

# **CONTINUOUS HIGH RESIDUE, MINIMUM SOIL DISTURBANCE BMP**

## **Definition and Recommended Sediment Reduction Efficiencies for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model**

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

#### **Introduction**

This document summarizes the recommendations of the Conservation Tillage Expert Panel for the revised tillage practice of Continuous High Residue, Minimum Soil Disturbance (HR), including a new practice definition and efficiency estimates for inclusion in the Phase 5.3.2 of the Chesapeake Bay Program Watershed Model. The report was approved and enacted for 2013 progress by the Water Quality Goal Implementation Team on October 15, 2013. This practice represents the highest level of soil conservation and soil cover management to improve soil organic matter content and soil quality, and to reduce runoff and sediment and nutrient losses. This practice is proposed to provide stackability with other best management practice (BMP) reductions, such as cover crops and nutrient management. HR will only be placed on acres of agricultural land already reported under conservation tillage. The HR BMP can be placed on the Watershed Model land uses, LWM (low-till with manure) and NLO (nutrient management low-till). This BMP is intended to replace the current CNT (continuous no-till) practice.

This document summarizes adopted recommendations and plans for future recommendations of the 2012-13 Conservation Tillage Expert Panel for nitrogen (N), phosphorus (P), and sediment reduction efficiencies associated with high-residue, minimum soil disturbance cropland management.

#### *Panel Members*

Member	Jurisdiction	Affiliation
Ben Coverdale	Delaware	DE-Agriculture
Phillip Sylvester	Delaware	University of Delaware
Jack Meisinger	Maryland	USDA-ARS
Josh McGrath	Maryland	University of Maryland
Ken Staver	Maryland	University of Maryland
Royden Powell	Maryland	MD-Agriculture
Dale Gates	New York	USDA-NRCS-NY
Kevin Ganoie	New York	Cornell

Bill Clouser	Pennsylvania	PA-Agriculture
Sjoerd Duiker	Pennsylvania	Penn State University
Mark Goodson	Pennsylvania	USDA-NRCS
Bill Keeling	Virginia	VA-Environmental
Mark Reiter	Virginia	Virginia Tech
Rory Maguire	Virginia	Virginia Tech
Tim Sexton	Virginia	VA-Environmental
Wade Thomason	Virginia	Virginia Tech
Patrick Bowen	West Virginia	USDA-NRCS-WV
Tom Basden	West Virginia	West Virginia University
Technical support by Steve Dressing, Don Meals, Jennifer Ferrando (Tetra Tech), Jeff Sweeney (EPA CBPO), Matt Johnston (UMD CBPO), Mark Dubin (UMD CBPO), and Emma Giese (CRC).		

### **Practice Definition: Continuous High-Residue Minimum Soil-Disturbance (HR)**

A high degree of soil cover dramatically increases water infiltration and storage, and decreases soil erosion and soil-bound nutrient losses. Over time, this practice also typically results in increased N retention in soil due to increased soil organic matter content. The Continuous No-Till (CNT) practice was proposed for inclusion in the Bay Model in 2005. CNT is considered an enhanced version of the Conservation Tillage BMP and thus can be applied to a subset of the acres receiving Conservation Tillage. However in previous iterations, the N, P, and sediment reduction efficiencies associated with CNT were inclusive of reductions due to Nutrient Management and Cover Crops, both associated cropland BMPs. In order to maximize the potential impact of the panels' limited time and scope for potential revisions to the overall set of conservation tillage practices, the panel decided to focus emphasis directly on a "stackable" CNT practice. After considerable time spent reviewing the literature and discussing the various effects of no-till practices, the panel agreed that the preponderance of evidence indicates that a high degree of soil cover, over 60%, has the greatest impact on water quality benefits. Research from soils and cropping systems within the Chesapeake Bay watershed and from similar conditions elsewhere suggests the effects on infiltration and sediment loss are predominantly determined by residue cover and not by soil disturbance, per-se.

The Continuous High-Residue Minimum Soil-Disturbance (HR) BMP definition does not currently exist in the model but is intended to replace the current CNT practice. The HR BMP is a new 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. HR involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living or dead material) is to be met immediately after planting of each crop.

The purpose of implementing the HR BMP is to improve soil organic matter content and soil quality, and to reduce runoff and sediment and nutrient losses coupled with a continuous high-residue management system. Multi-crop, multi-year rotations on cropland are eligible. The system must be maintained for a minimum of one full crop rotation, and tracked and reported on an annual basis.

The Chesapeake Bay Watershed Model has hi-till (0-29% crop residue or conventional tillage) crop land-uses and low till (30+% crop residue or conservation tillage) land-uses, but does not have an explicit land use that defines the properties of HR with minimum soil disturbance. Because HR will be considered a sub-set of the current conservation tillage land use, it is necessary to calculate the effects of HR as reduction efficiency relative to the efficiency already achieved by the conservation tillage land use. The HR practice can be combined with other associated, applicable BMPs for additional reductions, including nutrient management and cover crops.

#### *Applicable USDA-NRCS Practices*

No current USDA Natural Resource Conservation Service (NRCS) Conservation Practice standards are directly applicable to this practice. NRCS residue management practice standards are based on the Soil Tillage Intensity Rating (STIR) rather than the percent cover remaining after planting. All related practice standards describe practices to be implemented or avoided. The HR BMP is defined based on outcomes (>60% residue cover), not a particular practice or set of practices.

## Effectiveness Estimates

**Table 1. Proposed relative reduction efficiency estimates**

Panel Proposed HR BMP	
<p>Total N Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>TBD</p>	<p>Total N Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>TBD</p>
<p>Total P Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>TBD</p>	<p>Total P Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>TBD</p>
<p>Total Suspended Solids Uplands Continuous High-Residue Minimum Soil-Disturbance tons/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>-64.0%</p>	<p>Total Suspended Solids Coastal Plain Continuous High-Residue Minimum Soil-Disturbance tons/acre</p> <p>Low-Till → Continuous HR (Stackable) Load Reduction</p> <p>-64.0%</p>

TBD indicates that estimated load reduction is yet to be determined by the panel.

### *Sediment*

The panel found ample evidence in the existing literature comparing sediment losses from conservation tillage systems with those of high residue examples, generally from no-till systems. In many cases the cited work did not provide estimates of soil cover after the conservation tillage practice was applied, however the professional judgment of the panel was that the practices indicated would likely produce the minimum 30% residue for the Conservation Tillage category. Also in support of this was that the RUSLE2 estimates of sediment loss reduction calculated by NRCS for typical agricultural cropland soils in Pennsylvania and Virginia were very similar to the values from literature and these runs were conducted with at least 30% soil cover estimates for the conservation tillage practice.

In general, small plot studies with simulated rainfall produced higher reduction estimates than the watershed-scale studies, which the panel assumed to be more reliable and indicative of real-world conditions. Therefore, the panel decided to reduce reported erosion reduction values from small plot studies by 15% to compensate for this effect (Table 2). Values from watershed-scale studies, small plot experiments, and RUSLE2 simulation were evaluated for corroboration. While the absolute values for sediment losses varied by region, soil, and slope the relative reduction was similar across the watershed. The panel recommends a single efficiency value of 64% sediment reduction for this practice, based on averaging applicable reported efficiencies.

**Table 2. Reported sediment reduction values of high residue systems over conservation tillage from applicable peer-reviewed studies and RUSLE2 model runs.**

Brief Citation	% sediment reduction, Conservation Till to High-Res, Min Disturbance (NT)
<i>Small Watershed-scale studies</i>	
Shipitalo and Edwards, 1998	-61.5%
Staver, 2004	-67.5%
<b>AVG</b>	<b>-64.5%</b>
<i>Small plot studies</i>	
Verbree et al, 2010	-85.2%
Truman et al., 2005	-91.5%
Benham et al., 2007	-77.2%
Eghball and Gilley, 2001	-79.6%
Kleinman et al., 2009	-38.0%
<b>AVG</b>	<b>-74.3%</b>
<b>15% small plot adjustment</b>	<b>-63.1%</b>
<i>RUSLE2 model runs</i>	
Coastal Plain, 1% slope	-49%
Coastal Plain, 2% slope	-80%
Coastal Plain, 4% slope	-78%
Piedmont, 3-4% slope	-65%
Piedmont, 5-6% slope	-68%
Piedmont, 9-10% slope	-58%
Ridge & Valley, 3-4% slope	-66%
Ridge & Valley, 5-6% slope	-71%
Ridge & Valley, 9-10% slope	-70%
Plateau, 4% slope	-75%
Plateau, 6% slope	-77%
Plateau, 10% slope	-76%
<b>AVG</b>	<b>-69.4%</b>

### *Phosphorus*

After reviewing numerous papers reporting P losses in response to residue cover and tillage, panel members were unable to arrive at a clear consensus for a reduction value for P, based on the existing data. The panel discussed the possibility of using placeholder, estimated values for P reductions as well as relying more heavily on modeled results for inclusion in this progress run. The group decided to delay a recommendation until a solid base of evidence could be built and consensus for a reduction value reached by the panel. The panel expects to benefit from new simulation modeling capacity within USDA-ARS and from further refinement of the data available in the existing literature. The panel expects a final recommendation can be developed and available for future progress runs.

### *Nitrogen*

Due to a lack of available time, the panel was unable to evaluate a significant body of literature for Total N reduction efficiency from the new HR practice. The group decided to delay a recommendation until a solid base of evidence could be built and consensus for a reduction value reached by the panel. The panel expects to benefit from new simulation modeling capacity within USDA-ARS and from further refinement of the data available in the existing literature. The panel expects a final recommendation can be developed and available for future progress runs.

### *Recommendation and associated benefits*

The panel is currently recommending that the HR practice and sediment reduction values recommended for HR be treated as stackable with other applicable agricultural cropland BMPs on lo-till land uses. At this time, the stackable HR practice would be given no N or P reduction credit; however, any reduction values associated with other practices applied to that same area would be included. **The same acre could not be reported to CNT and HR. States must choose if they will submit HR or CNT. States cannot submit HR in one county and CNT in another county for the same scenario.**

In addition to the direct benefit of reduced erosion, reduced tillage cropping systems are often more profitable for farmers, retain more soil water, and result in higher soil organic matter levels over time. Less fuel usage can also reduce the carbon footprint associated with crop production.

The panel found no instances in the literature where this practice increased sediment losses or where pollutants (sediment) were relocated to a different location or loss mechanism. The panel was diligent about selecting data on sediment losses that would be representative of this practice alone and not dependent on the inclusion of other potential BMPs such as cover crops or nutrient management. The RUSLE2 simulations included only crop residue, with no cover crops included, to reach the minimum required levels of soil cover. However these factors can definitely interact and can synergistically enhance environmental benefits.

## References

- Andraski B.J., Mueller D.H., Daniel T.C. (1985) Phosphorus Losses in Runoff As Affected by Tillage. *Soil Sci. Soc. Am. J.* 49:1523-1527. DOI: 10.2136/sssaj1985.03615995004900060038x.
- Benham B., Vaughan D., Laird M., Ross B., Peek D. (2007) Surface Water Quality Impacts of Conservation Tillage Practices on Burley Tobacco Production Systems in Southwest Virginia. *Water, Air, and Soil Pollution* 179:159-166. DOI: 10.1007/s11270-006-9221-z.
- Bundy L.G., Andraski T.W., Powell J.M. (2001) Management practice effects on phosphorus losses in runoff in corn production system. *J. Environ. Qual.* 30:1822-28.
- Eghball B., Gilley J.E. (2001) Phosphorus risk assessment index evaluation using runoff measurements. *J. Soil Water Cons.* 56:202-206.
- Kimmell R.J., Pierzynski G.M., Janssen K.A., Barnes P.L. (2001) Effects of Tillage and Phosphorus Placement on Phosphorus Runoff Losses in a Grain Sorghum–Soybean Rotation Contribution no. 00-358-J from the Kansas Agric. Exp. Stn. *J. Environ. Qual.* 30:1324-1330. DOI: 10.2134/jeq2001.3041324x.
- Kleinman P.A., Sharpley A., Saporito L., Buda A., Bryant R. (2009) Application of manure to no-till soils: phosphorus losses by sub-surface and surface pathways. *Nutrient Cycling in Agroecosystems* 84:215-227. DOI: 10.1007/s10705-008-9238-3.
- Kleinman P.J.A., Sharpley A.N., Moyer B.G., Elwinger G.F. (2002) Effect of Mineral and Manure Phosphorus Sources on Runoff Phosphorus. *J. Environ. Qual.* 31:2026-2033. DOI: 10.2134/jeq2002.2026.
- Quincke J.A., Wortmann C.S., Mamo M., Franti T., Drijber R.A., García J.P. (2007) One-Time Tillage of No-Till Systems. *Agron. J.* 99:1104-1110. DOI: 10.2134/agronj2006.0321.
- Sharpley A.N., Smith S.J., Williams J.R., Jones O.R., Coleman G.A. (1991) Water Quality Impacts Associated with Sorghum Culture in the Southern Plains. *J. Environ. Qual.* 20:239-244. DOI: 10.2134/jeq1991.00472425002000010038x.
- Shipitalo M.J., Edwards W.M. (1998) Runoff and erosion control with conservation tillage and reduced-input practices on cropped watersheds. *Soil Till. Res.* 46:1-12.
- Staver K.W. (2004) Efficient utilization of poultry litter in cash grain rotations. Final Report submitted to: Maryland Grain Producers Utilization Board. MCAE Pub. 2004-03.
- Truman C.C., Shaw J.N., Reeves D.W. (2005) Tillage effects on rainfall partitioning and sediment yield from an ultisol in central Alabama. *Journal of Soil and Water Conservation* 60:89-98.
- Verbree D.A., Duiker S.W., Kleinman P.J.A. (2010) Runoff losses of sediment and phosphorus from no-till and cultivated soils receiving dairy manure. *J. Environ. Qual.* 39:1762-1770.

## References used for sediment estimates

- Shipitalo and Edwards, 1998  
Staver, 2004  
Verbree et al, 2010  
Truman et al., 2005  
Benham et al., 2007  
Eghball and Gilley, 2001  
Kleinman et al., 2009

Results from these references were averaged to arrive at the proposed efficiency estimates; reductions reported by small plot studies were discounted 15% as discussed previously (see Table 2).

Results reported in the literature reviewed for sediment and P reduction efficiencies are summarized in an attachment to this report.

All citations and data used in developing the sediment loss reduction values were from studies conducted in the CB region or on very similar soils under similar cropping systems. In general, small plot studies with simulated rainfall produced higher reduction estimates than the watershed-scale studies, which the panel assumed to be more reliable and indicative of real-world conditions. Therefore, the panel decided to reduce reported erosion reduction values from small plot studies by 15% to compensate for this effect (Table 2). Values from watershed-scale studies, small plot experiments, and RUSLE2 simulation were evaluated for corroboration. Specific information about each study cited is included in Appendix A.

#### **Application of Practice Effectiveness Estimates**

- Units of measure: acre
- Load sources addressed: 64% sediment reduction over that credited for low-till with manure (LWM).
- Conditions under which the BMP works: Relative effectiveness for sediment reduction is similar across regions, soils, and slopes. Uneven distribution of cover could decrease effectiveness.
- Considerations for benefits in load reduction: The panel reviewed and included seven peer-reviewed studies over a wide range of soil textures, slope and drainage. Because all studies reported similar relative sediment efficiency values, the panel did not differentiate by texture, etc. In our findings, there were no changes in load reductions among soil textures. Sediment values are only relevant as surface transport. Subsurface and other pathways relevant for nutrient losses are not relevant for sediment.

#### *Geographic Considerations*

- This practice is applicable to lo-till row crop land throughout the watershed.
- Load reduction estimates reflect edge-of-field reductions.
- The baseline condition was Conservation Tillage, as currently defined. Efficiency values represent reductions relative to this baseline.
- The same sediment reduction efficiency is appropriate across the watershed.

#### *Temporal Considerations*



- HR involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living or dead material) is to be met immediately after planting of each crop in rotation.
- The practice will be tracked and reported annually.
- The practice is expected to provide full benefits at all times when the minimum residue cover is in place and effecting as long as that condition persists.
- The efficacy of this practice is defined based on an outcome of at least 60% residue cover and not as implementation of a specific management practice. Therefore, imperfect operation and maintenance of the practice is not a factor for performance.

#### *Practice Limitations*

- The HR BMP is defined as a stand-alone practice that can be implemented with other BMP's however the sediment reduction values represent only that achieved by the HR practice.
- The practice is limited to lo-till cropland.
- Ancillary benefits include, over time, increase soil organic matter, increased soil cation exchange capacity, increase water-holding capacity, and improved soil quality.
- Eliminating or minimizing tillage can result in surface application of fertilizer and manures with no, or very little, incorporation. The result could produce greater ammonia volatilization and soluble P losses in certain circumstances and management systems..

#### *Modeling Considerations*

- BMP Name: Continuous, High Residue, Minimum Soil Disturbance (HR)
- Acres: Number of acres under HR meeting the definition of 60% residue cover
- Location: Approved NEIEN geographies: County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- Date of Implementation: Year of HR implementation or continued management of an HR system
- See Attachment C
- Applicable verification standards:  
The HR BMP has been defined by the panel as an annual crop residue and tillage practice which will can be applied onto applicable Conservation Tillage BMP acres. Annual crop residue and tillage practices have subsequently been categorized by the Chesapeake Bay Program's Agriculture Workgroup as Single-Year Visual Assessment BMPs. The panel recommends that the appropriate verification guidance associated with this category of BMPs be implemented by the partnership in the verification of acres reported under this BMP.
- Panel comments on verification protocols recommended by the Verification Panel:  
The panel recommendations for defining, tracking and reporting to the Chesapeake Bay Program partnership models the HR BMP, is compatible with and supports the

agricultural BMP verification guidance subsequent developed by the Agriculture Workgroup.

- Panel recommendations on what to use as default conditions or default benefits if not all information about a practice is reported or known:  
The panel recommendations for defining the HR BMP were developed from the baseline of the existing Conservation Tillage BMP and associated Phase 5.3.2 Modeling land uses. The default condition and benefits if not all information is known or reported on a subset of reported acreage would be as the baseline condition; i.e. represented as a Conservation Tillage BMP.

### **Practice Monitoring and Reporting**

This practice could be tracked through field transect surveys (CTIC methodology), potentially through remote sensing and limited field transect surveys in the future, or through state or federal programs that collect information on high-residue, minimum disturbance practices. The current CTIC methodology would need to be revised to include a category specifically with >60% cover. The panel discussed the importance of obtaining complete information about implementation of this practice. Therefore, information about implementation obtained through programs needs to be supplemented with other information to report acres where farmers practice HR voluntarily. The panel recommends that residue cover requirement (including living or dead material) is evaluated in the period shortly after planting a new crop. The acres that meet these criteria should be tracked and reported annually. A re-evaluation of the estimates should be conducted as new data are available.

### **Data Gaps and Research Needs**

If remote sensing of residue cover is adopted in the future as the technology improves to meet the partnership's verification expectations, additional research validation will likely be required and protocols for evaluation developed.

Additional small watershed scale studies of sediment and especially N and P losses from representative locations within the Bay watershed would provide highly valuable information.

### **Attachments**

- Attachment A: Summary of literature included in sediment reduction estimate
- Attachment B: Summary of literature reviewed for P reduction estimate

- Attachment C: Technical Requirements for Entering the Continuous, High Residue, Minimum Soil Disturbance (HR) Practice into Scenario Builder and the Watershed Model
- Attachment D: Initial Expert Panel survey summary, conducted by Tetra Tech
- Attachment E: Expert Panel meeting minutes/notes/attendance

DRAFT

## Attachment A: Summary of literature included in sediment reduction estimate

Summary of High Residue, minimum soil disturbance practice Sediment reduction efficiency						
Citation	Notes					
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	Central PA, limestone derived soil (WD) and colluvium-derived soil (SWPD), Flow-weighted average soil loss over 3 1-hr rainfall events (planting, mid-season,after silage harvest), Flow-weighted solids load (g m-2 h-1)			Flow-weighted solids load (g m-2 h-1)		
				Chisel/disk	NT	NT efficiency
			Well-drained	10.8	1.1	-89.8%
			Well-drained	27.7	2.1	-92.4%
			SWPD	10.6	2	-81.1%
			SWPD	8.36	1.9	-77.3%
				AVG	-85.2%	
Shipitalo, M.J. and W.M.Edwards. 1998. Runoff and erosion control with conservation tillage and reduced-input practices on cropped watersheds. Soil Till. Res. 46(1): 1-12	Average soil loss (kg/ha) in corn year of corn/wheat/meadow/meadow rotation, Research on about 0.5 ha watersheds, 7-13% slopes,	14 yr/location data		12 yr/location data		
		Chisel plowed		No-till	NT efficiency	
		Sed loss		Sed loss		
		3585.5		1380.5	-61.5%	
Truman, C.C., J.N. Shaw and D.W. Reeves. 2005. Tillage effects on rainfall partitioning and sediment yield from an ultisol in central Alabama. Journal of Soil and Water Conservation 60: 89-98.	Coastal plain of AL, sandy soil 1% slope, Total sediment loss (g) over two 1-hour rainfall simulation events (50 mm/hr), used 1m2 small plots, took treatments w/o paratill, but with residue (incorporated in chisel, left on surface in NT,	Total sediment loss (g) over two 1-hour rainfall simulation events (50 mm/hr)				
			Chisel	NT	NT efficiency	
			235	20	-91%	
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.	Speedwell sandy loam 1% slope, Alluvial soil, Strip till was 59% cover, NT 82%, Conventional was 5% cove,r Rainfall simulation on 2.1x7m plots at 50 mm/hr. average soil loss kg/ha of 6 runs reported	Conv	Strip till	NT	NT efficiency	efficiency vs Conv
			Soil Loss, kg/ha			
		320.8	115.2	73	-36.6%	-77.2%
Eghball, B. and J.E. Gilley. 2001. Phosphorus risk assessment index evaluation using runoff measurements. J. Soil Water Cons. 56: 202-206.	Sharpsburg sicl NE 6-7% and Monona si IA 12%, Did not use trtmnts with hedges		Disked	NT		
			Soil Loss, kg/ha			
			16.5	2.5		
			7	2.7		
			10.7	4.1		
			11.7	4.1		
			14	1.1		
			7	2		
			9.8	0.6		
			8.4	1.1		
			7.1	1.1		
			10.2	0.9		
			1.66	0.58		
			2.78	0.77		
			2.15	0.73	NT efficiency	
		Average	8.383846154	1.71384615		-79.6%

Citation	Notes						
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-	Staver (personal communication, based on figure 19 in report Staver 2004.						
	CT was chisel-disk rye cover crop NT planted in both tillage treatments from 1988-1998						
			CT	CT	CT	CT	
	date	precip. (cm)	runoff (cm)	residue nf (kg/ha)	residue nf (kg/ha)	residue nf (mg/l)	
	May 1- April 30						
	85-86						
	86-87	94.02	9.84	131.8	131.8	133.9	
	87-88	85.3	11.04	631.7	631.7	572.0	
	88-89	74.36	3.18	326.3	326.3	1027.2	
	89-90	99.18	9.51	1795.3	1795.3	1887.6	
	90-91	117.24	16.63	1051.4	1051.4	632.3	
	91-92	106.54	15.54	2581.9		1661.1	
	92-93	86.8	9.78	210.1	210.1	214.7	
	93-94	108.68	20.34	231.5	231.5	113.8	
	94-95	112.79	28.52	377.1	377.1	132.2	
	95-96	85.25	6.38	108.1	108.1	169.5	
	96-97	106.86	15.88	343.4	343.4	216.2	
	97-98	124.62	28.55	442.0	442.0	154.8	
	98-99	114.03	26.37	391.5	391.5	148.5	
	99-00	75.46	4.16	526.5	526.5	1267.2	
	00-01	128.8	21.75	82.4	82.4	37.9	
	01-02	103.91	11.01	256.2	256.2	232.7	
	02-03	100.77	10.52	28.9	28.9	27.4	
	03-04	118.31	26.73	155.5	155.5	58.2	
		143.37	42.82	187.0	187.0	43.7	
					404.3		
		residue nf = Residue non-filterable,all the material collected on a GFC filter pad with average pore size of 1.4 microns.					
					NT		
			NT	NT	residue nf		
date	precip. (cm)	runoff (cm)	residue nf (kg/ha)	(mg/l)			
				204.7			
85-86	94.02	12.08	247.2	298.2			
86-87	85.3	11.15	332.4	164.7			
87-88	74.36	3.85	63.5	96.4			
88-89	99.18	10.06	96.9	89.7			
89-90	117.24	23.11	207.3	150.8			
90-91	106.54	16.31	246.0	41.8			
91-92	86.8	8.86	37.0	40.2			
92-93	108.68	17.12	68.8	27.6			
93-94	112.79	27.55	75.9	42.7			
94-95	85.25	4.96	21.2	49.2			
95-96	106.86	15.76	77.5	29.9			
96-97	124.62	28.02	83.9	43.0			
97-98	114.03	23.71	101.9	803.4			
98-99	75.46	3.76	302.0	36.4			
99-00	128.8	17.02	61.9	172.2			
00-01	103.91	10.49	180.6	68.9			
01-02	100.77	8.09	55.8	28.5			
02-03	118.31	24.20	68.9	49.2			
03-04	143.37	33.37	164.1				
			131.2				
	NT efficiency						
	-67.5%						
Kleinman, P.A., A. Sharpley, L. Saporito, A. Buda and R. Bryant. 2009. Application of manure to no-till soils: phosphorus losses by sub-surface and surface pathways. Nutrient Cycling in Agroecosystems 84: 215-227. doi:10.1007/s10705-008-9238-3.	Used rainfall simulation at 75 mm/hr intensity, until 30 minutes of runoff had finished.		Sediment loss (kg/ha)				
			Rototill 20 cm	NT	NT efficiency		
		Clymer sandy loam	69.2	36.2	-47.7%		
		Wharton clay loam	166.3	119.3	-28.3%		
				av	-38.0%		

## Attachment B: Summary of literature reviewed for P reduction estimate

Summary of High Residue, minimum soil disturbance practice P reduction efficiency						
Literature Citation	Particulate P	Dissolved P	Subsurface P	Total P	Location	Notes
	% change Conserv-Till to HRMSD (NT)					
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.				-23%	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%
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	-73%	333%		-5%	PA	Central PA, limestone derived soil (WD) and colluvium-derived soil (SWPD). 3, 1-hr rainfall events (planting, mid-season, after silage harvest)
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.				147%	PA	3 soils, 4 P sources, 100 kg/ha TP applied, rainfall sim
Andraski, B.J., D.H. Mueller and T.C. Daniel. 1985. Phosphorus Losses in Runoff As Affected by Tillage. Soil Sci. Soc. Am. J. 49: 1523-1527. doi:10.2136/sssaj1985.03615995004900060038x.		57%		-15%	Wisconsin, three locations, (silt loam soils)	Various STP due to previous treatments, small plot studies with NT vs Chisel, manure applied at est rate of 50 kg/ha of first-year available P. Rainfall simulation preplant and in September, results averaged
Bundy, L.G., T. W. Andraski, and J. M. Powell. 2001. Management practice effects on phosphorus losses in runoff in corn production system. J. Environ Qual. 30(5):1822-28		-60%		-35%	no manure	STP, tillage and manure treatments. Fig 4 DRP concentration and Loss. Fig 5 TotP concentration and loss. History of biosolids to generate various STP. Spring manure application, chisel plow (CP), shallow till (ST), and no-till (NT). Rainfall simulation preplant and in September, results averaged
		0%		-80%	with manure	
Kimmell, R.J., G.M. Pierzynski, K.A. Janssen and P.L. Barnes. 2001. Effects of Tillage and Phosphorus Placement on Phosphorus Runoff Losses in a Grain Sorghum-Soybean Rotation Contribution no. 00-358-J from the Kansas Agric. Exp. Stn. J. Environ. Qual. 30: 1324-1330. doi:10.2134/jeq2001.3041324x.				-56%	Woodson sl, Ottawa KS 1.5% slope	ridge till vs NT, small plot, grain sorghum/soybean rotation, Fertilizer P, natural rainfall collected throughout two seasons (6-7 events/year)
Kleinman, P.A., A. Sharpley, L. Saporito, A. Buda and R. Bryant. 2009. Application of manure to no-till soils: phosphorus losses by sub-surface and surface pathways. Nutrient Cycling in Agroecosystems 84: 215-227. doi:10.1007/s10705-008-9238-3.	5%	80%	71%	10%	PA Plateau	Clymer and Wharton soil, manure application of 30 kg/ha TP, subwatershed, includes leachate



## **Attachment C: Technical Requirements for Entering the Continuous, High Residue, Minimum Soil Disturbance (HR) Practice into Scenario Builder and the 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 efficiency reductions can a jurisdiction claim by implementing and reporting the HR practice?***

A1: A jurisdiction will receive a 64% reduction to the edge-of-stream sediment losses from agricultural acres already under a low-till condition for every acre reported under HR. No phosphorus or nitrogen reduction credits will be given to this practice at this time (Table 1). The impact of these reductions in the Watershed Model will vary across the watershed as a result of hydrologic conditions, application rates to low-till land uses and sediment export from those low-till land uses.

### ***Q2: What land uses are eligible to receive the HR practice?***

A2: HR will only be placed on acres of agricultural land already reported under conservation tillage (lo-till). The HR BMP can be placed on the Watershed Model land uses, LWM (low-till with manure) and NLO (nutrient management low-till). This practice is not eligible on HOM (high-till without manure) or any other agricultural land uses in the Watershed Model. When an acre of row crops is reported under the conservation tillage BMP, that row crop acre is converted from a conventional tillage routine to a low-tillage routine in the Watershed Model. This conversion results in a reduction of sediment loads from that acre of row crop. HR is intended to be a reduction beyond this initial conversion from conventional to low-till. For this reason, an acre submitted as HR should also be submitted under the conservation tillage BMP (Table 1).

### ***Q3: Can other BMPs be placed on the same acre as HR?***

A3: Yes. All efficiency reduction BMPs that are currently eligible for LWM and NLO will receive credit in combination with this practice.

### ***Q4: Can states still report Continuous No-Till (CNT)?***

A4: Yes. However, states must choose if they will submit HR or CNT. States cannot submit HR in one county and CNT in another county for the same scenario (See: Associated Benefits, page 6).

### ***Q5: What are the main differences between HR and the currently approved, CNT?***

A5: An acre reported under CNT currently receives reductions to sediment, phosphorus and nitrogen loads. However, other BMPs eligible for low-till land uses including nutrient management and cover crops cannot currently be reported on the same acre as CNT. An acre reported under HR will receive only a sediment reduction, but will still be eligible for reductions from other low-till eligible BMPs such as nutrient management and cover crops.

### ***Q6: Why is there no phosphorus or nitrogen benefit given to HR?***



A6: The panel determined that more time was needed to evaluate the literature and results from various models before providing scientifically defensible reduction rates for phosphorus or nitrogen for this practice (See: Phosphorus and Nitrogen subsections, page 6).

***Q7: What does a jurisdiction need to report in order to receive credit for HR?***

A7: Jurisdictions should report the following information:

- BMP Name: Continuous, High Residue, Minimum Disturbance (HR)
- Acres: Number of acres under HR meeting the definition of 60% residue cover
- Location: Approved NEIEN geographies: County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- Date of Implementation: Year of HR implementation or continued management of an HR system

***Q8: Do states need to track and report HR annually?***

A8: Yes. All states currently report CNT as a cumulative practice, which means that they only report new acres each year, but receive credit for all acres reported and verified from previous years. Beginning in 2013, states should report HR and CNT as an annual practice, or as the snapshot of all acres on the ground in 2013. Again, states should submit only HR or CNT in a single scenario.

---