Draft Technical Memo

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To: Urban Stormwater Work Group and Agricultural Workgroup

Re: Draft Options for Crediting Pollutant Reduction from Roadside Ditch Management Practices (RDM) in the Chesapeake Bay Watershed

Section 1. Background and Purpose of Memo

The Scientific and Technical Advisory Committee (STAC) released a research report on improving roadside ditch management practices to meet TMDL water quality goals (Schneider and Boomer, 2016). One of the key report findings was that improved management of the roadside ditch network could be an effective pollutant reduction strategy in many rural and/or un-regulated portions of the Bay watershed. A short term RDM team was established to discuss a path forward for defining, crediting and verifying this group of practices (CSN, 2016).

The objectives for the RDM team were to:

1. Work on existing crediting options that could be applied to roadside ditches, based on more than a dozen existing or pending expert panel reports approved by the Chesapeake Bay Program over the last decade (See Appendix A).

2. Determine if any road-side ditch practices are not covered by existing or pending expert panel reports approved by the Chesapeake Bay Program, and have sufficient science to support a future expert panel (and what priority it should have in the overall BMP panel queue).

3. Evaluate how improved LiDAR mapping of the ditch and stream network in the watershed could assist in the assessment and crediting process.

4. Devise a strategy to increase implementation and reporting of RDM practices by engaging local and state highway agencies across the Bay watershed.

Section 2. Defining the Roadside Ditch Management Practice

The first step is to define the overall RDM practice and its subcategories in a manner that researchers and practitioners understand. This is not easy given the many different ways by which urban, suburban, rural, farm and forest ditch networks are designed and managed across the watershed.

Common Characteristics of Traditional Roadside Ditch Networks

Roadside ditches are used to convey stormwater away from roads and other areas and have a defined bed and side slopes. Traditional roadside ditch networks have many common characteristics:

- Ditches are primarily designed to move water away from roads, residential areas and farm fields, with very little regard for impacts to water quality or habitat.

- Ditches have widely different maintenance programs (i.e., design, frequency, and type of maintenance) which strongly influence conveyance function and downstream impacts

- Ditches can have widely variable impacts to downstream resources: Specific segments of a ditch network can act as a net "sink", "source" or “conduit” of sediment, nutrients, and/or other contaminants of concern, depending on their location, design, installation, and maintenance.

- The ditch network is poorly inventoried and mapped: There is an urgent need to develop a comprehensive inventory of roadside ditches to identify where more complex maintenance strategies are needed to reduce hydrologic connectivity between up-gradient contaminant sources and downstream regional water supplies.

Throughout the entire Chesapeake Bay watershed, in forested, agricultural, and developed landscapes, roadside ditches significantly influence regional water supplies through effects on the quantity, quality, and timing of surface water discharge.

Background:

In forested regions, roadside ditches often capture sediment-rich runoff from unimproved roads. Further, the slope and its direction and aspect can increase the rate of surface water discharge, thereby concentrating erosive power and impacts to down-gradient streams. In other rural areas, including agricultural and recreational lands and low density development, roadside ditches also can impose significant impacts to downstream waterbodies.

Recommendations for mitigating impacts from roadside ditches highlight that a range of practices, in terms of complexity and costs, can be applied to disconnect "rural stormwater systems." Where possible, eliminating rural roadside ditches through basic maintenance improvements is often the most effective and economical way to reduce sediment pollution. Alternative low-cost practices focus on cover management and can be applied universally throughout counties and watersheds to enhance infiltration, and to reduce runoff and sediment pollution to streams.

Roadside ditches that carry a high volume of contaminated waters may require more expensive, engineered practices. If advanced ditch management or elimination is not possible, it is possible to reduce the slope-length of the ditches or road surface by increasing the available drainage outlets and diffuse concentrated flows and runoff delivered to the ditch or stream network through buffers or other natural filters.

Note on Agricultural Ditches:

The agricultural sector has long realized that the ditch network draining farm fields and animal feeding operations is an important location to treat the quality of agricultural runoff. Needelman et al (2010) provides a good summary of current approaches to utilize agricultural ditches to increase sediment and nutrient removal. Further, this panel recognizes that 1) agricultural ditches often connect with roadside ditches; and 2) recommendations for best agricultural ditch management practices are relevant to advancing roadside maintenance. While agricultural ditches share many characteristics with roadside ditches, however, they are <u>not</u> part of the charge of this RDM team.

Proposed Definitions of Roadside Ditch Management (RDM) Categories

Roadside ditch management (RDM) practices fall into 7 broad categories, as follows:

Category 1. Ditch Buffers: This practice restricts or excludes agricultural crop and livestock production from the public road right-of-way and its associated roadside ditch. Where public road right-of-ways are not sufficient to provide an adequate ditch buffer, the possibility of an incentivized narrow-width vegetative buffer (15 to 30 feet) on the adjacent private property could be explored. The permanent vegetative ditch buffer would function to prevent direct applications of fertilizer, manure or pesticides in the ditch zone that can be easily mobilized during storms. This is not a common incentivized practice at this time, although some narrow ditch buffers have been implemented on the Maryland eastern shore.

Category 2. Ditch Elimination: This practice involves eliminating a roadside ditch to:

(a) reduce or eliminate flow volumes introduced into streams
(b) reduce or eliminate sediment and nutrient runoff to streams
(c) disconnect the road network from the stream network.

Ditch elimination can be accomplished by a variety of road design/maintenance improvements such as raising the road profile, removal of berms, and out-sloping the road in order to move water directly from the road surface to areas where it can be infiltrated prior to reaching the stream network.

Category 3. Ditch and Road Slope-Length Reduction: This practice involves management techniques to reduce the length of the road segment and the ditch to:

(a) reduce flow volumes in the ditch
(b) reduce sediment and nutrient runoff to streams
(c) minimize the road connection to the stream network.

Ditch and road slope-length reductions can be accomplished by a variety of road design/maintenance improvements such as the addition of drainage cross pipes (culverts), turnouts (bleeders or lead-off ditches), broad-based dips or grade break

Category 4. *Ditch Stabilization*: Restore a failed ditch that has become an active source of sediment and nutrient loads that are exported to downstream waters. The practice involves stabilizing the banks and ditch channel and rapidly establishing dense vegetative cover to prevent further ditch erosion. Often referred to as "stabilized drainage way", this practice is frequently specified in most state erosion and sediment control manuals, new roadway and ditch construction criteria, and forest road design manuals.

Category 5. Ditch Maintenance: The practice involves routine removal of <u>mobile</u> sediments and organic matter that are trapped in the roadside ditch network (and safely disposed in upland areas of the watershed). The roadside ditch is adequately stabilized after sediment removal to prevent future ditch stabilization issues. Delivery is a key issue for this practice since only a small fraction of the sediment particles removed from a ditch are small enough to have any chance of ever reaching the Bay.

Category 6. Ditch Treatment: This practice treats the quality of ditch runoff in several ways:

(a) changing the soil media in portions of the ditch to promote greater pollutant removal, using soil amendments, standard bioretention media, biochar, water treatment residuals and other media enhancements (see Hirschman et al, 2017)

(b) installing "nutrient removal" check dams or in-ditch bioreactors. These bioreactors are explicitly designed to remove nitrogen and/or phosphorus by maximizing stormwater runoff reduction, N de-nitrification and P adsorption

(c) re-shaping a "V"-shaped ditch to more trapezoidal or two-stage dimensions, installing internal structures within the ditch to increase hydraulic residence time, and/or planting ditch vegetation to create wetland or meadow habitat conditions

Category 7. Ditch Retrofit: This practice creates stormwater treatment (ST) and/or runoff reduction (RR) by excavating additional runoff storage volume within an existing ditch segment. The storage can be provided on-line or off-line, and most ditch retrofits are typically sized to provide water quality treatment for 0.5 to 1.5 inches of impervious cover equivalent from the contributing drainage area. The following ditch retrofit options have been approved:

(a) Retrofit of existing stormwater conveyance systems

(b) Converting existing ditch to a dry swale, wet swale, bioretention area or sand filter

(c) Restoring ditch function by major sediment cleanout/vegetative harvesting

(d) Enhancing ditch via soil or media amendments

(e) Dry channel regenerative stormwater conveyance systems (for steeper ditches)

(f) Continuous monitoring and adaptive control (CMAC) retrofits

Section 3. Mapping and Assessing Roadside Ditch Characteristics

Given limited resources and the expansive length and impacts from roadside ditches, it is critical to identify and manage roadside ditches that connect contaminant sources and regional waterways most effectively, thus impose the most significant adverse impacts to water quality and habitat concerns. Recent widespread availability of high resolution topography, aerial photography, and land use land cover data provide a promising opportunity to map these local features across county jurisdictions and to prioritize locations for advanced roadside ditch management.

Despite limitations, hydrologically enforced LiDAR-derived topography data, with 1 to 2 m horizontal resolution and greater than 20 cm vertical accuracy, have been used successfully to map roadside ditches, delineating local contributing areas, and prioritize roadside ditch treatments. In Talbot County, MD, for example, more than 1200 locations were identified along county road only (i.e., not state or town roads). Desktop and field verifications provided additional support to identifying critical locations where grant funds were successfully secured to implement advanced practices.

While the high resolution analysis provides valuable information to road managers, it should be recognized that at present, the quality of the LiDAR DEMs varies throughout the Bay watershed, due in part to differences in how the LiDAR data were collected and processed by the various vendors. Poor quality data lacking hydrologic enforcement can significantly complicate efforts to map roadside ditch networks and to assess hydrologic connectivity.

Section 4. Options for Crediting Pollutant Reduction by RDM Practices

This section briefly describes which prior expert panels are relevant to each RDM category and outlines key challenges involved in developing crediting protocols.

Category 1: Ditch Buffers

No expert panel has specifically addressed ditch buffers, although the forestry work group recently re-evaluated removal rates for both forest and grass buffers in agricultural settings (Belt et al, 2014). The original expert panel expressed grass buffer removal as both a land use change (crop to hay w/o nutrients) and a unique removal rate for different physiographic regions of the Chesapeake Bay watershed. In addition, the panel relied on a standard buffer definition (NRCS Practice 391) which enables them to be cost-shared under CREP and other agricultural BMP programs for perennial or intermittent streams, wetlands, or other qualifying waterbodies (FSA CRP/CREP). The new expert panel concluded that there was not enough new scientific data on riparian and grass buffers to justify different removal rates at the present time (Belt et al, 2014).

It is possible that some, but not all, roadside ditches would meet the current USDA-FSA definition of perennial or intermittent streams, wetlands, or other qualifying waterbodies to qualify for CRP/CREP program incentives to establish and maintain roadside ditch buffers. Other current or new sources of financial and technical assistance may need to be considered for their establishment and maintenance on a wider scale.

Category 2: Ditch Elimination

A previous expert panel report on Dirt and Gravel Road ESC recommended sediment removal credits for several practices that are used to eliminate ditches (Klimkos et al, 2008). Sediment reductions of 15 to 55% for various combinations of these practices were recommended, but the actual research support was limited, and that approach is no longer recommended by forest road experts.

Instead, the Center for Dirt and Gravel Roads has proposed a new and improved method to estimate sediment reduction associated with ditch elimination. Sediment loads from a road segment can be easily estimated before and after ditches are eliminated for specific forest road locations using the US Forest Service - Water Erosion Prediction Project Road program (WEPP:Road) https://forest.moscowfsl.wsu.edu/fswepp/docs/fsweppdoc.html#wr). WEPP:Road was specifically designed to evaluate sediment delivery potential from forest roads due to various ditch elimination practices, such as raising the road profile or berm removal. Most users should be able to use this simple method to assess their ditch elimination projects. Please consult Appendix B for a design example on how the proposed credit might work.

Some significant challenges arise when it comes to crediting this RDM category:

- WEPP:Road cannot predict nutrient loads from ditch elimination and very little monitoring data is available to assess forest ditch nutrient loads. Consequently, it is doubtful that a nutrient reduction credit for ditch elimination could be technically supported.

- In the last eight years, no one has ever reported the dirt and gravel road erosion and sediment control practice for sediment credit in the Watershed Model. This suggests that road and highway agencies will need additional guidance on how to report the sediment credit (and to whom) in the future.

Category 3: Ditch and Road Slope-Length Reduction

A previous expert panel report on Dirt and Gravel Road ESC recommended sediment removal credits for several practices that are used to reduce the slope length of road ditches (Klimkos et al, 2008). This can involve installation of grade breaks, additional drainage outlets and other practices to break up slopes and shorten up the effective ditch length. The Center for Dirt and Gravel Roads has recently proposed a new and improved method to estimate sediment reduction associated reducing the slope-length of road ditches using WEPP:Road. The model is used to calculate sediment reductions from installing multiple drainage features to break up the slope length and outlet the water into forested buffers in situations where it is not physically possible to eliminate the ditch. Consult Appendix B for a design example on how the proposed credit might work.

This RDM category faces the same crediting challenges as those described for ditch elimination.

Category 4: Ditch Stabilization

The enhanced erosion and sediment control (ESC) expert panel recommended sediment removal credits for three levels of ESC technology utilized at construction sites (ESC EPR, 2014). Some of the practices reviewed could be applied to stabilization of eroding ditches whether they are located at a construction site or not. These include practices such as grass channels, dikes and stabilized drainage ways, along with supporting practices such as geotextile fabrics, floc bags, wattles, check dams and grass seeding. The ESC expert panel did not grant any nutrient reduction credit for ESC practices, given the very high fertilization rates needed to initially stabilize construction sites.

Several serious issues arise when it comes to crediting this RDM category:

- What numerical triggers would be needed to define when a ditch warrants stabilization to prevent it from becoming a severe sediment source to downstream land uses? (slope, depth of gully erosion, lack of vegetative cover, contributing drainage areas)

- What scientific data exists to support (a) a unique sediment loading rate for unstable ditches and (b) the corresponding sediment load reduction after they are stabilized?

- What land use would un-stabilized roadside ditches correspond to in the Phase 6 watershed model? (the choices are fairly limited: construction sites, pervious land and transport IC).

Category 5: Ditch Maintenance

Two previous expert panels have looked at the issue of crediting removal of sediment and attached nutrients from the storm drain and stream network. The first provided a sediment and nutrient credit for storm drain cleaning (SSDC EPR, 2016) for the measured volume of solids/organic matter that are effectively captured and properly disposed during catch basin cleanouts. The credit is extended to open-concrete lined channels but does not apply to sediment cleanouts to maintain un-lined ditches along open section roads (p, 47 of SSDC EPR, 2016). Default mass volume conversions and nutrient enrichment factors are provided to calculate load reductions, which must be supported by a standard operating procedure. Only a handful of communities have historically reported storm drain cleaning for credit.

The second report looks at the sediment and nutrient load reduction for bank sediments that are prevented from eroding due to urban stream restoration practices (USR EPR, 2013). The credit is described under Protocol 1 from that report, and requires field measurements of sediment loss and default rates for sediment nutrient enrichment.

There are several challenges involved in developing credits for routine ditch maintenance.

- Scientists have found it hard to define what sediment particle sizes are "mobile" in the Bay watershed and can reach the estuary and which ones will never get there. Roadway maintenance crews find it hard to estimate the particle size of the material they muck out of ditches, without expensive laboratory sediment testing. The street cleaning expert panel noted that crediting protocols based on sediment mass volume are extremely sensitive to their input assumptions. Resulting load reduction estimates can vary by as much as three orders of magnitude for the same conditions (SSDC EPR, 2016). For this reason, that panel rejected the mass-based crediting approach in favor of one that relied on a more sophisticated engineering model.

- While the particle size distribution and nutrient content of street dirt and hopper waste appear to be fairly universal, there does not appear to be much actual monitoring data to define these parameters for roadside ditch sediments (although it is hard to think of a reason why street dirt and roadside ditch sediments would behave differently).

Category 6: Ditch Treatment

While this RDM category has not been the focus of a prior expert panel, it is actively being investigated by both the agricultural and urban workgroups. On the agricultural side, an expert panel was launched in August of 2016 to explore whether a list of innovative agricultural ditch management practices could be credited for pollutant removal within the context of the Chesapeake Bay watershed model. The new panel is evaluating two stage ditch design, in-ditch bioreactors, use of phosphorus absorbing materials, and other practices to increase nutrient processing in the ditch network.

On the urban side, it may be possible to credit them using the methods approved for new state stormwater performance standard expert panel (NSSPS EPR, 2013), especially when the physical dimensions of existing ditches are manipulated to achieve higher water quality functions. The expert panel developed simple adjustor curves to estimate removal rates based on the stormwater treatment or reduction volume provided by the upgrade. It should not be too difficult to adapt the curves to handle ditch treatment, but states and locals will need more detailed guidance and outreach on how to properly calculate the credit. In addition, the USWG is currently considering whether to credit performance enhancing devices (PEDs) for bioretention and dry swale retrofits (Hirschman et al, 2017). Several PEDs, such as media filter amendments and internal water storage zones, may apply to several RDM categories, such as ditch retrofit and treatment.

This RDM practice has fewer crediting problems than other categories, but still has a few technical issues. The foremost issue is when a ditch receives runoff from the road and adjacent non-urban land. Appendix D presents a method to define the equivalent impervious area so that the adjustor curves can be used. In addition, clarification is needed on which sector would "earn" the actual credit (i.e., agricultural, forest or urban pervious.

On a more practical level, detailed design and construction criteria for ditch treatment practices need to be developed so that highway and stormwater agencies can design, review and verify them.

Category 7: Ditch Retrofits

Prior expert panels have provided extensive guidance on swale and ditch retrofits. The primary one has been the stormwater retrofit panel (SR EPR, 2013) but several other panels have expanded on other possible ditch retrofit options (USR EPR, 2013, NSSPS, EPR 2013, UFS, 2014 and ICD, 2017). The procedures for crediting ditch retrofits all involve some variation of the retrofit adjustor curves, which are well established and documented. Some substantial work will need to be done to provide design examples and technical guidance on ditch retrofits crediting protocols for the highway engineering community.

The main challenge for crediting this RDM category involves how to deal with ditches with non-urban land in their contributing drainage area. Reid Christianson has developed a simple method to use runoff coefficients to define equivalent impervious area so that the adjustor curvets can be applied to non-urban drainage areas. His method is described in more detail in Appendix D. Some additional technical outreach may be needed to train state and local highway agencies on these new methods.

Section 6. RDM Team Recommendations for Going Forward

The team considered four options for crediting RDM practices.

> *Option 1: Launch a New Expert Panel*. The Chesapeake Bay Partnership has continuously refined its protocol for reviewing the sediment and nutrient removal capability of new and existing BMPs for all watershed sectors (WQGIT, 2015). The protocol places a strong emphasis on the rigorous review of research, monitoring data and engineering models to derive defensible removal rates. The protocol also requires clear practice definitions and methods to report, track and verify any BMPs that are credited in the Phase 6 watershed model. Consequently, most expert panels take at least a year to reach consensus and several more months to get full approval by the CBP partnership.
>
> *Option 2: Add to the Charge of Ongoing Expert Panels*. The agricultural workgroup has launched an expert panel on agricultural ditch management practices which could conceivably address RDM categories that occur on agricultural land. However, the

expert panel is not designed nor staffed to evaluate and form recommendations for public road right-of-way ditches and their management.

Option 3: Conduct a Threshold Review. The work groups can conduct a "threshold" literature review to ascertain if there is sufficient BMP monitoring data and/or engineering models to warrant launching a new panel. In several cases, these reviews concluded that such data were lacking and the work group decided against launching a panel.

Option 4: Map RDM Practices into Existing Expert Panel Reports. The USWG recently developed a formal process to determine whether certain BMP variations or innovations could be interpreted or classified in the context of existing expert panel reports (Schueler, 2016). This can be an attractive option as it reduces the time and resources needed to make crediting decisions.

The RDM team concluded that different crediting options will be needed for the different RDM categories, and recommended that further follow up work be conducted by the appropriate work groups, as outlined in Table 1 below:

Table 1 Recommended Crediting Options for RDM Practices

RDM Category	Pollutants	Crediting Difficulty	Available Protocol?	Recommended Option	WG?
Buffer	S? N, P	Moderate	Land Use Change?	Option 2	A
Elimination	S only	Easy	WEPP-Road	Option 4	A/U
L/S Reduction	S only	Easy	WEPP-Road	Option 4	A/U
Stabilization	S only	Moderate	ESC Level 2	Option 3	U
Maintenance	S, N? P?	Hard	Storm Drain Cleanout	Option 3	U
Treatment	S, N, P	Easy	Adjustor Curves	Option 4	A/U
Retrofit	S, N, P	Easy	Adjustor Curves	Option 4	U

S: Sediment N: Total Nitrogen P: Total Phosphorus
WG: Work Group A: Agriculture U: Urban

The RDM team recommends that the urban and agricultural work groups develop a crediting approach for each practice by the summer 2018. This will provide state and local governments with more options to include RDM practices as they develop and execute their Phase III Watershed Implementation Plans.

The RDM team further recommends that resources be allocated to provide outreach and technical support to key stakeholders to implement RDM practices more widely and increase awareness among local and state highway and road agencies. As RDM crediting protocols are developed to meet Chesapeake Bay TMDL goals, these key stakeholders will need more detailed guidance on how to implement RDM practices more widely.

References Cited

Belt, K. et al. 2014. Report of the Expert Panel to Reassess Removal Rates for Riparian and Grass Buffers Best Management Practices. Prepared for Forestry Work Group. Chesapeake Bay Program.

Bloser, S., D. Creamer, C. Napper, B. Scheetz and T. Ziegler. 2012. Environmentally sensitive road maintenance practices for dirt and gravel roads. Center for Dirt and Gravel Road Studies. Pennsylvania State University. University Park, PA.

Chesapeake Stormwater Network. 2016a. Path forward for crediting pollutant removal from roadside ditch management practices. For Chesapeake Bay Program Office. Revised December 6, 2016

Chesapeake Stormwater Network. 2016b. Visual indicators for inspecting and verifying grass channels, filter strips and sheet flow to buffers. Webcast powerpoint. Chesapeake Bay Stormwater Training Partnership. October, 2016.

Erosion and Sediment Control Expert Panel Report (ESC EPR). 2014. Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices. Approved by the CBP WQGIT. April 2014.

Hirschman, D., Brian Seipp and T. Schueler. 2017. Performance enhancing devices for stormwater best management practices. Final Technical Report. Chesapeake Stormwater Network and Center for Watershed Protection.

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Schneider, R. and K. Boomer. 2016. Re-plumbing the Chesapeake Watershed: Improving roadside ditch management to meet TMDL water quality goals. STAC Publication No. 16-001. Edgewater, MD -

Stormwater Retrofit Expert Panel Report (SR EPR). 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stormwater Retrofit Practices. Approved by the CBP WQGIT. March, 2013.

Urban Filter Strip Expert Panel Report (UFS EPR). 2014. Recommendations of the Expert Panel to Define Removal Rates for Urban Filter Strips. Approved by the CBP WQGIT. June, 2014.

Urban Stream Restoration Expert Panel Report (USR EPR). 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Approved by the CBP WQGIT. April, 2013.

Water Quality Goal Implementation Team (WQGIT). 2015. Revised protocol for the development, review and approval of loading and effectiveness estimates for nutrient and sediment controls in the Chesapeake Bay Watershed Model. US EPA Chesapeake Bay Program. Annapolis, MD.

Appendix A
List of Past and Pending CBP Expert Panel Reports
Related to Various Ditch Management Practices

BMP	Notes	Status
Agricultural Ditch BMP	Ag (Gill and Brosch)	Launched 8/30/2016
Water Controlled Structures	Ag	Approved
Phosphorus-absorbing Systems	Ag	Interim
Grass Buffer Strips	Ag	Approved
Dry Channel Regenerative Stormwater Conveyance	Urban Retrofit EPR Stream Restoration EPR	Approved
Retrofit of Existing Stormwater Conveyance System	Urban Retrofit EPR	Approved
Swale Enhancements (media)	Urban Retrofit EPR	Approved
Swale Conversions (dry swale)	Urban Retrofit EPR	Approved
Swale Restoration	Urban Retrofit EPR	Approved
Dry Swale, Wet Swale, Bioretention, Grass Channel, Constructed Wetlands	New State Stormwater Performance Standards EPR	Approved
Soil Amendment	ICD EPR	Conditionally Approved
Filter Strips	Urban Filter Strip EPR	Approved
Traditional ESC Practices (Stabilized Drainage Ways)	Enhanced Erosion and Sediment Controls EPR	Approved
ESC for Dirt and Gravel Roads	Scenario Builder Appendix	Approved in 1999
Lined Ditch Sediment Cleanout	Street/Storm Drain Cleaning EPR	Approved

Appendix B.
Proposed Crediting Method for Ditch Elimination and Slope Length Reduction Using WEPP: Road
(Source: CDGRS, 2017)

Ditch Elimination: Erosion from a 400 foot long unpaved road segment in York County was simulated to show how WEPP:Road works and the benefits of ditch elimination and breaking up slope length. Figure 2 shows the sediment erosion output from an in-sloped road where water is collected in a single bare ditch and outletted to a 100 foot long forested buffer as a point source. The total sediment leaving the forested buffer is 983 lbs per year. Figure 3 shows that by out-sloping the road and eliminating the ditch the total sediment leaving the buffer drops to 307 lbs per year, a reduction of 69%.

Ditch flow-length Reduction: Figure 4 shows the benefits of adding an extra cross-pipe to the insloped road with a single bare ditch simulated in Figure 2. The road was broken up into two, 200 foot long road segments and each segment produced a total of 344 lbs of sediment per year leaving the buffer or 688 lbs for a 400 foot long segment. By breaking up the original 400 foot long slope length and making no other improvements, the amount of sediment leaving the buffer was reduced by 30%.

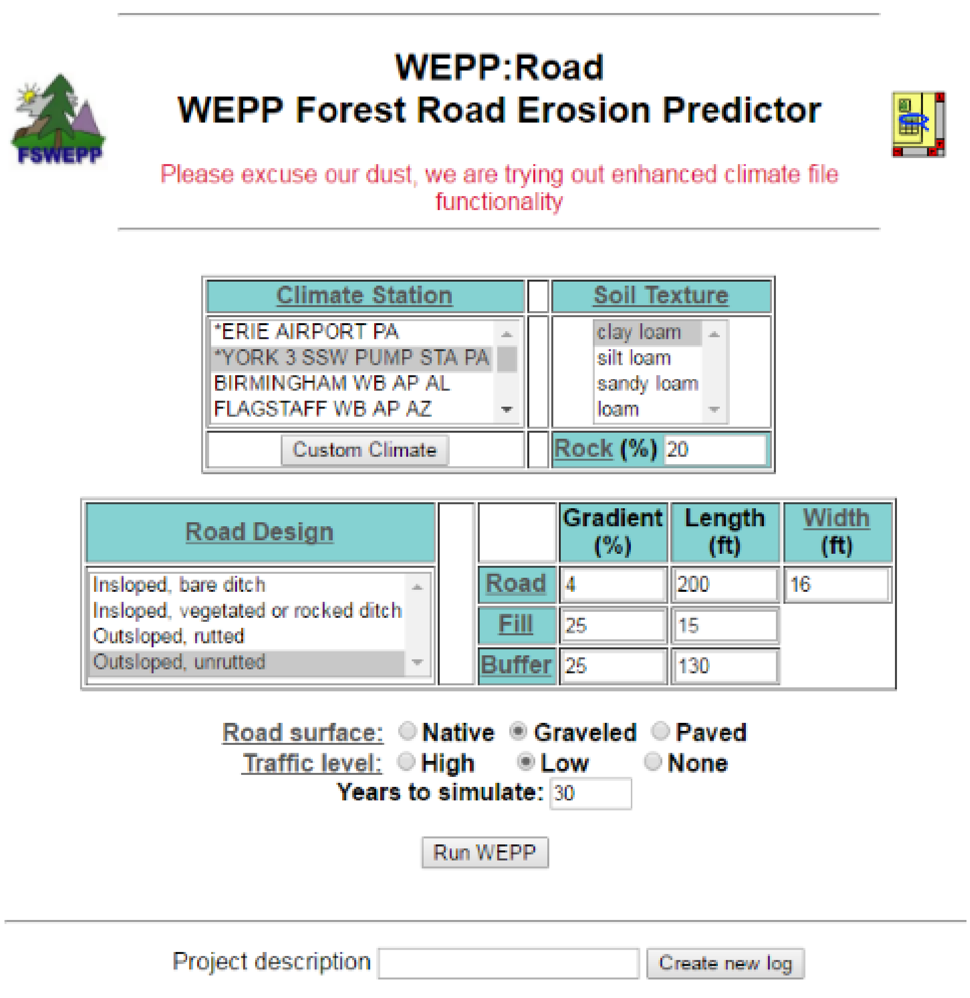

Figure 1. Screen shot of WEPP-Road input screen.

WEPP:Road Results

INPUTS			
Climate	YORK 3 SSW PUMP STA PA		
Soil texture	silt loam with 20% rock fragments (road: 65%; fill: 42.5%; buffer: 20% rock)		
Road design	Insloped, bare ditch		
Surface, traffic	graveled surface, low traffic		
	Gradient (%)	**Length (ft)**	**Width (ft)**
Road	4	400	16
Fill	25	15	
Buffer	25	100	

30 - YEAR MEAN ANNUAL AVERAGES				
			Total in 30 years	
41.05	in	precipitation from	3738	storms
1.83	in	runoff from rainfall from	499	events
0.10	in	runoff from snowmelt or winter rainstorm from	105	events
1073.79	lb	road prism erosion		
983.38	lb	sediment leaving buffer		

Run description: [ ] Add to log

Figure 2. Sediment erosion output from 400 foot long road segment with inslope ditch. Total sediment leaving the buffer is 983 lbs per year.

WEPP:Road Results

INPUTS			
Climate	YORK 3 SSW PUMP STA PA		
Soil texture	silt loam with 20% rock fragments (road: 65%; fill: 42.5%; buffer: 20% rock)		
Road design	Outsloped, unrutted		
Surface, traffic	graveled surface, low traffic		
	Gradient (%)	**Length (ft)**	**Width (ft)**
Road	4	400	16
Fill	25	15	
Buffer	25	100	

30 - YEAR MEAN ANNUAL AVERAGES				
			Total in 30 years	
41.05	in	precipitation from	3738	storms
0.31	in	runoff from rainfall from	510	events
0.00	in	runoff from snowmelt or winter rainstorm from	101	events
824.03	lb	road prism erosion		
306.95	lb	sediment leaving buffer		

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Figure 3. Sediment erosion output from 400 foot long road segment after outsloping the road and eliminating the ditch. Total sediment leaving buffer is reduced from 983 lbs to 307 lbs per year with ditch elimination (69% reduction).

WEPP:Road Results

INPUTS			
Climate	YORK 3 SSW PUMP STA PA		
Soil texture	silt loam with 20% rock fragments (road: 65%; fill: 42.5%; buffer: 20% rock)		
Road design	Insloped, bare ditch		
Surface, traffic	graveled surface, low traffic		
	Gradient (%)	**Length (ft)**	**Width (ft)**
Road	4	200	16
Fill	25	15	
Buffer	25	100	

30 - YEAR MEAN ANNUAL AVERAGES				
			Total in 30 years	
41.05	in	precipitation from	3738	storms
1.27	in	runoff from rainfall from	493	events
0.04	in	runoff from snowmelt or winter rainstorm from	104	events
494.13	lb	road prism erosion		
344.00	lb	sediment leaving buffer		

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Figure 4. Sediment erosion output after breaking the 400 foot long segment from Figure 2into two 200 foot long road segments while maintaining inslope ditch. Breaking up slope length decreases erosion from 983 lbs per year to 688 lbs per year for a 400 foot long segment (30% reduction).

APPENDIX C:
ROSEN IDEAS ON DITCH CATEGORIES

When I read through the memo the one area that made me stumble was how to easily tie together *B. Proposed Definition for Roadside Ditch Management (RDM)* in section 2 to section 5. This might be due to my lack of knowledge on the various expert panels or due to by ag centric ditch view I have from working on the Eastern Shore. I am not sure if this would be helpful moving forward, but for me it helped me better understand potential crediting when I broke road side ditches into three subcategories:

1) Roadside ditches designed exclusively for stormwater
    a. Created during the construction of the road
    b. Generally low in TN, have high sediment transport capacity if there is poor maintenance
    c. Generally do not help drain larger areas other than the road and adjacent areas
    d. Ephemeral-run during storm events or very wet periods only
2) Roadside ditches for the conveyance of streams
    a. Road built near stream and ditch was created to channelize stream
    b. Help reduce flooding of road and to move stormwater generated from road
    c. Drain larger areas and can be intermittent to perennial depending on stream size and physiographic region
    d. High erosion potential, TN/TP levels based on dominant land use in watershed and not by road
3) Roadside ditches connected to existing agricultural ditches
    a. Agricultural ditch network pre-existed road and road uses the agricultural ditch to move stormwater
    b. Primary purpose is to lower water table for farming purposes, not for road stormwater
    c. Can drain a small or large area
    d. TN/TP levels dictated by ag fields, erosion potential is generally low if good farming practices are used, but can be very high if poorly vegetated or if land is tilled up to the ditch.
    e. Generally in flat landscapes

This framework helped me better visualize where potential ditch BMPs fit and might help identify which option is best for crediting.

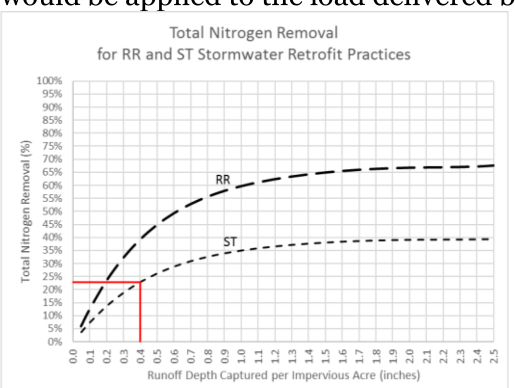
Appendix D.
Proposed Method for Runoff Equivalent Impervious Area for Non Urban Land Uses

The use of runoff coefficients can be use do normalize non-impervious drainage areas to an "runoff equivalent impervious area". For example, impervious has an Rv of 0.95, ag may have an Rv of 0.50, meaning 1 acre of ag would be "runoff equivalent" to roughly 0.53 acres of impervious (0.50/0.95=0.53).

Putting this into equation form, $I_{equivalent} = \frac{Rv_{contributory\ land\ use}}{Rv_{impervious}} * A_{contributory}$. where $I_{equivalent}$ is the equivalent impervious area, $Rv_{contributory\ land\ use}$ is the runoff coefficient of the drainage area, $Rv_{impervious}$ is the runoff coefficient of impervious (0.95), and $A_{contributory}$ is the size of the drainage area.

Water treatment volumes (i.e. cubic feet of water treated) for a specific BMP would be put in terms of volume treated per runoff equivalent impervious acre for direct use in the retrofit adjustor curves.

To further the above example, 1 acre of agricultural land (0.53 acres of runoff equivalent impervious) routed into a stormwater treatment (ST) ditch retrofit project providing 775 cubic feet of treatment would provide 0.4 inches of treatment. Using the runoff adjustor curves, the retrofit practice would provide 23%, 36%, and 46% reductions in TN, TP, and TSS, respectively. These reduction percentages would be applied to the load delivered by the drainage area.



Runoff coefficients can be gleaned from a number of sources. Here, runoff coefficients from Table 3.24 of Haan, Barfield, and Hayes (1994 -- Design Hydrology and Sedimentology for Small Catchments) are shown as an example.

Character of surface	Runoff coefficients
Streets	
Asphaltic and concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns; sandy soil	
Flat, 2%	0.05 to 0.10
Average, 2 to 7%	0.10 to 0.15
Steep, 7%	0.15 to 0.20
Lawns, heavy soil	
Flat, 2%	0.13 to 0.17
Average, 2 to 7%	0.18 to 0.22
Steep, 7%	0.25 to 0.35

Note: The coefficients in these two tabulations are applicable for storms of 5-year to 10-year frequencies. Less frequent higher intensity storms will require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff. The coefficients are based on the assumption that the design storm does not occur when the ground surface is frozen.

Table 3.24—*Continued*

Rural areas

Topography and vegetation	Soil texture		
	Open sandy loam	Clay and silt loam	Tight clay
Woodland			
Flat 0–5% slope	0.10	0.30	0.40
Rolling 5–10% slope	0.25	0.35	0.50
Hilly 10–30% slope	0.30	0.50	0.60
Pasture			
Flat	0.10	0.30	0.40
Rolling	0.16	0.36	0.55
Hilly	0.22	0.42	0.60
Cultivated			
Flat	0.30	0.50	0.60
Rolling	0.40	0.60	0.70
Hilly	0.52	0.72	0.82

To generalize, the following categories with corresponding runoff coefficients are proposed:

Land Use/Cover	HSG A/B	HSG C	HSG D
Urban Pervious	0.12	0.18	0.22
Woodland (<5% slope)	0.10	0.30	0.40
Woodland (>5% slope)	0.27	0.42	0.55
Pasture (<5% slope)	0.10	0.30	0.40
Pasture (>5% slope)	0.20	0.40	0.57
Cultivated (<5% slope)	0.30	0.50	0.60
Cultivated (>5% slope)	0.46	0.66	0.76

This can be further refined to "runoff equivalent impervious" where 1 acre of the given land use equals this many acres of impervious:

Land Use/Cover	HSG A/B	HSG C	HSG D
Urban Pervious	0.13	0.19	0.23
Woodland (<5% slope)	0.11	0.32	0.42
Woodland (>5% slope)	0.28	0.44	0.58
Pasture (<5% slope)	0.11	0.32	0.42
Pasture (>5% slope)	0.21	0.42	0.60
Cultivated (<5% slope)	0.32	0.53	0.63
Cultivated (>5% slope)	0.48	0.69	0.80