Appendix: Protocol to Define Nutrient and Sediment Removal Rates for Impervious Area Disconnection to Amended Soils - Maryland

Maryland originally included specifications and performance criteria for impervious area disconnection (e.g., rooftop and non-rooftop disconnection) in the *2000 Maryland Stormwater Design Manual, Volumes I and II*[i] (Design Manual). The initial credits for rooftop and non-rooftop disconnection (see Appendix E, pp. E.1.6 to E.1.10) allowed designers to subtract adequately disconnected areas from the total impervious coverage thereby reducing the water quality and groundwater recharge volumes (WQ_v and Re_v, respectively). Because these credits were provided as incentives for reducing impervious coverage, the initial design criteria did not include soil-specific design requirements.

With the implementation of environmental site design (ESD) in 2007 and subsequent changes to the Design Manual in 2009, the original system of credits was modified to reflect the newer runoff reduction requirements (see pp. 5.57 to 5.65). As a result, the new disconnection of rooftop and non-rooftop runoff techniques require that disconnected runoff be directed over hydrologic soil group (HSG) A, B, or C soils (e.g., sands, loams, sandy clay loams). Soil amendments may be used to increase permeability where there are HSG D soils (e.g., clay loam, clay) or in areas that have been compacted by heavy equipment.

The Design Manual assigns a specific rainfall target or "P_E" (in inches) that may be used when determining the amount of runoff treated by the disconnection. The P_E varies from 0.2 inches to 1.0 inches depending on the ratio of the disconnection length to the length or size of the contributing imperviousness (see Tables 5.6 and 5.7, pp. 5.59 and 5.62, respectively). The resulting P_E is subtracted from the total rainfall that must be captured and treated to meet runoff reduction (i.e., ESD) requirements.

In the body of this report, the Urban Stormwater Work Group (USWG) has developed protocols for determining the runoff depth treated by directing impervious area runoff onto compost-amended soils. These protocols are less stringent than current State stormwater standards (see subsequent discussion) and should not be used within Maryland. Instead, the Maryland Department of the Environment (MDE) offers the following method for determining runoff reduction where disconnected runoff is directed onto amended soils.

Method for Impervious Area Disconnection with Soil Amendments

For the purposes of assigning runoff reduction values where impervious area disconnections are directed over HSG D soils or areas that are compacted by construction equipment, MDE has developed the following simplified curve. This curve is based on Tables 5.6 and 5.7 from the Design Manual. The following conditions shall be considered when using this method:

- Disconnections shall meet the conditions listed for the Disconnection of Rooftop and Non-Rooftop Runoff listed in Chapter 5 of the Design Manual (see pp. 5.59 and 5.62)

- Soil amendments shall consist of the addition of at least 1 inch of compost and an incorporation depth of at least 3 inches into existing soil. Soil shall be loose (i.e., compaction factor of 1:1) and compost used shall have at least 50% organic matter (*OM*).

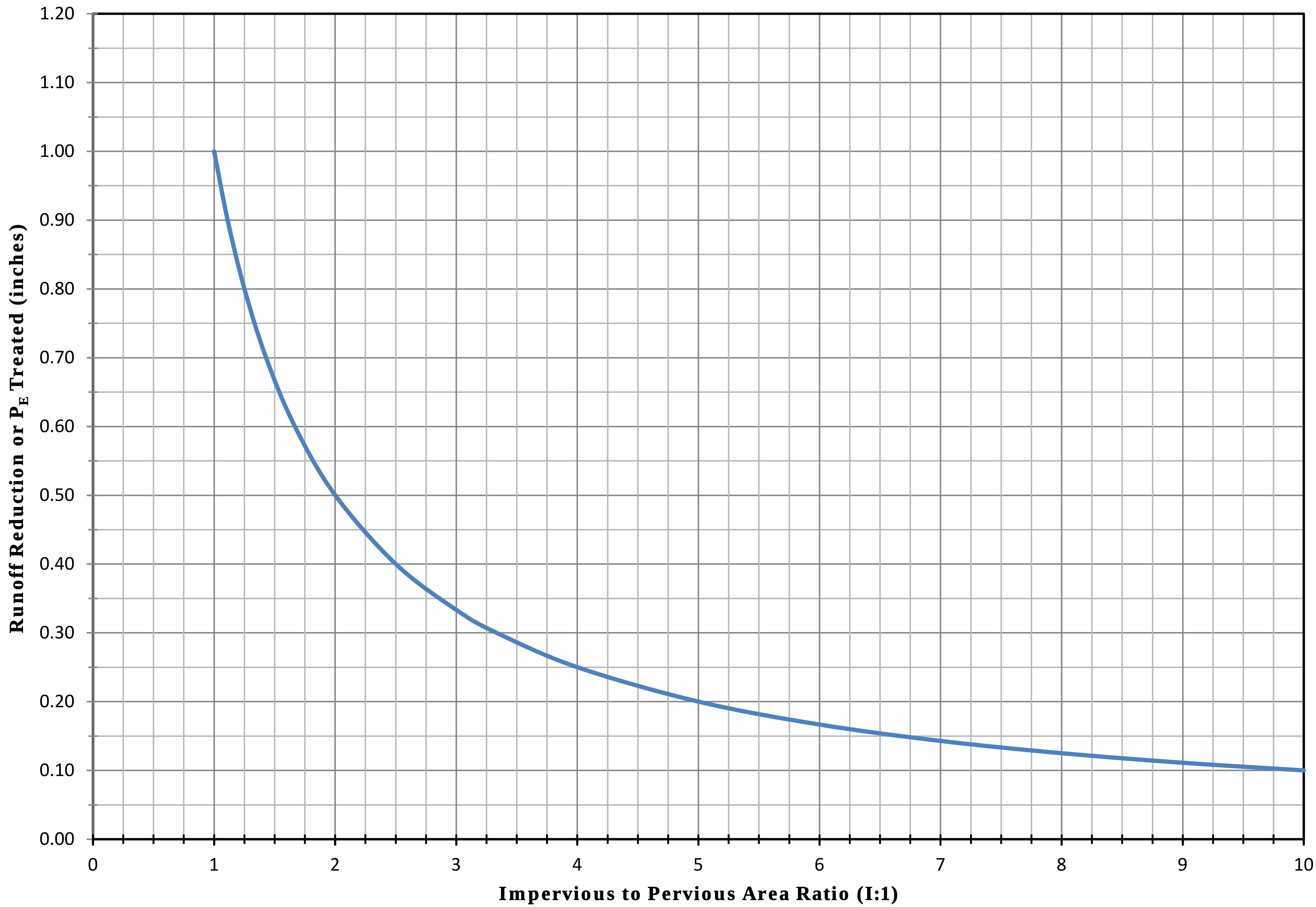
After determining the ratio of impervious to pervious area, use Figure 1 below to determine the amount of runoff reduced by the disconnection. Computation of the annual total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) load reductions is not required. However, these load reductions can be estimated using Table 1 below.

Table 1. Removal Rates for ESD/Runoff Reduction (RR) Practices[1]

Runoff Depth Treated (inches)	TSS	TP	TN
0.1	20.4%	18.9%	16.6%
0.2	35.5%	33.0%	28.6%
0.25	40.4%	37.6%	32.5%
0.3	44.4%	41.3%	35.6%
0.4	50.7%	47.2%	40.6%
0.5	55.6%	51.8%	44.5%
0.6	59.6%	55.5%	47.7%
0.7	62.9%	58.6%	50.3%
0.75	64.4%	60.1%	51.5%
0.8	65.9%	61.4%	52.6%
0.9	68.4%	63.8%	54.7%
1.0	70.7%	65.9%	56.5%

1. Values based on *the* CBP approved publication, *Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards* (Schueler and Lane, 2012)

Figure 1. Runoff Treated for Impervious Area Disconnection onto Amended Soils



Discussion: The use of soil decompaction and compost amendments to improve soil permeability has been well documented in literature. However, there are many different standards for this practice (e.g., soil amendment type, amount, and depth of incorporation), and in the assessment of the effects on the quality of impervious area runoff that is treated by the practice. As a result, the Expert Panel was unable to simply use an average (or median) of study results in the development of protocols described in Section 5 and Appendix E of this document. As a result, the Expert Panel developed a method that uses a standard of one inch of rainfall and the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Runoff Curve Number (RCN)[ii] method for a conservative and reproducible approach for estimating runoff reduction benefits in a large number of situations. The decision to use the NRCS RCN method over other, more rigorous rainfall runoff models was based on its prevalence in State stormwater manuals. For example, in the 2000 Maryland Stormwater Design Manual (MDE, 2000 & 2009), the RCN method and a variation of the Small Storm Hydrology Method (Claytor & Schueler, 1996 and Pitt, 2003) are used to better capture rainfall-runoff relationships over the full range of storm events.

The Expert Panel recognized that the RCN method is limited in capturing differences in rainfall intensity. The RCN method is also limited in the ability to accurately predict runoff amounts for smaller, more frequent storm events like one inch of rainfall. However, the method's popularity, practitioner familiarity, and overlap with standard stormwater procedures outweighed these limitations.

The Maryland Department of the Environment (MDE) has expressed reservations with the methods described in Chapters 4 and 5 of the report for determining the amount of runoff treated by amended soils. These reservations primarily concern the use of soil properties like saturated hydraulic conductivity (K_{sat}) to predict CN's and the amount of additional runoff treated by amended soils. More specifically, the computational method described in Section 5.1 includes an equation (see equation 5.1.3.2) that relates K_{sat} to a RCN.

MDE expressed concerned that there is no established relationship between K_{sat}, which is the rate of water movement, (inches per hour) through saturated soils and RCNs, which are dimensionless values that were developed by fitting rainfall (P) and runoff (Q) data from several monitored watersheds. In response to these concerns, and with the Expert Panel's acknowledgement, MDE asked several noted experts (see list below) on runoff curve number hydrology to independently review the "Recommendations of the Expert Panel to Define Removal Rates for Disconnecting Existing Impervious Area Runoff from Stormwater Drainage Systems."

MDE received several comments from this independent review that support the concerns expressed above. Most notably, Donald E. Woodward (NRCS-retired) commented that the correlation between K_{sat} and curve number is beyond the original concept of curve number usage. Mr. Woodward further commented that curve numbers were used to estimate runoff volume only, and not other hydrologic parameters as described in the report. Similarly, Mr. Woodward, Dr. Richard Hawkins, and Dr. Timothy Ward, members of the Environmental and Water Resources Institute's Curve

Number Hydrology Task Committee, commented that the curve shown in Figure 9 (see §5.1.3, p. 31) is neither realistic nor based on any known science or data. Finally, Dr. Richard McCuen expressed concern that relationships expressed in the report were poorly conceived and should be reevaluated.

MDE also received several detailed comments (see below) from Dr. Robert Pitt concerning the use of RCN hydrology for a broad range of rainfall events. He also questioned why the methods promoted within the report were not supported using readily available monitoring information. Most notably, Dr. Pitt expressed concern that the RCN method was used for small storm events that are below the model's recommended applicability. For example, in Chapter 2 of the NRCS Technical Release (TR) 55[iii] it states that "(t)he CN procedure is less accurate when runoff is less than 0.5 inch." Dr. Pitt further notes that CN values can vary greatly for more common, smaller rainfall events. Finally, Dr. Pitt observes that the procedures described in the report should be verified with actual urban rainfall-runoff data, which is available for the Chesapeake Bay urban area, for different areas and ranges of disconnections.

In the original comments, MDE commented that the report disregarded several of the core assumptions behind runoff curve number hydrology. Most notably, MDE expressed concern that the proposed method relied too heavily on a relationship between K_{sat} and CN; a relationship that noted experts in RCN hydrology claim does not exist. As discussed above, MDE's concerns are supported by comments received from the independent peer review process. Because this relationship is questionable, the method promoted in Section 5 and Appendix E cannot be supported by MDE. Therefore, in Maryland, the effect of directing runoff from impervious areas onto amended soils will be determined using the curve provided (see Figure 1. Runoff Treated for Impervious Area Disconnection onto Amended Soils).

<u>**Independent Peer Reviewers**</u>

Robert Pitt, Ph.D., P.E., BCEE, D.WRE
Cudworth Professor of Urban Water Systems
Dept. of Civil, Construction, and Environmental Engineering
University of Alabama

Richard McCuen, Ph.D., M.ASCE
Professor, Ben Dyer Chair in Civil Engineering
University of Maryland, College Park

Robert G. Traver, Ph.D., P.E., D. WRE, F.EWRI, F.ASCE
Edward A. Daylor Chair in Civil Engineering
Professor, Civil and Environmental Engineering
Director, Villanova Urban Stormwater Partnership
Director, Villanova Center for the Advancement of Sustainability in Engineering

Richard H. (Pete) Hawkins, PhD, P.E., F.ASCE, F.EWRI, Professor Emeritus
School of Natural Resources and Environment,
Watershed Resources and Ecohydrology
Department of Agricultural and BioSystems Engineering
Department of Hydrology and Water Resources
University of Arizona

Dr. Tim J. Ward, P.E., F.EWRI, F.ASCE
Dean, School of Engineering
Professor of Civil Engineering
Manhattan College in Riverdale, The Bronx, New York City

Donald E Woodward, P.E., P.H., F.ASCE
USDA, NRCS (ret.)
Former National Hydrologist with the USDA, NRCS

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[i] *2000 Maryland Stormwater Design Manual, Volumes I and II, MDE 2000 and 2009*

[ii] National Engineering Handbook (NEH) Part 630 Hydrology, 210-vi, United States Department of Agriculture, National Resources Conservation Service, September 1997

[iii] Technical Release 55 urban hydrology for Small Watersheds, United States Department of Agriculture, National Resources Conservation Service, June 1986