High Residue, Minimum Soil Disturbance: definition and recommended sediment and nutrient reduction effectiveness estimates

Report approved and enacted for Phase 5.3.2 for 2013 progress [pending approval by the Water Quality Goal Implementation Team] as of October 15, 2013.

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

Brief Summary

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, when fully implemented, is intended to replace the current CNT practice.

Introduction

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 nitrogen (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, phosphorus (P), and sediment reduction efficiencies associated with CNT were inclusive of reductions due to Nutrient Management and Cover Crops, both associated cropland BMP's. 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 indicated that a high degree of soil cover, over 60%, had 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.

This document summarizes adopted recommendations and plans for future recommendations of the 2012-13 Conservation Tillage Expert Panel for N, 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 Ganoe	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
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Technical support by Steve Dressing, Don Meals, Jennifer Ferrando (TetraTech), Jeff Sweeney (EPA CBPO), Matt Johnston (UMD CBPO) and Emma Giese (CRC).		

Practice Definition

Continuous High-Residue Minimum Soil-Disturbance (HR) Best Management Practice Definition and Nutrient and Sediment Reduction Efficiencies

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies recommended for the Continuous High-Residue Minimum Soil- Disturbance (HR) Best Management Practice. The definition does not currently exist in the model but is ultimately intended to replace the current CNT practice.

Continuous High-Residue Minimum Soil-Disturbance Best Management Practice Definition

The Continuous High-Residue Minimum Soil-Disturbance (HR) BMP is 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. 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.

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 continuous HR with minimum soil disturbance. Since continuous 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 continuous HR with minimum soil disturbance practice can be combined with other associated, applicable BMP's for additional reductions, including nutrient management and cover crops.

This practice could be tracked through field transect surveys (CTIC methodology), through remote sensing and limited field transect surveys, 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.

Effectiveness Estimates

Table 1. Relative Reduction Efficiency Estimates

Panel Proposed HR BMP	
TOTN Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD	TOTN Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD
TOTP Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD	TOTP Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD
TSS Uplands Continuous High-Residue Minimum Soil-Disturbance tons/acre Low-Till → Continuous HR (Stackable) Load Reduction -64.0%	TSS Coastal Plain Continuous High-Residue Minimum Soil-Disturbance tons/acre Low-Till → Continuous HR (Stackable) Load Reduction -64.0%

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 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. Erosion reduction values from small plot studies were thus reduced 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.

Table 2. Brief citation and sediment reduction values between conservation tillage practices and high residue systems from applicable peer-reviewed studies.

Brief Citation	% sediment reduction, Conservation Till to High-Res, Min Disturbance (NT)
Sm. Watershed-scale studies	
Shipitalo and Edwards, 1998	-61.5%
Staver, 2004	-67.5%
AVG	**-64.5%**
Small plot studies	
Verbree et al, 2010	-85.2%
Truman e al., 2005	-91.5%
Benham et al., 2007	-77.2%
Eghball and Gilley, 2001	-79.6%
Kleinman et al., 2009	-38.0%
AVG	**-74.3%**
15% small plot adjustment	**-63.1%**
RUSLE2 model runs	
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%
AVG	**-69.4%**

Phosphorus

While there were numerous papers reporting P losses in response to residue cover and tillage, there was no clear consensus among the panel membership 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 this 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 by spring, 2014 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 high-residue MSD practice.   The group decided to delay this 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 by spring, 2014 and available for future progress runs.

Recommendation and associated benefits

The panel is currently recommending that the HR practice and sediment reduction value recommended for HR be treated as stackable with other applicable BMP's. 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. Further, the panel recommends that until final N and P reduction estimates for HR can be developed (2014) that the jurisdictions still have the opportunity to report to the CNT (non-stackable) practice. 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.

Justification for Recommended Effectiveness Estimates

The panel found no instances in the literature where this practice increased sediment loss.

The panel was diligent about selecting data that would be representative of this practice alone and not dependent on the inclusion of other potential BMP's 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.

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.

<u>References used for sediment estimates</u>

Shipitalo and Edwards, 1998
Staver, 2004
Verbree et al, 2010
Truman e al., 2005
Benham et al., 2007
Eghball and Gilley, 2001
Kleinman et al., 2009
All included in estimate and weighted as described in earlier section

Application of Practice Effectiveness Estimates

- Units of measure: acre
- Load sources addressed: 64% sediment reduction over that credited for low-till with manure (LWM).
- Condition under which the BMP works: Relative effectiveness for sediment reduction is similar across regions, soils, and slopes. Uneven distribution of cover could decrease effectiveness. Values were derived with greater emphasis on watershed-scale studies and natural rainfall, which more closely represent the real work than rainfall simulations. Sediment values are only relevant as surface transport.
- 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 of this and the similar relative sediment efficiency values noted, the panel did not differentiate by texture, etc.

Geographic Considerations

- This practice is applicable to 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.

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 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.

Modeling Considerations

- 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

Practice Monitoring and Reporting

- This practice could be tracked through field transect surveys (CTIC methodology), through remote sensing and limited field transect surveys, or through state or federal programs that collect information on high-residue minimum disturbance practices.

Data Gaps and Research Needs

If remote sensing of residue cover is adopted, additional research validation will likely be required and protocols for evaluation developed

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

Attachments

- Summary of literature included in Sediment reduction estimate
- Summary of literature reviewed for P reduction estimate
- Technical Requirements for Entering the Continuous, High Residue, Minimum Disturbance (HR) Practice into Scenario Builder and the Watershed Model
- Initial Expert Panel survey summary, conducted by TetraTech

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 effiiciency	
			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	efficiiency 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	Staver (personal communication, based on figure 19 in report Staver 2004.					
UTILIZATION OF POULTRY	CT was chisel-disk rye cover crop NT planted in both tillage treatments from 1988-1998					
LITTER IN CASH GRAIN						
ROTATIONS. Final Report			CT	CT	CT	CT
submitted to: Maryland Grain	date	precip.	runoff	residue nf	residue nf	residue nf
Producers Utilization Board		(cm)	(cm)	(kg/ha)	(kg/ha)	(mg/l)
Maryland Center for Agro-	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	
		precip.	runoff	residue nf	(mg/l)	
	date	(cm)	(cm)	(kg/ha)		
					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.	Used rainfall simulation at 75 mm/hr			Sediment loss (kg/ha)		
Saporito, A. Buda and R. Bryant.	intensity, until 30 minutes of runoff had			Rototill 20 cm	NT	NT efficiency
2009. Application of manure to	finished.	Clymer sandy loam		69.2	36.2	-47.7%
no-till soils: phosphorus losses		Wharton clay loam		166.3	119.3	-28.3%
by sub-surface and surface					av	-38.0%
pathways. Nutrient Cycling in						
Agroecosystems 84: 215-227.						
doi:10.1007/s10705-008-9238-3.						

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, tilage 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

Literature Citation	Particulate P	Dissolved P	Subsurface P	Total P	Location	Notes
	% change Conserv-Till to HRMSD (NT)					
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
Quincke, J.A., C.S. Wortmann, M. Mamo, T. Franti, R.A. Drijber and J.P. García. 2007. One-Time Tillage of No-Till Systems. Agron. J. 99: 1104-1110. doi:10.2134/agronj2006.0321.	14%	0%		9%	Nebraska, 2 and 3% slope	NE, sharpsburg scl, Yutan scl, corn soy sorghum rotation, NT since 1992one time tillage after 15 yr NT, disc vs NT, rainfall sim, 2 yr after tillage
Sharpley, A.N., S.J. Smith, J.R. Williams, O.R. Jones and G.A. Coleman. 1991. Water Quality Impacts Associated with Sorghum Culture in the Southern Plains. J. Environ. Qual. 20: 239-244. doi:10.2134/jeq1991.00472425002000010038x.				-32%	OK, TX	grain sorghum in southern plains, rainfall sim
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	-65%	421%		238%	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) prior to corn planting and also in the fall (2 tons/acre) prior to wheat planning in 1998 and 2000. During the second year of the rotation, no additional poultry litter was applied but nutrient transport patterns were tracked during wheat/double-crop soybean production. To meet the project objectives poultry litter was applied to two fully instrumented field-scale watersheds where detailed studies have been conducted since 1984 of nutrient transport rates from cropping systems utilizing inorganic fertilizers. Field edge
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.				-87%	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 conducted over a two-day period. During the simulated rainfall events, runoff from the plots was measured and

APEL Runs

	Coastal Plain		Piedmont		Ridge and Valley		Plateau	
STP	H	VH	H	VH	H	VH	H	VH
% change CT to NT	**-48%**	**108%**	**-56%**	**-16%**	**-57%**	**-16%**	**-60%**	**-31%**

Technical Requirements for Entering the Continuous, High Residue, Minimum 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. 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 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 in 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.