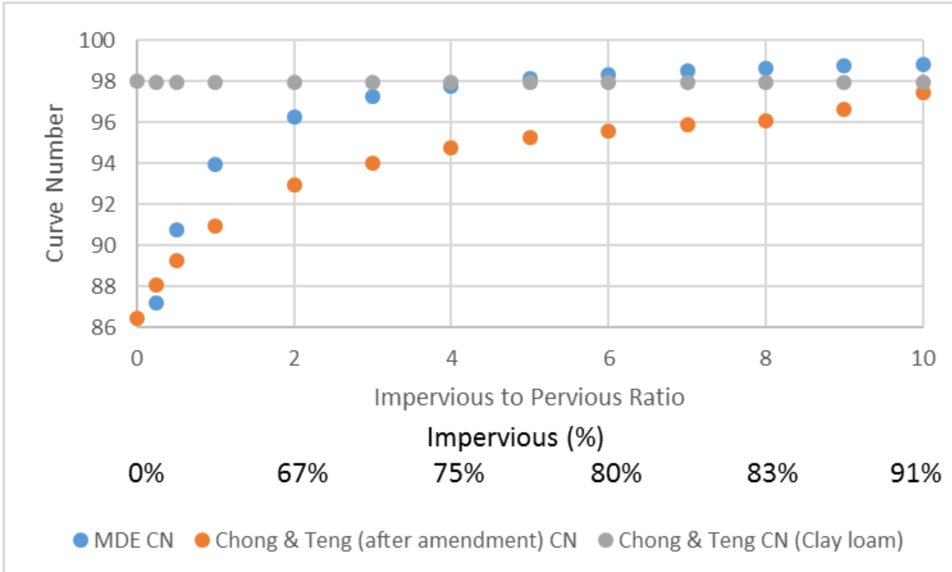
General response to the Maryland Department of the Environment's concern in using the CN method in the Impervious Cover Disconnection protocols

This is in response to MDE's concern about using the CN method in developing the impervious disconnection protocols. As noted by MDE, the standard CN method is not accurate for estimating runoff volume with small storms (like the 1" value this expert panel is recommending). This discrepancy has been noted in research (Pitt,1994 [as referenced by MDE]; Suresh et al., 2012; Christianson et al., 2016) and this trend seems to be generally accepted. The expert panel noted the limitations of the CN method and agreed using this non-standard CN method was appropriate in this situation for a number of reasons.

1) Other methods discussed included continuous simulation with various rainfall runoff models or single storm simulation using a Green-Ampt type infiltration approach. The panel noted these approaches may give better estimates of runoff at a given site, but the panel also noted the amount of information/computation required to do this appropriately made these methods unsuitable for protocol development broadly applicable across the Chesapeake Bay.
2) Looking at differences in runoff at a site before and after soil amendments due to changes in the saturated hydraulic conductivity was the basic approach used to develop the protocols, and the panel felt having a simple, broadly applicable, and consistent method was more important than having a highly site specific method taking into account all variables impacting runoff. Additionally, the RCN method are used to simply calculate a difference between before and after conditions. Since predicted RCN values tend to be high from the start the difference at such high RCNs before and after treatment are not impacted as greatly by the accuracy issues in predicting runoff volume as described in the first paragraph.
3) The Chong and Teng (1986) method converts saturated hydraulic conductivity to a RCN and because their method does not consider vegetation, the predicted CN values are higher CN values than traditional look-up tables. This helps to offset the accuracy issue associated with predicting runoff volume of small storms (1.0 inch and less). An example would be a clay loam (HSG C) using Open Space Fair Condition in a look-up table gives a CN of ~79, where the Chong & Teng approach (assuming a slightly compacted soil and 3.5% organic matter to match the Schwartz example below) gives a CN of 98 before amendments. Even after amendments (uncompacted and increased organic matter), the Chong & Teng estimated CN is 86 (still higher than the look-up table).
4) Runoff methods suggested, for example, in Appendix D.10 of the Maryland Stormwater Manual (Method for Computing Peak Discharge for Water Quality Storm), which uses methods from Clayton and Schueler (1996) and Pitt (1994), addresses the accuracy issues associated with predicting runoff volume from small storms, however, changes to onsite soil characteristics cannot be quantified (i.e. runoff reduction from amendments is zero) as there is no way to relate changes in saturated hydraulic conductivity to runoff volume.
    a. Though runoff reduction cannot be calculated using the MDE method, a comparison of the resulting CN from this method compared to before and after soil amendments

(using the Schwartz example highlighted below) can be done. The purpose of this figure is to simply show the initially high CN values (leading to high runoff estimates) AND high estimated CN values even after heavy soil modifications and decompaction using the Chong and Teng method.

i. 

Schwartz Example

Dr. Stuart Schwartz is a Senior Research Scientist at the Center for Urban Environmental Research and Education at the University of Maryland, Baltimore County who is doing research on the effect of soil amendments on runoff reduction. A comparison of the preliminary data generated by Dr. Schwartz in estimating infiltration associated with soil amendments to the method developed by the Expert Panel also demonstrates the Panel's method is conservative in estimating the infiltration of runoff associated with soil amendments. Using information from a report by Schwartz (2015) on a site with clay loam soil, here is a quick example comparing methods.

Site Characteristics:

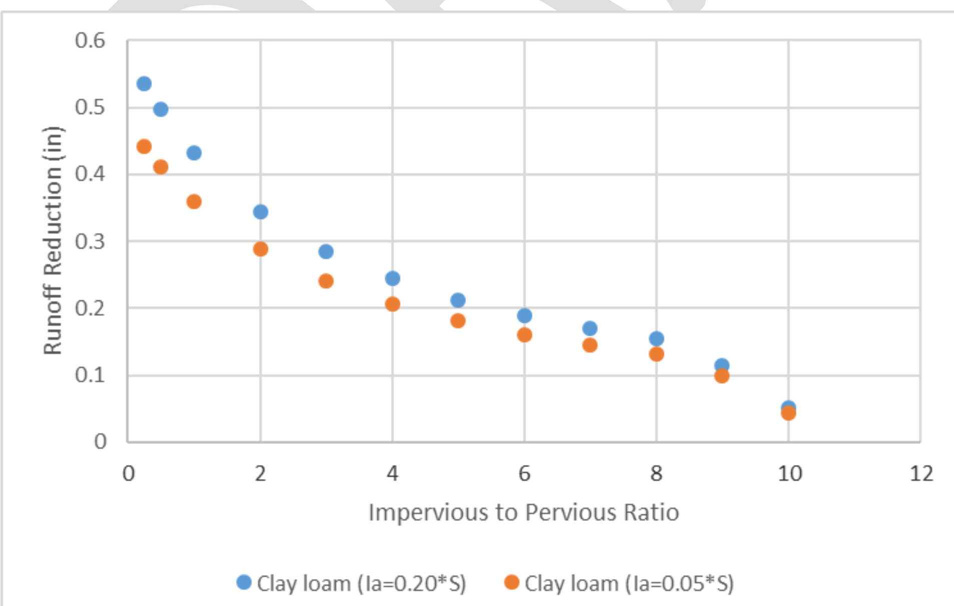
	Schwartz (2015)		Expert Panel Method	
Characteristic	Standard Turf	Suburban Subsoiling	Standard Turf	Suburban Subsoiling
Bulk Density (g/cm^3)	1.56	1.11	1.56	1.22
Organic Matter (%)	3.50	6.40	3.50	6.35
Infiltration (assumed steady state and analogous to Ksat) (in/hr)	0.04	8.43	0.04	0.43

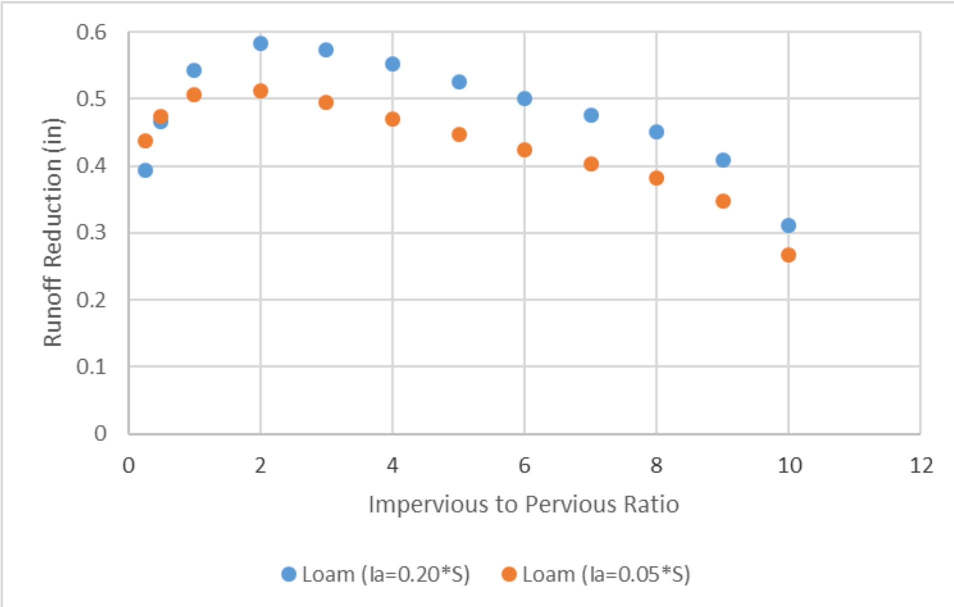
Since a measure of compaction is an input into the expert panel method, the bulk density for standard turf using the expert panel method was adjusted using the method's compaction factor to match the conditions outlined in the report. The infiltration rate as reported by Schwartz was assumed to be steady infiltration rate and assumed to be analogous to effective saturated hydraulic conductivity.

The decompaction depth was assumed to be 14 inches, which roughly corresponds with the soil strength figure in the report. In order to match the resulting organic matter content as shown in the report, 5.5 inches of compost at an organic matter of 50% was added to the expert panel method to match the reported organic matter.

New Assumption for Initial Abstraction

In discussions with MDE about their concerns in using the RCN method in predicting runoff from small storms, they had mentioned that there is considerable research being done to look at a different initial abstraction factor (e.g., 0.05) instead of the current factor used in the RCN approach (0.20) which would conceivably address the small storm issue. MDE suggested that we look at how a change in the initial abstraction factor might change the predicted runoff reduction volume using the Expert Panel method. The results show that there is a ~0.09 inch maximum difference in runoff reduction estimates between an Ia of 0.2 and 0.05 for the clay loam with heavy soil amendments considered in the Schwartz example above. For comparison, when considering a loam with the same soil amendments, the maximum difference is 0.08 inches. Finally, a loam with light soil amendments (1" compost incorporated 4" into existing soil) has a maximum difference in runoff reduction is 0.06 inches. The sharp drop after Impervious to Pervious ratio of 1 in the loam example is due to underlying soil not being amended. In all cases, the difference in the methods is less than 10% of the 1 inch rainfall. Therefore, we recommend not adding this layer of complexity since the bias associated with an Ia= 0.2 is relatively small for the expected RCN's used in the protocol; however, if this change is consistent with recommendation from other expert panels or if this assumption will not add confusion to implementation of these protocols, the expert panel may be amenable to the change.




0.6
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Runoff Reduction (in)
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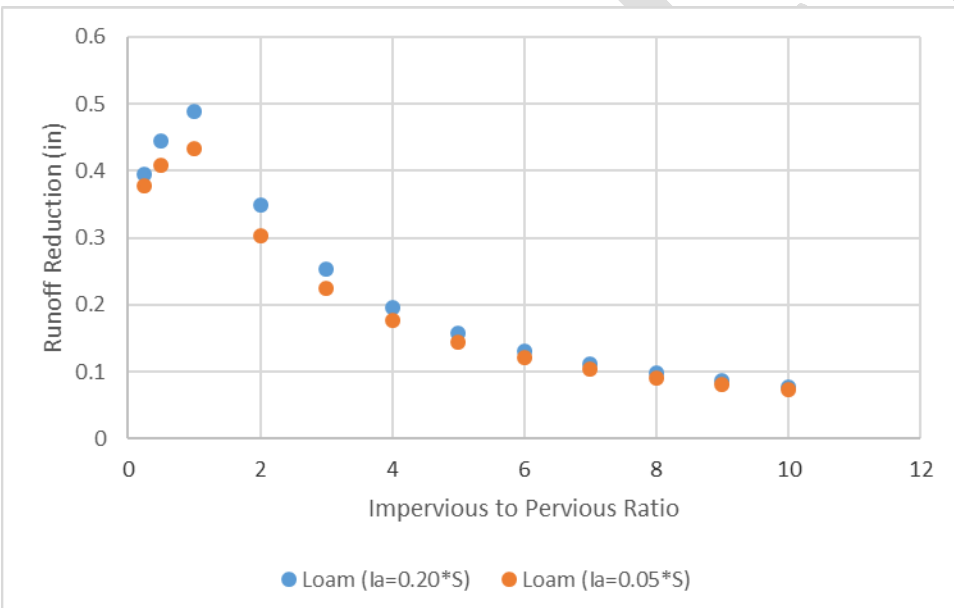
Impervious to Pervious Ratio
Loam (Ia=0.20*S)
Loam (Ia=0.05*S)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Runoff Reduction (in)
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Impervious to Pervious Ratio
Loam (Ia=0.20*S)
Loam (Ia=0.05*S)