values are included in Table 6.

The Panel found only a single study conducted on poorly-drained soils that reported runoff P losses under conventional and conservation tillage (Kleinman et al. 2002).

Data from studies reporting surface P losses for conservation tillage and HRMSD were used to calculate the relative difference between those practices. The difference in surface P losses between the two practices was averaged across all studies conducted on well-drained or moderately well-drained soils and across all studies conducted on poorly-drained soils. All of the studies used were conducted in the Chesapeake Bay watershed and the Panel agreed that the study practices are representative of those used on farmland in the Bay. The Panel used data from the following studies to calculate the difference in surface P losses between HRMSD and conservation tillage for well-drained or moderately well-drained soils:

- Benham et al. 2007
- Kleinman et al. 2009
- Johnson et al. 2011
- Ross et al. 2001
- Sharpley and Kleinman 2003

The Panel used data from the following studies to calculate the difference in surface P losses between HRMSD and conservation tillage for poorly-drained soils:

- Verbree et al. 2010
- Staver 2004
- Kibet et al. 2011
- Kleinman et al. 2009

In an attempt to compare the phosphorus loss values estimated from the literature with those from other sources, the Panel evaluated scenarios using the Annual Phosphorus Loss Estimator (APLE) model. The soil series Emporia, Pamunkey, Norfolk, Bojac, State, Cecil, Hagerstown, Frederick, Pope, Ernest and Laidig were modeled at both high and very high soil test levels over a range of total nutrients applied as manure (Table 8). Overall, when comparing conventional/high tillage to HRMSD, the model estimated a 55 percent reduction and an 11 percent increase when soil test levels were high and very high, respectively.

Table 8. Surface P loss reduction estimates from the APLE model by physiographic region and relative soil test level

Region							
Coastal Plain		Piedmont		Ridge and Valley		Plateau	
Relative Soil Test P Level							
High	Very High	High	Very High	High	Very High	High	Very High
P Loss Reduction, Conventional/High Tillage to HRMSD							
-48%	108%	-56%	-16%	-57%	-16%	-60%	-31%

The Panel used a single study, McDowell and McGregor 1984, to derive an estimate the relative difference in surface P losses between conservation/high tillage and low-residue, strip-till/no-till.

3.2.3 Sediment

The Panel calculated the average annual sediment loss for systems under low-residue, strip-till/no-till and conventional/high tillage based on sediment data provided in the following studies (full references provided in Section 7):

- McDowell and McGregor 1984
- Wendt and Burwell 1985
- Myers and Wagger 1996

The annual average loss under each tillage system was then used to calculate the relative decrease in sediment loss between conventional/high tillage and low-residue, strip-till/no-till. The three available studies were not conducted in the watershed, but climate and soil texture for the study locations are sufficiently similar to those in the Bay Watershed to support data applicability. The Panel extracted data for the relevant treatments from each study; in some cases it was necessary to estimate the percent cover based on the practice descriptions in the literature. Those estimates were developed using best professional judgement based on RUSLE2 runs using similar practices, the Panel's knowledge of conservation tillage systems, and the *Conservation Tillage Systems and Management* handbook (Dickey and Siemens 1992). The Panel averaged the sediment loss over the three studies and multiple treatments to estimate the relative difference in annual sediment loss for systems under low residue, strip-till/no-till and conventional/high tillage.

The Panel relied on the work of the previous Phase 5.3.2 Conservation Tillage Panel for reductions in sediment loss under conservation tillage and HRMSD, and therefore refers to the Phase 5.3.2 Conservation Tillage Expert Panel report (2014) for a discussion of the use of relevant references to derive those efficiencies.

4 Application of Practice Effectiveness Estimates

The Phase 6.0 Conservation Tillage practices are simulated as BMPs with associated N, P, and sediment reduction efficiencies. Credit for a tillage practice requires achievement of both the residue and the soil disturbance portions of the definition. Tillage practices can be reported in either acres or percentage of acres implementing the practice. The BMP addresses P (Table 5) and N and sediment (Table 4) loads from agricultural land uses where conservation or reduced tillage practices are implemented.

The usefulness or effectiveness of reduced tillage varies by the item of interest (N, P or sediment), the amount of residue present and potentially the soil test P value (affecting P loss) and slope (affecting P and sediment loss).

Panel recommendations are based on values derived from peer-reviewed literature from studies either conducted in the Chesapeake Bay Watershed or under applicable conditions. Studies included sites treated with dairy manure, poultry litter and commercial fertilizer. Both small plot rainfall simulations and natural rain, small watershed studies were present in the dataset as were the use of slightly different tillage tools. This variation in study conditions likely helps ensure that the results are representative of the various conditions actually present in the watershed, but the limited number of studies does not allow a critical mass of data that can be further subdivided (e.g., based on fertilizer type, soil test P, slope).

4.1 Geographic Considerations

Conservation Tillage can be applied to specified land uses everywhere within the Chesapeake Bay Watershed. The practices may have localized limitations on applicability, including steep slopes, stony soils, and wet conditions. Nitrogen reduction efficiencies are different for the Coastal Plain and the Uplands based on different runoff/infiltration partitioning coefficients. Phosphorus reduction efficiencies vary by the proportion of well-drained versus poorly drained eligible cropland with an HGM region.

Conservation Tillage practices apply to the Phase 6.0 Agricultural Land Uses listed in Table 9.

Table 9. Phase 6.0 Agricultural Land Uses eligible for Conservation Tillage Practices.

Land Use	Description
Full Season Soybeans	Soybeans ineligible for double cropping
Grain with Manure	Corn or sorghum for grain eligible for manure application and ineligible for double cropping
Grain without Manure	Corn or sorghum for grain ineligible for manure application and ineligible for double cropping
Silage with Manure	Corn or sorghum for silage eligible for manure application and ineligible for double cropping
Silage without Manure	Corn or sorghum for silage ineligible for manure application and ineligible for double cropping
Legume Hay	Legume forage crops eligible for manure
Small Grains and Grains	Small grains and grains other than corn or sorghum eligible for manure and ineligible for double cropping
Small Grains and Soybeans	Soybeans double cropped with small grains and ineligible for manure
Specialty Crop High	Specialty crops with relatively high nutrient inputs with some crops eligible for manure
Specialty Crop Low	Specialty crops with relatively low nutrient inputs with some crops eligible for manure
Other Agronomic Crops	Other high commodity row crops such as tobacco, cotton, etc., with some crops eligible for manure
Other Hay	Non-legume forage crops eligible for manure
Pasture	Grazed land that receives direct manure deposition from animals

The baseline condition for each conservation tillage practice is assumed to be conventional/high tillage where tillage practices result in 15 percent residue or less after harvest or where post-harvest residue is less than 30 percent or less and full-width tillage is used. The proposed efficiencies represent edge-of-field reductions relative to conventional/high tillage practices for the acres where the conservation or reduced tillage practice is applied.

4.2 Temporal Considerations

Tillage practices are an annual practice and are expected to be fully functional (i.e., achieve full reductions) in each year that they are implemented. Efficiency estimates are appropriate year round as the definition defines the minimum amount of residue needed at seeding of the next crop in rotation, the time when residue carryover should be least.

4.3 Practice Limitations

Potential interactions with other practices include those mentioned earlier: cover crops, manure injection/incorporation, and nutrient management No relevant environmental impact of this practice other than previously mentioned for N, P and sediment is expected.

4.4 Modeling Considerations

Currently, two of the three management levels for the existing Conservation Tillage definition are modeled as land uses and only one of the management levels is modeled as a BMP; that level (HRMSD, currently designated “HR Till” in the model) is only available to a subset of the low till land use acreage. The revised definition and efficiencies for Phase 6.0 simplify application of the Conservation Tillage management levels in the model by applying all effectiveness estimates as edge-of-field reductions in surface total N, surface total P and total sediment from agricultural land uses, relative to nutrient and sediment loads resulting from conventional/high tillage systems.

The practice is described based on the defined levels of residue cover and the evidence of the extent of surface soil disturbance by practices other than seeding. Additionally, the Panel described cropping and tillage management practices that would likely result in the surface cover levels for various tillage categories (Table 3).

Verification will be possible through field visits (using CTIC protocol) and records of implementation of NRCS practice codes, either 329 or 345. Remotely sensed (aerial/satellite) estimates are also likely feasible given proper calibration.

5 Practice Monitoring and Reporting

5.1 Phase 6.0 Conservation Tillage Tracking, Verification, and Reporting

In Phase 6, states are responsible for reporting county acres or percentages for conservation tillage practices to the National Environmental Information Exchange Network (NEIEN) for all years. If a state does not have information beyond the latest CTIC values for a county, they should continue to report the latest CTIC values to NEIEN in future years. However, the full implementation of CBP BMP verification requirements in 2018 will necessitate the tracking and reporting of practice implementation data for future reduction credits.

The Panel recommends that conservation tillage practice implementation tracking, verification, and reporting on a county-by-county or state-by-state basis be based on the premise that the practices represent Visual Assessment (Single Year) BMPs. States will report BMP implementation annually to the CBPO as the number or percentage of acres meeting the definitions and qualifications set forth by the Panel in this report for low residue strip-till/no-till, conservation tillage, and HRMSD BMPs.

Conservation tillage BMPs represent an historic and expanding suite of BMPs for the CBP modeling tools over the history of the Program. As such, conservation tillage BMPs are included in the jurisdictions' verification plans that were submitted to the CBP in late 2015. As with all BMPs, the jurisdictions will be expected to document their verification protocols and procedures in their Quality Assurance Project Plans (QAPP) for conservation tillage BMPs that are reported to the CBPO for N, P, and sediment crediting reductions. The jurisdictions will determine if modifications of those verification plans are required after this Expert Panel recommendation report is approved by the CBP partnership following the WQGIT BMP Protocol, and before the jurisdictions are able to start reporting these BMPs in the Phase 6 modeling tools for annual progress implementation. As the states consider how to verify conservation tillage BMPs and as they document those procedures in their QAPPs, state partners should follow the existing Agriculture Workgroup's (AgWG) BMP Verification Guidance (http://www.chesapeakebay.net/about/programs/bmp/additional_resources).

The current verification guidance from the AgWG organizes BMPs into three general categories: Visual Assessment BMPs (Single Year), Visual Assessment BMPs (Multi-Year), and Non-Visual Assessment BMPs. The complete AgWG guidance is quite extensive and is not restated in this section; the Panel refers to the AgWG guidance for additional detail and definitions of these assessment methods. The Panel is not proposing any new or unique aspects of BMP verification for purposes of the BMPs described in this report. This section simply explains how the recommended BMPs correspond to the existing BMP verification guidance.

Conservation tillage practices are often part of a larger conservation management system or plan that often involves multiple management and physical components (e.g., grassed waterways, diversions) that can be visually assessed over time. Conservation practices as part of systems or plans also incorporate single year visual components (e.g., tillage and crop residue management), in addition to other documentation as needed under applicable state or federal agricultural programs, and/or permits. Thus, conservation tillage BMPs can reasonably be verified using elements of the Visual Assessment (Single-Year) category described by the AgWG.

Each state will determine the most appropriate methods for verifying conservation tillage BMP implementation given their specific priorities, programs, needs, and capacity. For example, one state may leverage existing farm site visits to also verify that the operation meets applicable conservation tillage BMP definitions as recommended by the Panel. Another state may implement field transect surveys based on the CTIC standards to provide sufficient county-level verification, incorporating quality assurance and quality control (QA/QC) spot-checks. Ideally, states will leverage multiple existing and perhaps new avenues to verify that conservation tillage practices are sufficient to meet the BMP criteria as determined by a trained and/or certified independent third party, and that the data records are accurate and up-to-date.

Jurisdictions can follow the AgWG's guidance for Visual Assessment (Single Year) BMPs to verify the low residue strip-till/no-till, conservation tillage, and HRMSD BMPs recommended in this report for N, P, and sediment reduction credits in the Phase 6 Chesapeake Bay Watershed Model. Verification for Visual Assessment (Single Year) BMPs depends more on an annual visual assessment of physical features than on oversight and checks on operational records or documentation.

The N, P, and sediment reductions for conservation tillage BMPs described in this report are to be based on the verified required elements of the conservation tillage BMPs following the AgWG's guidance for Visual Assessment (Single Year) BMPs. Because Conservation Tillage is an annually reported BMP, the most important criteria (i.e., soil residue cover and disturbance) could be documented in records available to the applicable state agency. Given the close association between conservation tillage and other CBP-approved BMPs (e.g., conservation planning, manure incorporation and injection) the state agency can potentially use relevant data or associated verification methods for other reported BMPs to verify the type and acres that were managed via one of the conservation tillage BMPs described by the Panel. If the state agency finds that this basic information cannot be verified through its spot-checks, transect surveys, or other annual BMP verification procedures described in its QAPP, then the BMP cannot satisfy the definitions and expected N, P, and sediment reductions described in this report.

For more information about the CBP Partnership's BMP Verification Framework

The full CBP partnership BMP Verification Framework is available online at http://www.chesapeakebay.net/about/programs/bmp/additional_resources (scroll down to October 2014 Basinwide BMP Verification Framework Document).

The current AgWG's BMP Verification Guidance is included in Appendix B of the full Framework Document, available at http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf.

5.2 Future Verification of Conservation Tillage Practices

The Panel envisions that potential opportunities may exist in the future for utilizing alternative forms of BMP verification, such as remote sensing from satellite, aerial, and drone imagery.

6 Data Gaps and Research Needs

University recommendations for P nutrient application are based on crop- and site-specific soil test P concentration. Currently, soil test P concentration data for cropland in the watershed are not available to the CBP. The Panel recommends that, in the future, crop- and site-specific soil test P concentration data should be collected, aggregated to the appropriate scale, summarized to eliminate disclosure of confidential business information, and used as the foundation for determining P application rate goals. Methods to incorporate soil test P level and potential for surface, soluble P loss should be included where appropriate. Studies that include the interaction of soil test P level, placement, and agricultural drainage category will be necessary.

Calibration of remotely-sensed information for residue cover data should be continued and expanded through the watershed.

As new studies are conducted and new information generated, the assumptions in this report should be revisited.

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Appendix A: Technical Requirements for Reporting and Simulating Conservation Tillage Practices in the Phase 6 Watershed Model

Background: In June, 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert report. The purpose of the technical appendix is to describe how the expert panel's recommendations will be integrated into the modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Q1. What are the definitions of the conservation tillage practices?

A1. Any tillage routine that achieves less than 15 percent crop residue coverage immediately after plating each crop is considered conventional tillage, and does not qualify for the conservation tillage practice credits. The definitions for those conservation tillage practices which do qualify are listed below:

Low Residue Tillage – A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 15 to 29 percent crop residue coverage immediately after planting each crop. Some common practices that qualify under this definition are: NRCS practice code 329; strip tillage and no-tillage; and reduced tillage as defined by CTIC.

Conservation Tillage – A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 30 to 59 percent crop residue coverage immediately after planting each crop. Some common practices that qualify under this definition are: NRCS practice code 345; mulch tillage as defined by CTIC; and ridge tillage as defined by CTIC.

High Residue, Minimum Soil Disturbance Tillage – A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain at least 60 percent crop residue coverage immediately after planting each crop.

Q2. What are the nutrient and sediment reductions associated with each conservation tillage practice?

A2. The panel recommended varying nutrient reductions by hydrogeomorphic region, but keeping sediment reductions consistent across all regions. The nutrient and sediment reductions for each practice are listed in the table below.

Nutrient and Sediment Reductions from Conservation Tillage Practices

HGMR	N Reductions			P Reductions			Sediment Reductions		
	Low Residue	Conservation Tillage	High Residue	Low Residue	Conservation Tillage	High Residue	Low Residue	Conservation Tillage	High Residue
Appalachian Plateau, Siliciclastic	0.05	0.1	0.14	0.07	0.17	0.27	0.18	0.41	0.79
Appalachian Plateau, Carbonate	0.05	0.1	0.14	0.07	0.27	0.38	0.18	0.41	0.79
Blue Ridge	0.05	0.1	0.14	0.08	0.5	0.63	0.18	0.41	0.79
Coastal Plain Dissected Upland	0.02	0.04	0.12	0.08	0.35	0.47	0.18	0.41	0.79
Coastal Plain Lowland	0.02	0.04	0.12	0.06	0.02	0.11	0.18	0.41	0.79
Coastal Plain Upland	0.02	0.04	0.12	0.07	0.16	0.26	0.18	0.41	0.79
Mesozoic Lowland	0.05	0.1	0.14	0.07	0.21	0.32	0.18	0.41	0.79
Piedmont Carbonate	0.05	0.1	0.14	0.09	0.6	0.74	0.18	0.41	0.79
Piedmont Crystalline	0.05	0.1	0.14	0.09	0.58	0.71	0.18	0.41	0.79
Valley and Ridge Carbonate	0.05	0.1	0.14	0.09	0.57	0.71	0.18	0.41	0.79
Valley and Ridge Siliciclastic	0.05	0.1	0.14	0.08	0.49	0.62	0.18	0.41	0.79

Q3. Which land uses can receive nutrient and sediment reductions for qualifying conservation tillage practices?

A3. All land uses that require a tillage routine to plant and maintain crops will be eligible for the conservation tillage practice benefits. Those land uses are:

- Full Season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Small Grains and Soybeans
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops

Q4. Are the conservation tillage practices considered annual practices for NEIEN reporting purposes?

A4. Yes. States should submit acres which qualify under each practice each year.

Q5. Can conservation tillage practices be combined with other practices to treat runoff from agricultural land uses?

A5. Yes. For example, a single acre of cropland could be eligible for reduction credits from conservation tillage, manure injection, nutrient management, cover crops and upslope reductions from buffers.

Q6. What information should a state report to NEIEN in order to receive credit for conservation tillage practices?

A6. States should report the following information to NEIEN.

- *BMP Name:*
  - Low Residue Tillage may be reported under the names: Reduced Tillage
  - Conservation Tillage may be reported under the names: Conservation Tillage; Mulch Tillage; No Tillage; and Ridge Tillage
  - High Residue, Minimum Soil Disturbance may be reported under the name, High Residue Tillage Management
- *Measurement Name:* Acres
- *Land Use:* Approved NEIEN agricultural land use classes; if none are reported, the default will be CROP
- *Geographic Location:* Approved NEIEN geographies: County; County (CBW Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW Only)
- *Date of Implementation:* Year residue cover was observed.

Q7. Can an acre qualify for multiple conservation tillage practices?

A7. No. Each acre may qualify for only one conservation tillage practice based upon the residue cover stated in the definitions for each practice above.

Appendix B: Conservation Tillage Phase 6.0 Expert Panel Charge Document

Recommendations for the Conservation Tillage Phase 6.0 Expert Panel
Prepared for the Chesapeake Bay Program Partnership's Agriculture Workgroup by the Conservation Tillage Phase 6.0 Expert Panel Establishment Group
March 4, 2015

Background

The current version of the Chesapeake Bay Program (CBP) partnership's Watershed Model (Phase 5.3.2) includes three management levels for crop residue management. High till (0-29% crop residue) otherwise known as conventional tillage, and low till (30+% crop residue) known as conservation tillage, are both simulated as land uses and not as BMPs. A subset of the low till acreage is eligible for the High Residue, Minimum Soil Disturbance Tillage (HRTill) Management BMP, which is defined as "a crop planting and residue management practice in which soil disturbance by plows and implements intended to invert residue is eliminated. Any disturbance must leave a minimum of 60% crop residue cover on the soil surface as measured after planting. This annual practice involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living and dead material) is to be met immediately after planting of each crop." The HRTill practice can be combined with other associated, applicable BMPs for additional reductions, including nutrient management and cover crops.

The Phase 5.3.2 Conservation Tillage Expert Panel (EP) recognized the potential for including additional management levels for crop residue management in the Phase 6 modeling tools, which have been documented by USDA-NRCS and implementation data captured by the Conservation Tillage Information Center (CTIC). The ability to potentially incorporate a more diverse representation of crop residue management in the Phase 6 models, and to recognize these as BMPs versus land uses, is an area of interest for the partnership. Crop residue implementation data is currently represented in the CTIC database for the following categories:

- Conventional Tillage 0 - 15% Residue
- Reduced Tillage 15 - 30% Residue
- Mulch Tillage >30 % Residue
- Ridge Tillage >30 % Residue

The Conservation Tillage Expert Panel Establishment Group (EPEG) was formed to:

- Identify priority tasks for the Conservation Tillage Phase 6.0 EP,
- Recommend areas of expertise that should be included on the Conservation Tillage Phase 6.0 EP, and
- Draft the Conservation Tillage Phase 6.0 EP's charge for the review process.

From February 10, 2015 through March 2, 2015 the EPEG met 3 times by conference call and worked collaboratively to complete this charge for presentation to the Agriculture Workgroup (AgWG) on March 18-19, 2015. Members of the EPEG are listed in Table 1.

Table 10. Conservation Tillage Phase 6.0 Expert Panel Establishment Group membership and affiliations.

Member	Affiliation
Dale Gates	US. Department of Agriculture-Natural Resources Conservation Service
Jeff Hill	Lancaster County Conservation District
Tim Sexton	Virginia Department of Conservation and Recreation
Wade Thomason	Virginia Tech
EPEG Support Staff	
Mark Dubin	University of Maryland
Emma Giese	Chesapeake Research Consortium
Jennifer Ferrando	Tetra Tech, Inc.

Method

The Conservation Tillage EPEG developed its recommendations in accordance with the process specified by the AgWG (AgWG 2014). This process is informed by the strawman proposal presented at the December 11, 2014 AgWG meeting, the Water Quality Goal Implementation Team (WQGIT) Best Management Practice (BMP) protocol, input from existing panelists and chairs, and the process recently undertaken by the AgWG to develop the charge for the Manure Treatment Technologies EP.

The collective knowledge and expertise of EPEG members formed the basis for the recommendations contained herein. Most of the EPEG members have had experience on BMP expert panels, including the Phase 5.3.2 Conservation Tillage EP. EPEG members and the technical support team also have knowledge and/or expertise in state and federal programs, the Chesapeake Bay model, and conservation tillage practices within the Chesapeake Bay watershed.

Communication among EPEG members was by conference call and email. All decisions were consensus-based.

Recommendations for Expert Panel Member Expertise

The AgWG expert panel organization process directs that each expert panel is to include eight members, including one non-voting representative each from the Watershed Technical Workgroup (WTWG) and Chesapeake Bay Program modeling team. Panels are also expected to include three recognized topic experts and three individuals with expertise in environmental and water quality-related issues. A representative of USDA who is familiar with the USDA-Natural Resources Conservation Service (NRCS) practice standards should be included as one of the six individuals who have topic- or other expertise.

In accordance with the WQGIT BMP protocol, panel members should not represent entities with potential conflicts of interest, such as entities that could receive a financial benefit from Panel recommendations or where there is a conflict between the private interests and the official responsibilities of those entities. All Panelists are required to identify any potential financial or other conflicts of interest prior to serving on the Panel. These conditions will minimize the risk that Expert Panels are biased toward particular interests or regions.

The Conservation Tillage EPEG recommends that the Conservation Tillage Phase 6.0 EP should include members with the following areas of expertise:

- Tillage and cropping practices in the Chesapeake Bay watershed jurisdiction(s).Knowledge of the CTIC National Crop Residue Management Survey.
- Experience with carrying out research projects relating to conservation tillage.
- Expertise in fate and transport of nitrogen, and/or phosphorus, and/or sediment in agricultural systems under various tillage management systems.
- Knowledge of how BMPs are tracked and reported, and the Chesapeake Bay Program partnership's modeling tools.
- Experience with verification of conservation tillage practice implementation.
- Knowledge of, and experience with, USDA-NRCS conservation practice standards and codes.

Staff from the Chesapeake Bay Program and Tetra Tech will provide technical support for the Conservation Tillage Phase 6.0 EP.

Expert Panel Scope of Work

The general scope of work for the Conservation Tillage Phase 6.0 EP will be to define and configure the Conservation Tillage BMPs in the Phase 6.0 model. The EP will review the Phase 5.3.2 definitions and effectiveness estimates for both Conservation Tillage and HRTill and make adjustments or modifications as needed for Phase 6.0. The EP also will determine which Phase 6.0 land uses conservation tillage practices can be applied to. This scope of work addresses conservation tillage reduction efficiencies for N, P, and sediment.

The panel will work with the Agriculture Workgroup and Watershed Technical Workgroup to develop a report that includes information as described in the Water Quality Goal Implementation Team's *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*[2] (see Attachment 1).

Specifically, the Conservation Tillage EPEG recommends the following five charges with associated tasks for the Conservation Tillage Phase 6.0 EP:

1. Evaluate the existing Phase 5.3.2 representation of Conventional Tillage (HiTil) and Conservation Tillage (LoTil) land uses and provide recommendations where scientifically supported to define low residue management systems as BMPs vs. land

[2] http://www.chesapeakebay.net/documents/Nutrient-Sediment_Control_Review_Protocol_v7.14.2014.pdf

uses, with associated nutrient and sediment efficiency values, using existing CTIC data as a reference.
2. Consider how to structure the Conservation Tillage BMPs to incorporate the HRTill BMP and determine whether the HRTill BMP will need any adjustments to fit with the management levels proposed for Phase 6.0.
3. If feasible, develop a relationship matrix between visual assessments of residue cover (e.g. CTIC) and residue levels predicted by USDA-NRCS index tools (e.g. RUSLE2) to allow cross-referencing between the two assessment methods.
4. Incorporate winter vegetation cover as part of a definition value for enhancing crop residue levels for crediting.
5. Consider sediment and phosphorus load reductions as a function of soil health.

The first charge relates to the current Phase 5.3.2. Chesapeake Bay Model representing conservation tillage as a land use with the addition of the HRTill as a supplemental BMP. Both the land use and the BMP are currently primarily based on visual observation of crop residue levels at planting. The model calibration runs rely on historic data from CTIC's National Crop Residue Management Survey from 1985 to 2004. Calibration for the Phase 6.0 model will need to consider historical data beginning in 1995.

The second EP charge considers how to structure the Conservation Tillage BMPs to incorporate the HRTill BMP and whether the HRTill BMP needs any adjustments to fit with the management levels proposed for Phase 6.0. In evaluating the HRTill BMP, the EP should consider the RUSLE2 runs conducted by the Conservation Tillage Phase 5.3.2 panel to support development of the HRTill BMP and additional RUSLE2 runs conducted as part of the EPEG process (Attachment 2). The EP should use the CTIC historic data (from 1995 through 2004 or 2008, as available in the CTIC database) for visual assessment data.

The third charge pertains to the proposed development of a matrix that describes the relationship between observed crop residue cover and predicted residue levels, and, as appropriate, soil disturbance characteristics, predicted by the NRCS tools. In the early- to mid-2000s, NRCS began moving away from field residue measurements in favor of modeled RUSLE2 outputs (Soil Tillage Intensity Rating [STIR]) and indices (e.g. Soil Conditioning Index [SCI]) to predict residue levels. The matrix should reflect the four categories of crop residue implementation represented in the CTIC database (Conventional Tillage, Reduced Tillage, Mulch Tillage, Ridge Tillage) as well as residue management consistent with the HRTill BMP from the Phase 5.3.2 model.

The fourth charge addresses incorporation of winter vegetation cover as part of a definition value for enhancing crop residue levels for crediting. In several of the Chesapeake Bay jurisdictions, typical farming practices include the establishment of a winter vegetative crop that receive manure nutrients in the fall and is harvested in the following spring. These winter vegetative crops are not eligible for crediting based on the current definitions in the Phase 5.3.2 model for either traditional or commodity cover crops. The EPEG believes that the Cover Crops Phase 6.0 EP will not be able to address systems where nutrients are applied to a cover crop in the fall. However, these systems may provide benefits for reduction of sediment and associated particulate phosphorus compared to fields left fallow over the winter with reduced crop residues. The EP should consider the development of a BMP definition and effectiveness values to account for sediment and phosphorus reductions achieved when winter cover is provided in supplement to reduced crop residues using a vegetative crop that receives fall nutrient applications. The EP should use the USDA-NRCS Soil Health Literature Summary, Matrix of Soil Properties, Matrix Data Dictionary and Summaries and Citations along with other appropriate references and resources in addressing this charge.

A variety of factors, in addition to residue cover, can affect rates of soil loss under various conservation tillage systems. The last panel charge to consider soil health considers soil cover as well as soil structure, organic matter content, and presence of a healthy biotic community. Soil health, therefore, is a more comprehensive representation of the various factors that can affect soil loss. The EP should explore how to incorporate soil health considerations when determining effectiveness values for Conservation Tillage BMPs. For example, a soil with a high functioning soil health system might function better in terms of runoff and erodibility factors than a soil with more residue cover but lower functioning soil health system. The EP should use the USDA-NRCS Soil Health Literature Summary, Matrix of Soil Properties, Matrix Data Dictionary and Summaries and Citations along with other appropriate references and resources in addressing this charge.

Timeline and Deliverables

The Expert Panel project timeline for the development of the panel recommendations is based on the Phase 6.0 model development schedule. This timeline includes the development of a provisional recommendation for this BMP prior to the finalization of a fully documented recommendation report with effectiveness values. Provisional panel recommendations will be used only for initial Phase 6 model development and calibration, and not for future implementation progress reporting by the jurisdictions.

- April 2015 – Panel stakeholder kickoff meeting
- Spring/Early summer 2015 – Provisional BMP paper

  Based on their written EPEG charge, the panel will develop a proposed scope of work including BMP structure and type, draft BMP definition(s), and initial elements of the BMP such as associated components and conservation practices, and USDA-NRCS associated conservation practice standard codes. Initially identified literature citations will be included to provide a range of potential effectiveness values that the panel will consider and supplement with further evaluation. The panel will present their provisional BMP paper to the AgWG, WTWG, and WQGIT for informational purposes, and for initial partnership comments on the proposed direction of the panel's evaluation. The paper will not represent a full recommendation report, and the partnership will not be asked for formal approval at this time.

- Prior to October 1, 2015 – Target date for partnership approval of full panel recommendations (see Attachment 1 for an outline of the final report).

  If approved by the partnership, the CBPO modeling team will build the recommendations in to the Phase 6 Beta Scenario Builder tool to meet an early October deadline. If a partnership approved panel report will not be available at this time, the CBPO modeling team will request a decision by the partnership of whether the BMP will be represented using the Phase 5.3.2 information, or if the panel's provisional paper will be the interim representation of the BMP.

- Early October 2015 – All inputs are final and delivered to the WSM by the Scenario Builder team for the final calibration run. Final targets are based on this information.
- April 2016 – **Final date** for panel to release full recommendations for approval by the AgWG, WTWG, and WQGIT.
- July 2016 – If approved by the partnership, panel recommendations are final and will replace the interim representation of the BMP in the final version of the Phase 6 modeling tools.

Phase 6.0 BMP Verification Recommendations

The panel will utilize the Partnership approved *Agricultural BMP Verification Guidance*[3], as the basis for developing BMP verification guidance recommendations that are specific to the BMP(s) being evaluated. The panel's verification guidance will provide relevant supplemental details and specific examples to provide the Partnership with recommended potential options for how jurisdictions and partners can verify Conservation Tillage practices in accordance with the Partnership's approved guidance.

[3] http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf

Attachment 1: Outline for Final Expert Panel Reports

- Identity and expertise of Panel members
- Practice name/title
- Detailed definition(s) of the practice
- Recommended nitrogen, phosphorus, and sediment loading or effectiveness estimates
  - Discussion may include alternative modeling approaches if appropriate
- Justification for the selected effectiveness estimates, including
  - List of references used (peer-reviewed, unpublished, etc.)
  - Detailed discussion of how each reference was considered, or if another source was investigated, but not considered.
- Description of how best professional judgment was used, if applicable
- Land uses to which the BMP is applied
- Load sources that the BMP will address and potential interactions with other practices
- Description of pre-BMP and post-BMP circumstances, including the baseline conditions for individual practices
- Conditions under which the BMP works:
  - Should include conditions where the BMP will not work, or will be less effective. An example is large storms that overwhelm the design.
  - Any variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.
- Temporal performance of the BMP including lag times between establishment and full functioning (if applicable)
- Unit of measure (e.g., feet, acres)
- Locations within the Chesapeake Bay watershed where this practice is applicable
- Useful life; effectiveness of practice over time
- Cumulative or annual practice
- Description of how the BMP will be tracked, reported, and verified:
  - Include a clear indication that this BMP will be used and reported by jurisdictions
- Suggestion for a review timeline; when will additional information be available that may warrant a re-evaluation of the estimate
- Outstanding issues that need to be resolved in the future and a list of ongoing studies, if any
- Documentation of any dissenting opinion(s) if consensus cannot be reached
- Operation and Maintenance requirements and how neglect alters performance

Additional Guidelines

- Identify ancillary benefits and unintended consequences
- Include negative results
  - Where studies with negative pollution reduction data are found (i.e. the BMP acted as a source of pollutants), they should be considered the same as all other data.
- Include results where the practice relocated pollutants to a different location. Examples include where a practice eliminates a pollutant from surface transport but

moves the pollutant into groundwater, or where the practice will move manure from the farm credited for the practice to another farm more in need of nutrients.

In addition, the Expert Panel will follow the "data applicability" guidelines outlined Table 1 of the Water Quality Goal Implementation Team *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*.

Attachment 2: RUSLE2 runs demonstrating potentially missed benefits based on the Phase 5.3.2 model definitions

RUSLE2 Worksheet Erosion Calculation Record

Background:
With the advent of the RUSLE2 erosion prediction model in the early 2000's, it became possible to more precisely model the effect of soil disturbance from specific tillage systems on soil erosion, soil health, and runoff. Instead of residue levels defining the tillage system, RUSLE2 accurately models tillage system soil disturbance and crop biomass production to define predicted residue levels on a daily time sensitive basis. Thus NRCS has moved away from using only measured residue levels in the field as a sole indication of soil disturbance through tillage. RUSLE2 outputs can compare tillage systems due to their modeled soil disturbance characteristics through a Soil Tillage Intensity Rating (STIR) output. Furthermore, predicted soil surface residue levels are available as outputs at any given time during the management sequence. Other relevant outputs in addition to STIR and residue levels include soil loss, Soil Conditioning Index (SCI), fuel use for the management system, soil detachment level, sediment delivery, and inches of runoff from a hill slope profile.

NRCS maintains two Conservation Practice Standards for Residue and Tillage Management: CPS 329 Residue and Tillage Management –No Till/Strip Till/Direct Seed and CPS 345 Residue and Tillage Management-Mulch Till. Both practice standards require modeling with RUSLE2. CPS 329 has a requirement to be less than full width tillage. Generally anything greater than 40% surface disturbance results in "surface soil splash" and would fall into a full width tillage category. CPS 329 has a maximum allowable STIR of 30 (in most cases the less than full width tillage definition limits the STIR to much less than 30). To meet either standard, relevant soil loss levels and/or soil health objectives must be benchmarked and met.

NRCS uses a Conservation Measurement Tool (CMT) to measure existing levels of conservation stewardship as a requirement for participation in the Conservation Stewardship Program (CSP). Meeting a stewardship threshold is required to enter the program with higher levels of measured stewardship rewarded accordingly. Within the CMT, tillage disturbance is measured through characterization of a producer's tillage system into one of 6 categories. The categories proceed from category (a) through category (f) with the highest levels of disturbance described in (a) and the lowest in (f). The point made through this illustration is that the tillage systems are specified in terms of relative disturbance in addition to providing target residue levels.

a) full width tillage, deeper than 4 inches that involves soil inversion and lifting (such as plows or deep disking). This does not include fertilizer injectors.

b) full width tillage, deeper than 4 inches that involves soil fracturing and lifting (such as sub-soilers, rippers or paraplows).

c) full width tillage performed after harvest and leaves more than 30% residue cover. Does not include seedbed preparation immediately prior to planting of a cover crop.

d) conservation tillage (includes mulch tillage) and maintain greater than 30% residue cover after planting. Residue cover includes crop residues, cover crops, composts or other natural mulch materials; it does not include plastic.

e) no till system that maintains greater than 50% residue cover after planting. Residue cover includes crop residues, cover crops, composts or other natural mulch materials; it does not include plastic.

f) no till system that maintains greater than 75% residue cover after planting. Residue cover includes crop residues, cover crops, composts or other natural mulch materials; it does not include plastic. For systems using perennials with no tillage after year of establishment, include the number of years of perennials. For vineyards, orchards or other permanent crops, enter 1 here.

Discussion:
Two RUSLE2 runs are provided below. The first run provides 7 tillage system alternatives for corn grain (high residue crop). The second run provides 7 similar alternatives for corn silage (low residue). Alternatives start with high disturbance inversion primary tillage (conventional) and proceed incrementally to lower disturbance systems. Residue levels do play an important role in reducing soil loss and runoff as evidenced from the runoff outputs. However in low residue systems there seems to be a benefit potentially missed at residue levels below the 30% residue benchmark defined as a Conservation Tillage (CT) land use. There may be benefits that deserve some credit in low residue systems where there is very low disturbance from tillage and only moderate residue levels as a BMP. Likewise in the high residue crop system there seems to be the potential for benefits missed in a low till, very high surface residue system compared to a moderate residue, moderate disturbance system as BMPs.

Possible Challenges:
1) Is there a need or opportunity to redefine the CT land use to something other than residue levels?

2) Is there a need or opportunity to apply additional BMPs levels?

3) Is there a need or opportunity to define BMPs in terms of tillage system used (either as a system narrative or STIR value) in addition to residue levels?

Info:

Inputs:

Owner name	***Location***	**--**
****Owner name****	**USA\New York\Chenango County**	

Location	*Soil*	*T value*	*Slope length (horiz)*	*Avg. slope steepness, %*
USA\New York\Chenango County	Chenango County, New York\BaC Bath channery silt loam, 8 to 15 percent slopes\Bath Channery silt loam 90%	3.0	100	9.0

High Residue-Corn Grain- Outputs

Description	*STIR*	*Residue cover after plant %*	*SCI*	*Soil detachment, t/ac/yr*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*	*Net Event Runoff in/yr*
Corn Grain High Residue, Full width, inversion, two pass secondary.	117	3.7	.024	4.1	4	4.1	5.1
Corn Grain, full width, non-inversion, 8 in. deep, one pass secondary at 6 in deep, second pass secondary at 2 in deep.	117	30	.14	2.4	2.5	2.4	4.6
Corn Grain, one pass full width, shallow, 4 in. deep	29.9	74	.55	1.9	1.8	1.9	4.7
Corn Grain, one pass deep zone builder, and then plant in zone. Less than 40% surface disturbance.	15.7	77	.63	1.5	1.5	1.5	5.0
Corn Grain, one pass with strip till planter, shallow, 2 in. depth, less than 30% surface disturbance.	5.63	85	.79	0.21	.4	0.21	4.2
Corn Grain, one pass full width, vertical till, shallow, 2 in depth.	5.41	83	.81	0.21	.2	0.21	3.6
Corn Grain, one pass direct seed with No-Till planter	4.00	86	.83	0.21	.2	0.21	3.9

Low Residue-Corn Silage- Outputs

Description	*STIR*	*Residue Cover after plant %*	*SCI*	*Soil detachment, t/ac/yr*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*	*Net Event Runoff in/yr*
Corn silage, full width primary inversion, two pass secondary.	117	<1	-.59	6.95	6.95	6.95	6.3
Corn silage, low residue, full width, non-inversion primary 8 in depth, one pass secondary, 4 in. depth	68.7	9.4	-.31	5.84	5.84	5.84	6.0
Corn Silage, one pass non-inversion, full width shallow tillage, 4 in depth.	29.7	24	-.12	5.39	5.39	5.39	6.0
Corn Silage, one pass deep zone builder then plant in zones. 40% or less surface disturbance.	15.6	26	.012	4.42	4.42	4.42	6.5
Corn Silage, one pass zone till with strip till planter, 2 in depth, 30% surface disturbance.	5.48	30	.16	3.08	3.08	3.08	6.1
Corn Silage, one pass full width vertical tillage tool, 2 in depth.	5.26	32	.22	2.38	2.38	2.38	5.6
One pass direct seed with no-till planter.	3.85	31	.23	2.41	2.41	2.41	5.8

RUSLE2 Users Guide http://fargo.nserl.purdue.edu/rusle2_dataweb/userguide/RUSLE2_User_Ref_Guide_2008.pdf

PA STIR Fact Sheet http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1119754.pdf

Appendix C: Approved Conservation Tillage Expert Panel Meeting Minutes

8/10/2015

Welcome and Introductions
Wade Thomason, Panel Chair, welcomed everyone to the kick-off meeting. Panel members briefly introduced themselves.

Discussion of panel charge
Mark Dubin, Panel coordinator, discussed the tillage BMPs currently included in the Chesapeake Bay Program's Watershed Model, the work of the Phase 5 expert panel in defining high residue minimum soil disturbance as a BMP, and the work needed for the Phase 6 model. Wade reviewed the written scope of work for this Panel as assigned by the Agriculture Workgroup.

Tasks and timeline
Mark discussed the timeline for Panel deliverables, which is also included in the Panel charge. Panel members noted that the CTIC tillage categories listed in the charge, should include no-till in addition to the other four categories.

Open session with panel members and interested stakeholders 10:30-11:15AM
Dr Robert Barr, President, gave a presentation on the NRG Crop Cooperative. You can see access his handout here: http://www.chesapeakebay.net/channel_files/22885/nrg_crops_co-op_-_the_concept,_the_plan_-_08212014_(1).pdf.

Panel-only discussions
Panel members discussed the previous literature search and summary, and began brainstorming categories for Phase 6.0 tillage BMPs.

- Option to break conventional (<30% cover) in to lo and hi (lotill, silage) SCI

Strawman:

- Conventional (<30% cover)
  - SCI low
  - SCI high
- Conservation (> 30%)
  - SCI low
  - SCI high
- HR Till (>60% all crops)
  - SCI high

Mark suggested comparing RUSLE runs to CTIC categories and Bay Program definitions to compare break points for categories of tillage.

Another proposal:

- 0-15 conventional
- 15-30 conservation tillage
  - Lo SQ
  - Hi SQ

- 30-60 conservation tillage
  - Lo SQ
  - Hi SQ
- >60% high residue, low disturbance

What terminology would fit the categories?

- Ridge-till not as common, and may not need its own category.

Should length of no-till be a factor?

- Continuous no-till could be an additional category.
- VA has acres to track and report of CNT. Other states may have ability to do so in the future.
- Panel members decided to include CNT in provisional paper at least.
- Alternative would be to add another higher category for >75% cover.

Follow up actions:

Wade has additional literature to add to the Phase 5 Panel's list of sources.

- Mark Reiter and Sjoerd Duiker will help Wade compile newer literature to add to the existing list.
- Panel members will then divide up the available literature and summarize.

RUSLE2 runs need to define new management levels

- Use the same parameters that were used for the Phase 5 Panel.
- Dale Gates will organize the RUSLE runs.

Draft a provisional paper with the framework outlined by Panel today.

- Mark, Emma, and Wade will draft and distribute provisional paper to the Panel members.

Panel will review the original conservation tillage land use change efficiencies at an upcoming call or meeting.

- Mark will locate original literature sources to inform Panel review.

The Panel will work on the manured winter cover crop portion later in the fall. There will need to be a hybrid effort between this Panel and Phase 6.0 Cover Crop Panel.

- There will be limited data on manured winter cover crop, although Cornell may have some data.

Conference call will be scheduled mid-September to check-in. A second face-to-face meeting will be held in the October timeframe.

Panel members will fill out conflict of interest disclosure forms and return to Mark to keep on file.

- Emma will send out the blank forms for Panel members to sign and return to Mark.

<u>Participants:</u>

Wade Thomason	VT
Dale Gates	NRCS
Bill McCollum	Pioneer
Kevin Ganoe	Cornell
Mark Reiter	VT
Mark Dubin	UMD
Emma Giese	CRC
Bill Keeling	VADEQ
Sjoerd Duiker	PSU

<u>9/8/2015</u>

<u>Actions & Decisions:</u>

ACTION: The panel will move forward with the inclusion of a no-till/strip till (NRCS practice code 329) with 15-30% residue category. Before the next meeting, panel will conduct literature searches in order to

find supporting evidence of this category. Wade to work on collecting this information, and will distribute lists of previous literature searches to the rest of the panel members.
ACTION: Dale will run a few more RUSLE2 scenarios for some low disturbance, full-width tillage programs with corn silage. In the meantime, the panel will consider ways to include these practices into the proposed new category.
ACTION: Panel will provide preliminary recommendation to give to Gary and modeling team so they can calibrate Phase 6 beta version of the model. Panel needs to provide a best guess for % reduction of sediment, Nitrogen, and Phosphorous for each category, in reference to conventional tillage without residue cover.
ACTION: Jeff Sweeney to retrieve modeling information of what the 5.3.2 model credited as a reduction from an acre going from full-width tillage to no-till. This information to help inform Phase 6 % reduction estimates.

Meeting notes:

- Dale Gates reviewed some results of the RUSLE2 simulation (run for New York only) for corn silage alternatives, corn grain and soy alternatives, and corn grain alternatives, and resulting proposed CB Tillage classes for each alternative.
- Proposing 4 levels of tillage/residue management to the committee:
  - 0-15% residue, with Full width tillage (commonly known as "full-on conventional tillage").
  - 15-30% residue, consistent with NRCS Practice 329 (no-till/strip-till), and no Full width tillage.
    - This would be a new category, and as such would require some additional research.
    - Perhaps include a check box asking whether the practice is full-width tillage or no-till/strip-till.
  - 30-60% reside, consistent with NRCS Practice 345 (mulch till).
    - This category would receive reductions associated with conservation till.
  - >60% residue, No-Till-High Residue.
- Wade: Field verification may be an important piece in order to ground-truth some of the practices we predict to see. I'm concerned, though, that it may be difficult to differentiate between parameters when out in the field, without knowing what the actual practices have been.
- Sjoerd: We need to find supporting literature for the reductions in nutrient/sediment loss associated with these practices.
- Kevin: I'm wondering whether the 15-30% residue cover with strip-till would be a worth-while category to have. I wouldn't think that this would be a common practice, at least in my region.
- Bill K: Will there be sufficient variation in nutrients and sediment in the 0-15%, so that you can differentiate between the 15-30%?
  - Dale: I think so, considering the fact that the primary measurement that will be taken in the field is residue cover. Although we still need to work on how we will be able to discern what else was done to a particular fields.
- The panel reached partial consensus on the 4^{th} (15-30% residue) category, but further investigation and research is needed before it can be fully recommended.
- Agenda topics for next meeting:
  - Group to re-convene in a few weeks
  - Status of literature review concerning 4^{th} category (no-till 15-30% residue cover)
  - Valuation of % reductions for sediment, Nitrogen, and Phosphorous.

- What will happen with cover crops and manure in terms of how they will be credited along with reductions in tillage?
- Status of the review of fertilized cover crops.
    - Wade will work on passing information along to Ken Staver (Cover Crops Panel chair) in order to determine which panel will tackle this issue. Possibility of a sub-committee being formed.

Participants:

Wade Thomason	VT
Sjoerd Duiker	PSU
Bill Keeling	VA DEQ
Jennifer Ferrando	Tetra Tech
Kevin Ganoe	Cornell
Lindsey Gordon	CRC Staff
Mark Reiter	VT
Jeff Sweeney	CBP
Dale Gates	NY USDA
Bill McCollum	Pioneer

10/15/2015

Actions & Decisions:
ACTION: Panel will work to incorporate N leaching by residue cover and/or tillage data into the literature review table.
ACTION: Wade will work to incorporate differences among physiographic regions into the N and P loss data.
ACTION: Mark Dubin and Lindsey Gordon to work on scheduling a cross-panel meeting in order to resolve issue of fertilized cover crops.
DECISION: Panel agreed to not assign efficiency values to the full-width tillage 16-30%. Rather, it will be grouped with the 0-15% category.

Meeting Notes:

- Wade reviewed the work that has been made on the literature review and data that's been collected so far for Sediment and P, and presented on tentative early draft relative loads. Mark Reiter reviewed his work on the literature reviews and data mining for Nitrogen.
- Wade to reach out to Ken Staver for additional information on Sediment to collect more references.
- Potentially reach out to Jack Meisinger or Curt Dell to gather some of the USDA ARS data and sources, and Gene Yagow for references from work done by the Ag Land Use Subcommittee.
- Mark Dubin suggested collecting data on physiographic regions of the sources.
- Mark Dubin suggested whether including leachable N in Mark Reiter's graph of % residue after tillage and relative N loss reduction would strengthen the relationship.
- Items for next conference call:
    - Approve meeting minutes from previous 2 meetings
    - Panel to review preliminary recommendations during a follow-up conference call.
    - Postponed discussion of NRCS CP until next meeting, so that Dale Gates may participate.

Participants:

Kevin Ganoe	Cornell
Jennifer Ferrando	Tetra Tech
Wade Thomason	VT
Mark Dubin	UMD
Mark Reiter	VT
Sjoerd Duiker	PSU
Lindsey Gordon	CRC Staff

11/2/2015

Actions & Decisions:
ACTION: Dale and Wade to work together to provide STIR and SCI values from representative cropping systems for the relationship matrix
ACTION: Wade and Sjoerd will work to add additional results to the P loss reduction section.

Meeting notes:

- Meeting minutes were approved from the previous two meetings (9/8/15 and 10/15/15) were approved by the panel
- Wade provided an update on the status of the literature reviews, noting that he had made no significant changes to the sediment piece.
- Wade argued that there is good justification to not separate the sediment piece by physiographic region based on the available data and literature.
- Wade reviewed the literature citations for N leaching, and suggested there is no difference in leaching between no till and conventional till practices on most cropland soils. His recommendation is that N leaching remains constant regardless of the tillage system.
  - Panel agreed with Wade, and noted that the rate of N leaching may be different.
  - Wade stated that the amount of N leached is linearly proportional to amount of N applied. Rate essentially drives losses in regards to N leaching.
- Wade asked the panel how they felt about his proposed methodology to fill in data for the low-res no-till coastal plain data.
  - Panel had no significant comments.
- Panel to work on reviewing P values for all categories, and coming up with a framework for dividing them by physiographic region. Panel also needs to review values that will go into the conservation tillage category.
- Panel discussed purpose of relationship matrix. Bill Keeling expressed concern about how this would be created and implemented, and panel will discuss in future meetings.
- ACTION: Dale and Wade to work together to compile numbers for the relationship matrix
- ACTION: Wade and Sjoerd will work to add more P numbers
- The panel is close to finalizing the sediment values found in the literature, and is almost ready to finalize N numbers. The panel still has to work on P, and will discuss this in their next meeting.
- Topics for discussion during next meeting:
  - Focus on P and review of matrix between cover and NRCS index tools

Participants:

Dale Gates	USDA NRCS
Jennifer Ferrando	Tetra Tech
Kevin Ganoe	Cornell
Wade Thomason	Virginia Tech
Bill McCollum	DuPont Pioneer
Mark Reiter	Virginia Tech
Bill Keeling	VA DEQ
Lindsey Gordon	CRC Staff

3/21/2016

Actions & Decisions:
ACTION: Sjoerd will coordinate with Doug Beegle on incorporation systems in order to potentially include this information in the P component of the literature review.
ACTION: Dale will begin preliminary work to gather more information on linking together CTIC data and RUSLE2 data in order to characterize low till data based on SCI, STIR, and residue after planting values. Dale will begin working on New York as a pilot run of this approach, and will present it back to the group.
ACTION: Jennifer will work on developing this white paper in collaboration with Wade. The draft white paper will be shared with the panel before being presented to the AgWG for approval.

Review of previous discussion

- Wade provided an overview of the nutrient efficiencies they are currently working with, building on the work of the Phase 5.3.2 Cons. Tillage Panel. The panel needs to work on developing values for total P in the low res no-till , conservation tillage and high residue no-tillage categories.
- Duiker: The -5% on low residue no till in the uplands for N – that's the combo of surface loss and sub-surface loss?
    - Thomason: Not quite. It's complex – we estimated the impact of this practice on surface N losses. But then we had to relate that back to overall losses. So we looked only at a reduction in surface N losses, but applied that reduction to only either 15% in the coastal plain or 30% of total losses in the uplands.
    - Duiker: So why not keep -5% there? I'm not quite sure what that means.
    - Keeling: I think that's a 5% efficiency.
    - Thomason: A 5% reduction in N losses compared to conventional tillage in the uplands. There's probably a bigger reduction in surface N losses, but we only applied that back to the total.
    - Duiker: So it's the total of both surface and sub-surface loss N. But not volatilization.
    - Thomason: Correct.

Phosphorus lit review and summary

- Wade reviewed the literature for P low-residue no till. He noted that the sediment piece used 3 studies, including the McDowell study from northern Mississippi. It had a huge sediment loss in the report, which would not be typical of what we would normally see in the Bay watershed. The panel should keep this in mind as they continue their discussions.
- Wade reviewed different approaches to calculating efficiency values for tillage for P.
- Duiker: No residue/no till – is that an important practice that's widely used?
    - Panel agreed that in parts of western MD and eastern PA, this is a fairly common practice.
    - Thomason noted that the Phase 5.3.2 panel mentioned that they would appreciate if the Phase 6 panel would review this.

- Gates: So you've benchmarked between the high residue and conventional?
    - Thomason: In some ways, yes. When we put these numbers in, we'll express these as a relative change in comparison to conventional till or reduced till – one or the other.
    - Gates: That's definitely better than having nothing. Leaving out the outlier data from way outside the watershed that may have no bearing on our watershed is not a bad idea.
- Dubin: The Phase 5.3.2 panel looked at RUSLE2 values, which gave us some framework to work within, so I appreciate seeing the APEL values in here. Did you carry that information out and do a comparison on the research data values that you presented?
    - Thomason: The APEL values are from the presentation given to the Land Use Loading Rates Subgroup - what the model predicted from that particular system, watershed-wide.
    - Dubin: They're not exactly the same numbers as the research data, so I'm looking at the proportional range, or comparison between the two sets.
    - Thomason: That's what that 12% number is – APEL attributes a 12% reduction in P losses from conventional to reduced, so the numbers I ran through as an example would be 31%. You can look at a couple of other ways to look at the difference, and looking at the research data it still comes up around 31%.
    - Dubin: So the APEL numbers are a little more conservative than the research papers (without McDowell).
    - Thomason: If you mean lower, then yes.
- Dubin: What was the scale of the research plots?
    - Thomason: They're small. The ones in Mississippi were 4x20 meters. Typical research size, though.
- Dubin: We saw some research data from Jack Meisinger last week for the Cover Crops panel. Do you think there's any value in looking at that information?
    - Thomason: Specifically, what?
    - Dubin: Using those variations of tillage in the lysimiter tests, and I just was thinking whether there was a correlation in there for us.
    - Thomason: I don't think so in that particular set, because they didn't measure any runoff due to the design of the lysimeters "container"
- Wade asked the panel for alternative suggestions on data for P efficiencies on low residue no till.
    - Mark suggested a colleague's unpublished data that might be useful for the panel to review. He suggested resources from the ARS.
- CTP needs to consider whether to remove the McDowell report from the literature review for P values on low residue no till. This would bring the n value down to 1, but may improve the variation in the values between the two sources.
- Duiker: In the Wisconsin study – was that all no-till? Because they only have low-cut silage, high-cut silage, and grain.
    - Thomason: Correct.
    - Duiker: I was surprised to see such a difference between low-cut and high-cut silage. But you are comparing reduction, where you have low-residue no till, you consider that to be the high-cut silage.
    - Thomason: I used the high-cut silage number, and I averaged it with the no-till silage from the Mississippi study.
    - Duiker: I only mention this because that seems like a huge reduction just by changing the length of stalk cut off.
    - Dubin: Was there any other treatment done on that?
    - Thomason: The only other factors were manure timing. I averaged them all for these treatments based on regressions in that paper. The relative differences among treatments are still pretty high.
- Duiker: And when we say low residue no tillage, that still has a fair amount of cover?

- Thomason: We said 15-30%. This would be at the upper end of that, but within the range.
- Duiker: That low cut silage treatment looked similar to what we consider to be low residue no tillage. But it's classified as conventional tillage.

- Dubin also suggested looking at the work by Doug Beegle on incorporation systems in Rock Springs, and wondered whether there was a control used in that study.
- Duiker proposed that the panel move forward with the data that has been collected by Wade, specifically the second table in the spreadsheet (line 34).
    - Wade proposed that this be used as a draft recommendation, and that the panel vote on this over email or in a future call.

Relating residue-based determination to STIR, SCI, etc.

- Wade and Dale reviewed the RUSLE2 information from the USDA on corn silage alternatives. The panel could generate RUSLE2 runs that would be representative of the cropping systems that would represent certain levels of residue.
- Duiker: What are you going to compare this to? What scenario would the yellow highlighted scenario be?
    - Thomason: An example of how you would end up in that low residue, no till category – strip till corn silage with no more than 40% of the surface disturbed. So a STIR value close to 15 would likely fall into this category.
- Keeling noted that the panel should only use this approach if it is reasonable, and that this is not a requirement in their charge.
- Duiker: So this would be to characterize the practices? Based on the SCI, STIR, and residue after planting values.
    - Thomason: It could be, yes.
    - Dubin: I think the thought here was that NRCS was using different information than CTIC, and if they're developing a conservation plan that's incentivized based on STIR and SCI values, then that could be a way to relate that back to the CBP and a BMP category. It's just that they're using a different measuring stick (RUSLE2), and we wanted to relate that to CTIC.
    - Keeling: Verification is a different animal than what Dubin is discussing. Verification would be more along the lines of a transect survey or measuring tape on actual residue.
    - Dubin: I agree, Bill – verification would be a visual inspection. Using RUSLE2 would not equate to verification by itself.
- Duiker: We were only asked to do this for low residue no tillage because they already have this for the other practices?
    - Thomason: I don't think so – these relative comparisons of STIR and residue cover, or cropping systems and tillage practices that result in a STIR value and predicted residue cover have been run for any of these categories.
    - Dubin: The intent was to look at this and see if creating a comparison would be feasible, and that comparison would be across the board.
    - Thomason: Which brings up a good point – who would be doing this?
    - Dubin: We'd need to work with Dale and his colleagues. If we want help on the CTIC work, then we could have someone work with the group and I could provide the group some assistance to move that forward.
    - Wade will talk to Dale to see if doing this work would be feasible.
    - Gates: I could try to get something going to present to Wade, and maybe pull the rest of the group in to see if we want to continue a broader effort.
    - Thomason suggested Dale start with the low residue as an example.
  - Discussion on translating NRCS practice codes to CBP BMP definitions.

Upcoming white paper (panel status) to AgWG

- Mark Dubin explained that the panels are requested to develop and draft a brief, one-page ‘white paper’ that outlines the BMP definition, generalized structure of the BMP in the Phase 6 model, and the land uses that would be eligible for this BMP. The AgWG would then be able to review these white papers and provide interim approval in order to fast-track BMP incorporation into the model and state historic reporting efforts.
- Keeling: The WTWG has had more issues with the USWG because of them showing up with a finished product and expecting an endorsement. But the protocol says the source sector workgroup in conjunction with the WTWG works on developing this report. So this would help get everyone get up to speed as to where the panel is likely to go.

Panel discussion

- Sjoerd and Wade will work on revising P loss values in the low res no till system.
- Dale to work on examples of using rusle2 runs to generate relative values that would provide residue by STIR, cropping system matrix that could be related back to NRCS practices.
    - The panel will be asked to assist in this effort.
- Jennifer will work on the white paper with Wade and redistribute to the panel with comments.

<u>Participants:</u>

Lindsey Gordon	CRC
Bill McCollum	DuPont Pioneer
Bill Keeling	VA DEQ
Dale Gates	USDA NRCS
Wade Thomason	VT
Jennifer Ferrando	Tetra Tech
Mark Dubin	UMD

<u>8/18/2016</u>

<u>Actions & Decisions:</u>

ACTION: Wade will work to create weighted averages for the P efficiency values across the tillage categories using the cropland data layer, and will present it back to the panel for review.
ACTION: Wade will provide additional information on uncertainty values and the standard deviations of the proposed efficiency values. He will provide additional detail on the literature review results to the panel, and will clarify that the TOTN and TOTP values represent surficial loss.
ACTION: Lindsey and Wade will redistribute the proposed efficiency values for nitrogen and sediment to the panel, and ask for a final adoption of those values to be included in the report. The phosphorous values will not be considered in this poll, and will not be presented to the AgWG at their August meeting.

<u>Meeting notes:</u>

- Wade reviewed the progress made by the panel thus far.
- Bill Keeling: In conventional tillage, we have the description reading <15% cover, and then 15-29% cover. I thought it would include full-width tillage, and the low-residue would be 15-29%.
    - Thomason: The difference is the tillage practice that would be accepted. Even if we had 15-29% coverage and we had full-width till, the numbers we looked at would call it a high-till category.
    - Dubin: The full-width till definition is based on NRCS definitions, and it’s pretty restrictive.

  - Bill Keeling noted that there needs to be clear communication of the differences between the conventional versus low-residue tillage categories.
  - Wade noted that the report would include examples of cropping systems that would fall into the low-residue/no till category.
- Wade proposed to the panel adopt the sediment reduction efficiency value used in the Phase 5.3.2 report (64%) moving from conservation tillage to high-residue till.
  - The panel supported the proposed efficiency values for sediment across the tillage categories.
- Questions regarding how the Manure Incorporation and Injection panel's recommendations will fit within the tillage panel's BMP framework and efficiency values.
- Wade reviewed the results of the Phosphorous literature review.
- Concerns raised about parsing out the efficiency values by hydro-geomorphic regions, specifically for P, and the data informing the efficiency values.

Participants:

Lindsey Gordon	CRC
Wade Thomason	VT
Mark Dubin	UMD
Jennifer Ferrando	Tetra Tech
Bill Keeling	VA DEQ
Mark Reiter	VT
Dale Gates	USDA NRCS
Matt Johnston	UMD

9/28/2016

Actions & Decisions:
ACTION: Wade will revise the proposed P values, and work with Lindsey to distribute a poll to panel members to gauge consensus on the P efficiency values.
Meeting notes:

- Wade reviewed the work of the panel thus far. The panel is currently considering P losses in the watershed for tillage practices, and literature values have suggested a wide range in efficiency values.
- The panel worked to examine the % of well-drained and poorly-drained cropland by county in the watershed. After discussing with the Modeling Team, the panel was able to get these values for hydro-geomorphic regions, and Wade presented maps showing available cropland in the watershed broke out by drainage type.
- Wade reviewed the spreadsheet of P calculations by HGMR, and presented the calculated P loss reduction values for each tillage category across HGMRs.
  - Kevin Ganoe noted that communicating the practices and their definitions clearly will be important in the panel's final report.
  - Sjored asked if these reduction values would be applied across the board to different farming types – dairy farmers and row crop farmers, etc.
  - Panel members expressed support for the proposed values.
- Kevin asked if studies looked at soil test P levels, and Sjoerd asked how many studies informed the calculations.
  - Wade noted that there were roughly 15-20 studies that informed the numbers.

    - Wade: If our objective is to combine soil test P, runoff, and other variables – there are models that can simulate this. We could go to the modelers and recommend they use this, however I'm apprehensive about using model data in another model.
- Sjoerd suggesting breaking out the reduction factors from studies that have a combination of well- and poorly-drained soils in the P Efficiencies spreadsheet to better inform the P efficiency estimates by HGMR. Also expressed concern about using such aggregated and averaged values across the entire CBW.
- Once the panel reaches agreement on the proposed P values, Wade and Jennifer will begin work drafting the report for release to the partnership. Wade, Mark, and Lindsey will work to hold a webinar on the report once it's released.

Participants:

Lindsey Gordon	CRC
Mark Dubin	UMD
Bill McCollum	DuPont Pioneer
Wade Thomason	VT
Kevin Ganoe	Cornell
Jennifer Ferrando	Tetra Tech
Dale Gates	USDA NRCS
Mark Reiter	VT
Bill Keeling	VA DEQ
Sjoerd Duiker	Penn State University

Appendix D: Technical Documentation for Conservation Tillage BMP Efficiency Estimates

Calculations: Sediment efficiencies for Low-residue no-till

Citation	Notes	Treatments	Data and calculations								
McDowell, L. L., and K. C. McGregor. "Plant nutrient											
losses in runoff from conservation tillage corn."											
Soil and Tillage Research 4.1 (1984): 79-91.	northern Mississippi, 1975-77										
	Providence silt loam	CT corn for silage	TRT		sediment, t/ha					Sediment	
	nutrients:	CT corn for grain			1975	1976	1977		est cover, pos	kg/ha	
	170-30-50 (roughly)	Reduced till corn for grain	c-sil		29.89	24.76	17.54		3	24063	
	natural rainfall	NT corn for silage	c-gr		21.61	23.81	7.2		7	17540	
		NT corn for grain	r-gr		1.72	1.62	0.96		35	1433	
			n-sil		0.85	0.64	.		25	745	
			n-gr		0.81	0.82	0.72		82	783	
Wendt, R. C., and R. E. Burwell. "Runoff and soil	Missouri, 1970, 3.2 by 27.5 m plots,										
losses for conventional, reduced, and no-till corn."	Mexico silt loam, 3.3.5% slope, natural										
Journal of Soil and Water Conservation 40.5 (1985):	rainfall										
450-454.											Sediment
		CT for grain	TRT		sediment Mg/ha						kg/ha
		Reduced till for grain		est cover, post, %	1971	1972	1973	1974	1975	1976	
		NT for grain	CG	7	1.3	1.6	1.8	11.7	5.9	0.8	3850
		NT silage with cover	Red-till grain	40	1	1.2	1.1	4.6	4.3	0.4	2100
		NT silage without cover	NT grain	75	0.4	0.4	0.3	0.9	1.4	0.2	600
			NT-sil+cover	24	0.2	0.9	0.70	0.9	2.4	0.1	866.6667
			NT-sil-cover	4	10.5	50.7	10.40	19.6	39	2.1	22050
Myers, J. L., and M. G. Wagger. "Runoff and											
sediment loss from three tillage systems under											
simulated rainfall." *Soil and Tillage Research* 39.1											
(1996): 115-129.	Pacolet silty clay loam, NC	CT corn grain									
		NT corn grain with surface residue		sediment, kg ha-1							
	residue cover was	NT corn silage w/o residue				Date 2			HI		
	>90% in NTG			Date 1		LO	Lo	HI			
	41% in NTS			1990	1991	1990	1991	1990	1991		
	<10% in CT		CT	397	417	564	1154	932	1608		
	at corn planting		NTS	672	186	499	313	735	333		
	about 200 kg N/ha applied, split		NTG	203	21	158	62	208	53		
	simulated rainfall, 2 events,										
	one week apart			cover, %	sediment, kg ha-1						
			CT	8	845.33						
			NTS	41	456.33						
			NTG	90	117.50						

Calculations: Nitrogen reduction efficiencies as a function of residue cover

Citation	Notes	Data and calculations						
McDowell, L. L., and K. C. McGregor. "Plant nutrient losses in runoff from conservation tillage corn." *Soil and Tillage Research* 4.1 (1984): 79-91.	northern Mississippi, 1975-77							
	Providence silt loam	TRT		Runoff NO3 + NH4	Total N	Fert._Lost	Rel_Change	Total N = (Runoff NO3 + NH4) + Sediment T
	nutrients:		est cover, post, %	kg/ha/yr		%	%	
	170-30-50 (roughly)	c-sil	3	3	47.8	28.1176471	0	
	natural rainfall	c-gr	7	3.4	37.9	22.2941176	-20.711297	
	Ammonium nitrate at-planting	r-gr	35	5.3	11.1	6.52941176	-76.778243	
	Side-dressed with urea	n-sil	25	5.6	10.4	6.11764706	-78.242678	
		n-gr	82	4.6	11.4	6.70588235	-76.150628	

Citation	Notes			TRT	est cover, post, %	Runoff Nitrate	Total N	Fert_Lost	Rel_Change	
Shipitalo, Martin J., et al. "Effect of no-till and extended rotation on nutrient losses in surface runoff." *Soil Science Society of America Journal* 77.4 (2013): 1329-1337.	Coshocton, 1990-2005									
				TRT	est cover, post, %	kg/ha/yr		%	%	Runoff NH4 was all less than 1 kg/ha
	Avg. Nitrogen Application Rates to corn:			Chisel	40	9	11	5.38555692	3.23244687	
	Chisel	204.25	kg/ha	Disk	25	6.6	12.1	5.21692266	0	
	No-Till	204.25	kg/ha	NT	75	5.8	11.6	5.67931457	8.86330761	
	Disk inorg	73.9375	kg/ha							
	Disk Org.	158	kg/ha							
	Total Disk	231.9375	kg/ha							
	Disk was a low input system									

Citation	Notes	TRT	est cover, post, %	Runoff NO3+NH4	Sediment	Total N	Fert_Lost	Rel_Change	Total N = Runoff NO3+NH4 + Se
Romkens, M.J.M, D.W. Nelson, and J.V. Mannering. "Nitrogen and Phosphorus composition of surface runoff as affected by tillage method." JEQ (1973). 2(2):292-295.				Runoff NO3+NH4	Sediment	Total N	Fert_Lost	Rel_Change	Total N = Runoff NO3+NH4 + Se
	170 kg N/ha applied to corn	TRT	est cover, post, %	kg/ha			%	%	Two succussive rainfall events a
	using ammonium nitrate	Chisel	38	22.2	4.46	26.66	15.6823529	-47.8584	
		Reduced Tilled	20	16.64	20.38	37.02	21.7764706	-27.59632	
		Conventional	1	1.16	49.97	51.13	30.0764706	0	
		Double Disk	43	12.16	9.1	21.26	12.5058824	-58.41971	
		Reduced Coulter	68.5	45.78	4.87	50.65	29.7941176	-0.938783	

Citation	Notes	Est. Cover		1971	1972	1974			1971 Inorganic N		1972 Inorga	1974 Inorg	3YrTotal_Inorganic	
Chichester, F.W. 1977. Effectsof increased fertilizer rates on nitrogen content of runoff and percolate from monolith lysimeters. JEQ. 6(2):211-217.	N applied in kg/ha for mulch minimum and conventional tilled	Est. Cover		1971	1972	1974			1971 Inorganic N		1972 Inorga	1974 Inorg	3YrTotal_Inorganic	
		%	Watershe	N Rate	N Rate		TRT	est cover,	kg/ha/yr		kg/ha/yr	kg/ha/yr	kg/3year	otalN/3Yea
		100	101C	179	179	56	Grass meadow		0.7		2.1	1.4	4.2	4.5
		70	103A	336	336	178	mulch-minimum		2		4.8	3.2	10	10.3
		1	103B	336	336	178	Conventional		2.2		11.6	14.6	28.4	58.4
		70	103C	672	336	178	mulch-minimum		2.7		2.3	3	8	8.3
		1	103D	672	336	178	conventional		6.4		19.4	21.1	46.9	76.9

Phosphorus loss change, Conventional tillage to Conservation tillage, studies highlighted in blue were conducted on well-drained soils on those in tan conducted, at least partially, on poorly-drained soils.

Literature Citation	Region	Drainage	Soil Type	Total P % change Hi_Till to Conservation-till	Location	Notes
Angle, J. S., G. McClung, M. S. Mcintosh, P. M. Thomas, and D. C. Wolf. 1984. Nutrient losses in runoff from conventional and no-till corn watersheds. J. Environ. Qual., 13:431-435. 2	Piedmont Plateau	Well	Manor Loam	-90%	Howard Co MD, CP	NT vs contour plot+disk harrow+cultipack, barley cover crop on both. Paired watershed studies. Surface runoff water collection, 3 sy summary
Mostaghimi, S., Dillaha, T.A. and Shanholtz, V.O., 1988. Influence of tillage systems and residue levels on runoff, sediment, and phosphorus losses. *Transactions of the ASAE*, *31* (1), pp.128-0132.	Piedmont Plateau	Well	Groseclose silt loam	-71%	Blacksburg, VA, 8-15% slopes, Groseclose silt loam	comparison of conventional tillage (rototill) with NT, rainfall simulation with control, no fert (control) N and P fertilizer (147 and 46 kg/ha respectively), wastewater sludge (147 kg N/ha and 230 Kg P/ha). Mean of sludge P reduction (44%) and fertilizer P reduction (97%)
Butler, J.S. and Coale, F.J., 2005. Phosphorus leaching in manure-amended Atlantic Coastal Plain soils. J. Environ. Qual., 34(1), pp.370-381.	Coastal Plain	Well	Keyport and Donlonton fine sandy loam; Matapeake and Mattapex silt loam	0%	Beltsville, Upper Marlboro, Queestown, Poplar Hill MD; Coastal Plain	NT vs Chisel and disk with broiler litter or dairy manure (after application). P rates of 0 100 200 300 400 kg P/ha
Benham, B., D. Vaughan, M. Laird, B. Ross and D. Peek. 2007. Surface Water Quality Impacts of Conservation Tillage Practices on Burley Tobacco Production Systems in Southwest Virginia. Water Air Soil Pollut 179: 159-166. doi:10.1007/s11270-006-9221-z.	Ridge & Valley	Well	Speedwell sandy loam	-64%	Smyth County, Virginia	Rainfall simulation on 2.1x7m plots at 50 mm/hr. average soil loss kg/ha of 6 runs reported; Speedwell sandy loam, 1% slope; alluvial soil; No till was 82% cover, strip till was 59%, conventional till was 5%
Ross, B. B., Davis, P. H., and Heath, V. L. June 11, 2001. Water Quality Improvement Resulting from Continuous No-Tillage Practices. Final Report. Colonial Soil and Water Conservation District.	Coastal Plain	Well	Pamunkey loam	-93%	Charles City County, VA - Demo at VA Ag Expo	A rainfall simulator was used to demonstrate and evaluate the effectiveness, in terms of NPS pollution control, of various nutrient inputs, as well as corn pre-planting and post-harvest tillage operations in preparation for small grain planting. An average 85.9 mm (3.38 in.) of artificial rainfall was applied to ten runoff plots during three separate runs conducted over a two-day period. During the simulated rainfall events, runoff from the plots was measured and sampled for sediment and
			Mean	**-64%**		
			Median	**-57%**		
Kleinman, P.J.A., A.N. Sharpley, B.G. Moyer and G.F. Elwinger. 2002. Effect of Mineral and Manure Phosphorus Sources on Runoff Phosphorus. J. Environ. Qual. 31: 2026-2033. doi:10.2134/jeq2002.2026.	Plateau	Poor	Hagerstown - Well: Lewbeach - Well; Buchanan - Poor to Mod	149%	Eastern Alleghany Plateau, PA	3 soils, 4 P sources, 100 kg/ha TP applied, rainfall sim

Phosphorus loss change, Conservation tillage to No-tillage, studies highlighted in blue were conducted on well-drained soils on those in tan conducted, at least partially, on poorly-drained soils. Blue text indicates P loss increase in well-drained category.

Literature Citation	Region	Drainage	Soil Type	Total P % change Conservation_Till to NT	Location	Notes
Benham, B., D. Vaughan, M. Laird, B. Ross and D. Peek. 2007. Surface Water Quality Impacts of Conservation Tillage Practices on Burley Tobacco Production Systems in Southwest Virginia. Water Air Soil Pollut 179: 159-166. doi:10.1007/s11270-006-9221-z.	Ridge & Valley	Well	Speedwell sandy loam soil (fine-loamy, mixed, mesic Fluventic Dystrochrepts, coarse-loamy) with moderate permeability, avg 0.8% northeasterly slope	-29%	Smyth County, VA; Ridge and Valley	Rainfall simulation on 2.1x7m plots at 50 mm/hr. average soil loss kg/ha of 6 runs reported; Speedwell sandy loam, 1% slope; alluvial soil; No till was 82% cover, strip till was 59%, conventional till was 5%
Ross, B. B., Davis, P. H., and Heath, V. L. June 11, 2001. Water Quality Improvement Resulting from Continuous No-Tillage Practices. Final Report. Colonial Soil and Water Conservation District.	Coastal Plain	Well	Pamunkey loam soil at 7.5% slope	-4%	Charles City County, Virginia-Coastal Plain	A rainfall simulator was used to demonstrate and evaluate the effectiveness, in terms of NPS pollution control, of various nutrient inputs, as well as corn pre-planting and post-harvest tillage operations in preparation for small grain planting. An average 85.9 mm (3.38 in.) of artificial rainfall was applied to ten runoff plots during three separate runs
Kleinman, P.J., Sharpley, A.N., Saporito, L.S., Buda, A.R. and Bryant, R.B., 2009. Application of manure to no-till soils: phosphorus losses by sub-surface and surface pathways. *Nutrient Cycling in Agroecosystems*, *84* (3), pp.215-227.	Plateau	Well	Clymer sandy loam (coarse-loamy, siliceous, active, mesic Typic Hapludult)	-49%	Eastern Alleghany Plateau, PA	Clymer and Wharton soil, manure application of 30 kg/ha TP, subwatershed, includes leachate
Sharpley, A. and Kleinman, P., 2003. Effect of rainfall simulator and plot scale on overland flow and phosphorus transport. *Journal of Environmental Quality*, *32* (6), pp.2172-2179.	Ridge & Valley	Watson - mod well; Berks - well	Berks loam; Watson clay loam	-39%	FD-36 watershed, Mahantango Creek, PA	Rainfall simulation WEPP unit, 75mm/hr rate, 2 simulation on consecutive days. Berks tilled; Watson in NT corn. Tillage was chisel+disk.
Verbree, D. A., S. W. Duiker, P.J.A. Kleinman. 2010. Runoff losses of sediment and phosphorus from no-till and cultivated soils receiving dairy manure. J. Environ. Qual. 39:1762-1770	Plateau	Hagerstown - Well	Well drained-Hagerstown silt loam soil (fine, mixed, semiactive, mesic Typic Hapludalf) with avg slope of 8%; Poorly drained Buchanan gravelly loam soil (fine-loamy, mixed, semiactive, mesic Aquic Fragiudult) with avg slope of 7%	-49%	Rock Springs, PA	Central PA, limestone derived soil (WD) and colluvium-derived soil (SWPD). 3, 1-hr rainfall events (planting, mid-season,after silage harvest)
Johnson, K. N., Kleinman, P. J., Beegle, D. B., Elliott, H. A., & Saporito, L. S. (2011). Effect of dairy manure slurry application in a no-till system on phosphorus runoff. *Nutrient Cycling in Agroecosystems*, *90* (2), 201-212.	Plateau	Well	Hagerstown silt loam (fine, mixed, semiactive, mesic Typic Hapludalf), 3-5% slope	83%	Rock Springs PA	Treatments: 1) broadcast slurry, chisel incorp, shallow disk injection, pressure injection, aeration with banded appliction, no manure and no tillage. Rainfall simulation 72 hr after application, in two consecutive years; 45 mm rainfall @ 68 mm/hr rain 25-50 year storm event equivalent
			Mean	-14%		
			Median	-34%		
Verbree, D. A., S. W. Duiker, P.J.A. Kleinman. 2010. Runoff losses of sediment and phosphorus from no-till and cultivated soils receiving dairy manure. J. Environ. Qual. 39:1762-1770	Plateau	Buchanan - Poor to Mod	Well drained-Hagerstown silt loam soil (fine, mixed, semiactive, mesic Typic Hapludalf) with avg slope of 8%; Poorly drained Buchanan gravelly loam soil (fine-loamy, mixed, semiactive, mesic Aquic Fragiudult) with avg slope of 7%	51%	Rock Springs, PA	Central PA, limestone derived soil (WD) and colluvium-derived soil (SWPD). 3, 1-hr rainfall events (planting, mid-season,after silage harvest)
Staver, KW. 2004. EFFICIENT UTILIZATION OF POULTRY LITTER IN CASH GRAIN ROTATIONS. Final Report submitted to: Maryland Grain Producers Utilization Board Maryland Center for Agro-Ecology, MCAE Pub. 2004-03	Coastal Plain	Elkton - Poor; Matapeake - Well; Mattapex - Mod Well	Classified within the Elkton, Matapeake, and Mattapex Series (Typic Ochraquults, Typic Hapludults , and Aquic Hapludults) with 0-3% slope and a range in hydraulic characteristics from poorly- to moderately well-drained	238%	Wye Research and Education center in Queen Anne's County Maryland, Coastal Plain	Wye REC, MD: 4-yr study. small watershed scale study. The primary objective of this project was to evaluate the effect of nitrogen-based poultry litter applications on phosphorus and nitrogen transport rates in tilled and no-till settings during a three crop/two year rotation of corn/wheat/double-crop soybeans. Two complete cycles of the rotation were completed. Poultry litter was applied in the spring (3 tons/acre)
Kibet, L.C., Allen, A.L., Kleinman, P.J., Feyereisen, G.W., Church, C., Saporito, L.S. and Way, T.R., 2011. Phosphorus runoff losses from subsurface-applied poultry litter on coastal plain soils. *Journal of environmental quality*, *40* (2), pp.412-420.	Coastal plain	Othello - Poor; Matapeake - Well	Field soils grade from the poorly drained Othello series (fi ne-silty, mixed, active, mesic Typic Endoaquults) to the well-drained Matapeake series (finesilty, mixed, semiactive, mesic Typic Hapludults)	184%	Princess Anne, MD; UMES	Treatments included subsurface application of litter using the USDA–ARS applicator, surface application of litter, immediate incorporation of surface-applied litter by disking (broadcast/disked), and no litter applied (control), Broiler litter at 6.7 Mg ha-1
Kleinman, P.J., Sharpley, A.N., Saporito, L.S., Buda, A.R. and Bryant, R.B., 2009. Application of manure to no-till soils: phosphorus losses by sub-surface and surface pathways. *Nutrient Cycling in Agroecosystems*, *84* (3), pp.215-227.	Plateau	Poor	Wharton clay loam (fine-loamy, mixed, active, mesic Aquic Hapludult)	26%	Eastern Alleghany Plateau, PA	Clymer and Wharton soil, manure application of 30 kg/ha TP, subwatershed, includes leachate

Phosphorus loss change, Conventional tillage to Low residue no-till, studies highlighted in blue were conducted on well-drained soils on those in tan conducted, at least partially, on poorly-drained soils.

Literature Citation	Region	Drainage	Soil Type	Total P % change Conservation_Till to NT	Notes
McDowell, L. L., and K. C. McGregor. "Plant nutrient losses in runoff from conservation tillage corn." *Soil and Tillage Research* 4.1 (1984): 79-91.	MS	Well	Providence silt loam (Typic Fragiudalfs)	-9%	Runoff and soil loss measures on 0.1 ha plots (5% slope). 1975-1977. Treatments were: contentional till corn silage; conventional till corn grain; reduced till corn grain; no-till corn silage; no-till corn grain.

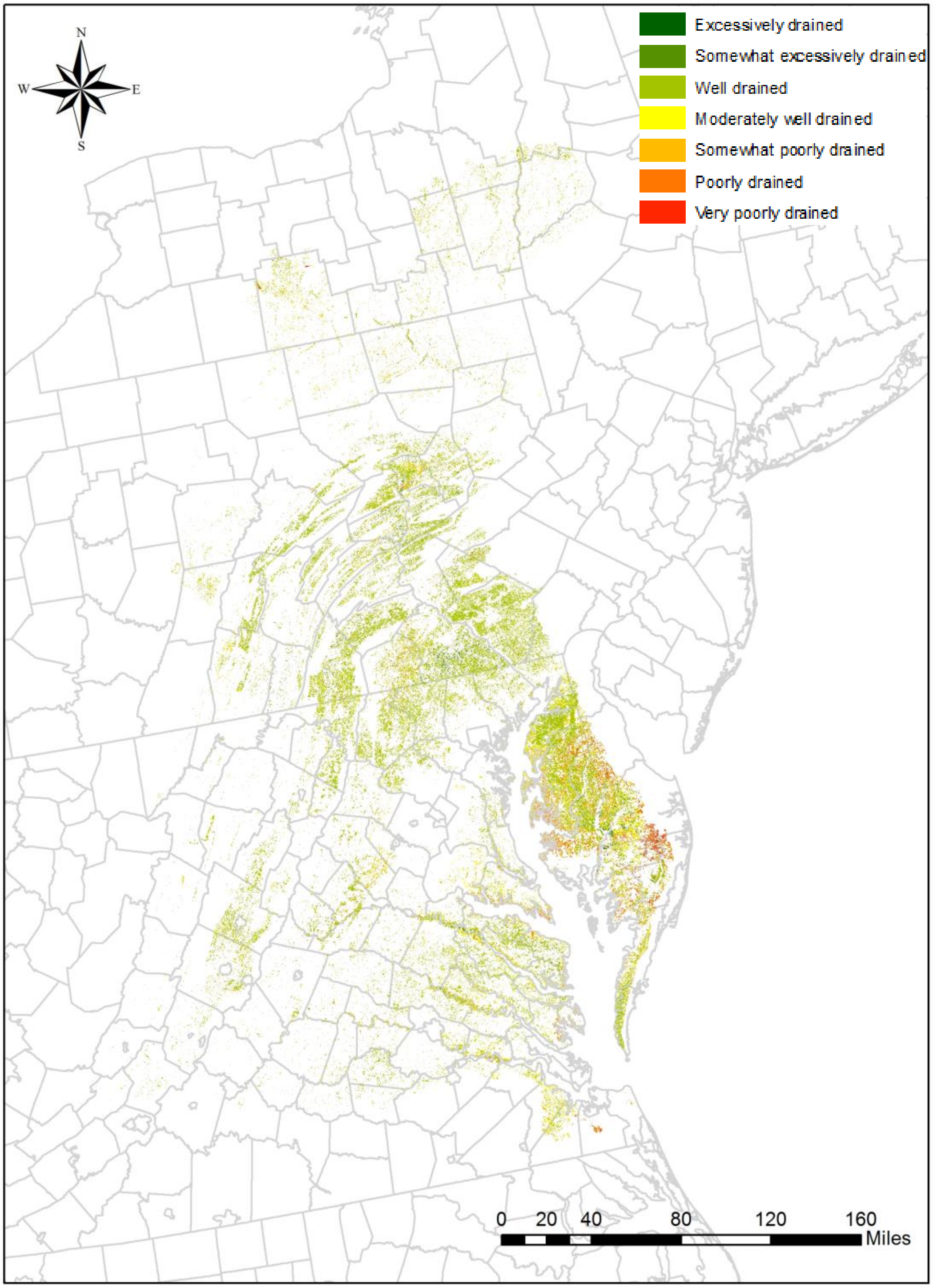
Appendix E: Technical Documentation for Estimates of Cropland by Drainage Class

Area, in m^2 of cropland area in each of the HRM regions in the Chesapeake Bay Watershed by agricultural drainage class.

Drainage	APS	APC	BR	CPD	CPL	CPU
Well Drained (m^2)	792350100	71865900	75294000	1988585100	1308602700	1463210100
Poor Drained (m^2)	256084200	17174700	5688900	347945400	620746200	485221500
%Well	76%	81%	93%	85%	68%	75%

Drainage	ML	PCA	PCR	VRC	VRS
Well Drained (m^2)	794421900	655815600	2260963800	2357144100	1984712400
Poor Drained (m^2)	223376400	13360500	78328800	84371400	161982900
%Well	78%	98%	97%	97%	92%

Chesapeake Bay Watershed cropland acres by agricultural drainage category.



Appendix F: Response to Comments on: Definitions and Recommended Nutrient and Sediment Reduction Efficiencies of Conservation Tillage for use in Phase 6.0 of the Chesapeake Bay Program Watershed Model

Summary of Comments Received on Phase 6.0 Conservation Tillage BMP Expert Panel Report (Version 11/3/16)

General Comments

- **PA SCC & DEP:** Please include the statements made in the Manure Injection and Incorporation report regarding the consistency of the type of NRCS standard tillage practice with the type of manure incorporation. This will link the two reports together, as both types of practices are connected.
    - *Response: This requested language has now been copied into the tillage panel report on 9, in addition to being included in table 2 and in Appendix A.*
- **PA SCC & DEP:** As requested in our comments with the Manure Injection and Incorporation Draft Panel Report, please explain how the Manure Incorporation/Injection nutrient loss reduction efficiencies in Table 2 and 3 compare with the Conservation Tillage nutrient loss reduction efficiencies in Table 4 and 5 of the Conservation Tillage Panel Draft Report. One would expect that the estimated efficiencies for surface runoff would be similar, if not the same. It is difficult to discern whether or not the reduction efficiencies are similar due to the way that the data is provided in each report.
    - *Response: The Low Disturbance Incorporation category in the Manure Injection report and the Conservation Tillage category in the Tillage report refer to similar practices. The tillage panel report provided a greater breakdown of reduction values by hydro-geomorphic region (HGM) than was done by the Manure Injection panel, however a weighted average (that considers relative land area of each HGM) gives similar values from the two panels for the uplands and Coastal Plain. There is some variation between panels which is likely due to the fact that the Manure Injection panel considered only studies with organic nutrient sources, while the CT panel considered both organic and inorganic nutrient sources. Given similarity in those two categories from the two panels, allowing credit for either the Low Disturbance Incorporation BMP or the Conservation Tillage BMP (but not both) should be considered. The High Disturbance Incorporation category addresses practices that are not eligible for credit under any of the tillage categories described in the Tillage panel report. It is anticipated that credits for the Injection category would be taken in conjunction with the Tillage Panel values for no-till/strip till. The Manure Injection panel does not have a category corresponding to the CT panel's High Residue category (HRMSD, ≥60% residue cover), because that intensity of tillage would not be likely to remove enough manure from the soil surface to provide incorporation benefits.*
- **PA SCC & DEP:** We appreciate the documentation of the methods by which these practices may be verified.
    - *Response: No specific response. Thank you.*

- **Ken Staver UMD:** Concern expressed over P reduction credit for reduced tillage in instances where manure is applied and not incorporated.

    - *Response:The use of manure, either incorporated or unincorporated, is included by default in the values derived from various tillage practices from the literature as many of the studies cited included manure or other organic nutrient source. So the loss estimates reflect the presence of surface manure application (or incorporation, per the treatments in each study)*
        - *Angle, 1984, used commercial fertilizer (previously had a history of manure application)*
        - *Mostaghimi, 1988, used commercial fertilizer and wastewater sludge*
        - *Butler, 2005 used dairy manure*
        - *Benham, 2007 used commercial fertilizer*
        - *Ross, 2001 used commercial fertilizer*
        - *Kleinman, 2002, used dairy manure, poultry manure, swine slurry, and commercial fertilizer*
        - *Kleinman, 2009 used dairy slurry*
        - *Sharpley, 2003 had no P applied*
        - *Verbree, 2010 used dairy manure*

Section 2: Practice Definition

- **PA SCC & DEP:** Page 9 – If the practice cannot be verified using the thresholds for SCI and STIR, how should it be verified?

    - *Response: As indicated in Table 2, the panel recommends that surface residue cover, either living or dead, but used as the criteria for verification. This measure has the advantage of being simple to use and to verify in the field. It also aligns with previously available data from CTIC for the watershed.*

- **PA SCC & DEP:** Page 10 – Table 3. The table is incomplete, as the soil type, slope length, and percent slope are variable factors when determining soil loss/acre (T). Also, is this a one year or multi-year rotation – if multi-year, how many years? Please include these factors when showing the relative soil loss, SCI and STIR values.

    - *Response: Information for the location, soil series, T value, slope length, and slope have been added to the table. Discussion has been added to the text describing when RUSLE2 runs represent single year or two-year cropping scenarios.*

Section 3: Effectiveness Estimates

- **PA SCC & DEP:** Page 11 – Table 4. How are sediment reduction efficiencies the same throughout the watershed, regardless of location in either upland or coastal plains? Sediment loss, when using RUSLEII, is determined using a number of different parameters, including soil type, percent slope, slope length. It would seem that the upland areas would have a greater reduction in sediment loss than the coastal plains area.

    - *Response: The absolute losses of sediment (erosion) is definitely greater with steeper slopes. However our review of the literature and various models for corroboration found* *that the RELATIVE erosion reduction due to reduced or no-tillage were similar across the landscape. So in the uplands, we may experience a 41% reduction for what would have been a total loss of 5 ton/ac, while in the Coastal Plain we would expect a 41% reduction from what would have been a 1.5 ton/ac loss.*

- *We would refer the reviewers to the previous report on Conservation Tillage for Phase 5.3.2 for more in-depth discussion.* http://www.chesapeakebay.net/documents/Tillage_p5.3.2_Report_WQGIT_Approved_11-10-14.pdf

- **Jenn Volk UD:** Regarding Table 5 for the Coastal Plain Lowland surface P losses, it appears that for every other HGM region, the surface P losses increase from low residue/strip till/no till to conservation tillage to HRMSD. Except, in the coastal plain lowland it drops for conservation tillage (-7%, -2%, -11%). I looked through the justification section that followed, but I didn't see any specific discussion of why this one HGM had a different pattern.

  - *Response: The description of how the reduction were calculated and presented just after Figure 2, on page 14.*

  - *Literature values for P losses for the HRMSD and conservation tillage practices were then applied to the appropriate proportion of cropland by drainage as follows:*

  - *(% well drained cropland)*(literature reduction value) + (% poorly drained cropland)*(literature increase value) = P loss value for HGM region*

  - *Because of the absence of data on the effect of the low residue, strip-till/no-till practice on poorly drained soils estimates of P losses are presented as the literature value for the study conducted on well-drained soils but do vary based on the proportion of cropland drainage by category. The calculation used for the low residue, strip-till/no-till practice was:*

  - *(% well drained cropland)*(literature reduction value) = P loss value for HGM region*

  - *The lowland coastal plain HGM region has the greatest proportion of poorly-drained soils so the increase in P load attributed to these sites has a significant effect on the final calculation.*

- **Beth McGee, CBF (comment submitted after deadline):** As noted in the draft report, there is a perception that conservation tillage increases N leaching. The panel dismisses those concerns by looking at 5 studies that looked at subsurface N loss and concluding there is no difference among tillage intensity and leaching. This conclusion needs to be reconciled with that of the 2009 BMP Assessment report by Simpson and Weammert that cites more than a dozen studies documenting increased infiltration rates and presumably increased leaching of soluble nitrogen with reduced tillage. This is a pretty big disconnect and I think worthy of further explanation in the final report.

  - *Response: The panel reviewed the following resources which are believed to be the most relevant to the region as they were conducted either within the watershed or in areas with similar soils, management and cropping systems.*

        - *Angle, J.S., Gross, C.M. and McIntosh, M.S., 1989. Nitrate concentrations in percolate and groundwater under conventional and no-till Zea mays (L.) watersheds. Agric. Ecosystems Environ., 25: 279-286.*
        - *Angle, J. S., Gross, C. M., Hill, R. L., & McIntosh, M. S. (1993). Soil nitrate concentrations under corn as affected by tillage, manure, and fertilizer applications. Journal of Environmental Quality, 22(1), 141-147.*
        - *Owens, L. B. (1987). Nitrate leaching losses from monolith lysimeters as influenced by nitrapyrin. Journal of environmental quality, 16(1), 34-38.*
        - *Menelik, G., R. Reneau, D. Martens, T. Simpson, G. Hawkins. 1990. Effects of tillage and nitrogen fertilization on nitrogen losses from soil used for corn. VPT-VWRRC- Bul 167. Virginia Tech, Blacksburg, VA.*
        - *Zhu, Y., & Fox, R. H. (2003). Corn–soybean rotation effects on nitrate leaching. Agronomy Journal, 95(4), 1028-1033.*
        - *M. M. Alley, J. T. Spargo, C. H. Sequeira, and T. R. Woodward (2011). Nitrate and Orthophosphate Leaching Losses in Agronomic Crop Production in the Virginia Coastal Plain. Final report to The Virginia Environmental Endowment.*
        - *Angle et al, 1989, concluded that there was no effect of tillage on nitrate leaching.*
        - *Angle et al, 1993, reported that soil nitrate levels were consistently lower for no-till than conventional.*
        - *Owens, 1987, reported a 3% increase in leachate for no-till.*
        - *Menelik et al, 1990, reported no difference in soil profile N (0-100 cm) between no-till and tilled treatments.*
        - *Zhu and Fox, 2003, concluded that tillage treatment had no effect on leachate nitrate losses.*
        - *Alley et al, 2011, reported no difference in nitrate level in leachate between tilled and no-tilled systems*

    - *In addition, the panel reviewed the 2009 BMP assessment report in response to this query. The report appears to rely heavily on the work of Dinnes, 2004 which was a very thorough review conducted at that time, though it was focused on Iowa.*

    - *While the table (included in both documents) that shows greater relative N leaching due to NT is based on a plausible theory, none of the studies that the panel found most relevant to the Bay watershed provided evidence for higher leaching losses for NT. In our own review of the sources in the Dinnes paper, we found three citations that report no difference in nitrate leaching due to tillage system, two with higher nitrate leaching with no-till systems, two with lower nitrate leaching due to the use of no-tillage systems, and three with lower nitrate in the soil profile (which could indicate more leaching or could indicate N moving into a number of other potential pathways). Dinnes appears to rely on studies that link higher leaching with greater infiltration conducted under urban conditions. That relationship is extrapolated in the 2009 BMP report which provides sources reporting greater infiltration in no-tillage systems. However we found no consistent effect of tillage on N leaching, either increased or decreased, in the available literature.*

Section 4: Application of Practice Effectiveness Estimates

- **PA SCC & DEP:** Page 19 – Are there any agricultural land uses that are not eligible for Conservation Tillage Practices?

- *Response: Yes. Those crops (trees, vineyards, etc) where tillage is not typically practiced. A listing of eligible land uses is included in Appendix A.*

Section 6: Data Gaps and Research Needs

- **PA SCC & DEP:** Page 22—How do P application rates relate to Conservation Tillage?
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    - *Response: Perhaps the real question revolves around how application rate (or soil test P level) affects the relative losses or loss reductions due to conservation tillage/greater residue cover. The most plausible answer is that greater P rates and STP likely result in greater loss. Marginal increase are likely to occur until soil is P-saturated, then much greater losses are likely. Models, like APLE and others show this. Unfortunately the data that would allow us to validate or test this question do not exist in the literature most applicable to the Bay Watershed. There simply aren't enough studies over enough rates or STP levels to use to develop a relationship or conclusion. And in the end, if what is desired is a site-specific loss value, then models should be used. However the panel has significant scientific concerns about using model outputs as the base inputs in another model or routine.*

Appendix G: Conformity with WQGIT BMP Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT 2014) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

1. **Identity and expertise of panel members:** *See Table 1 in Section 1.*

2. **Practice name or title:** *Conservation Tillage; includes the following categories*
   - *Conventional/high tillage*
   - *Low residue, strip-till/no-till*
   - *Conservation tillage*
   - *High residue, minimum soil disturbance (HRMSD)*

3. **Detailed definition of the practice:** *See Section 2 for detailed definitions of the BMP categories.*

4. **Recommended N, P and sediment effectiveness estimates:** *See Table 4. Recommended efficiency values for sediment and surface N reductions due to low residue strip-till/no-till, conservation tillage, and HRMSD practices, relative to conventional/high tillage practices) and Table 5. Recommended surface P loss reductions due to reduced tillage practice compared to conventional/high tillage practices, by hydrogeomorphic region) in Section 3 for recommended sediment and surface runoff TN and TP reductions for use in the Phase 6.0 Watershed Model.*

5. **Justification of selected effectiveness estimates:** *See Section 3.1 for justification of the effectiveness estimates.*

6. **List of references used:** *See Section 7 for the full list of references.*

7. **Detailed discussion on how each reference was considered:** *See Sections 3.1 and 3.2 for details on the review of available science.*

8. **Land uses to which BMP is applied:** *See Table 9. Phase 6.0 Agricultural Land Uses eligible for Conservation Tillage Practices.) in Section 4.1 for applicable agricultural land uses.*

9. **Load sources that the BMP will address and potential interactions with other practices:** *See Sections 3.1.5 and 4.3 for potential interactions with other practices and Table 9. Phase 6.0 Agricultural Land Uses eligible for Conservation Tillage Practices.) in Section 4.1 for applicable load sources.*

10. **Description of pre-BMP and post-BMP circumstances and individual practice baseline:** *See Sections 2 and 4.1.*

11. **Conditions under which the BMP works, including conditions where the BMP will not work, or will be less effective:** *See Section 4.*
    a. **Variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.** *See Table 5. Recommended surface P loss reductions due to reduced tillage practice compared to conventional/high tillage practices, by hydrogeomorphic region) in Section 3 and Section 4.1.*

12. **Temporal performance of BMP including lag times between establishment and full functioning:** *See Section 4.2.*

13. **Unit of measure:** *Acres or percentage of acres implementing practice.*

14. **Locations in Chesapeake Bay watershed where the practice applies:** *All acres of the applicable land uses in Table 9 (Section 4.1) in the Bay watershed.*

15. **Useful life of the BMP:** *Conservation Tillage is intended to be represented as an annual practice, so for the purposes of this report, the useful life of the practice is 1 year.*

16. **Cumulative or annual practice:** *Annual.*

17. **Description of how BMP will be tracked, reported, and verified:** *See Section 5 for a discussion of how Conservation Tillage should be tracked and reported to the Bay Program.*

18. **Ancillary benefits, unintended consequences:** *See Section 3.1.6 for ancillary environmental benefits. The Panel did not identify any unintended consequences (see Section 3.1.1).*

19. **Timeline for a re-evaluation of the panel recommendations:** *There is currently no specific timeline to re-evaluate Panel recommendations (see Section 6).*

20. **Outstanding issues that need to be resolved in the future and list of ongoing studies, if any:** *See Section 6 for a discussion of data needs and future research needs.*

21. **Documentation of dissenting opinion(s):** *While no dissenting opinions were expressed or recorded, significant notes related to recommendations were recorded in Appendix C (Approved Conservation Tillage Expert Panel Meeting Minutes).*

22. **Operation and maintenance requirements and how neglect alters performance:** *The requirements and performance are covered by the state programs, which in their own way document these elements.*