# APPENDIX E

# TREATMENT VOLUME PEAK FLOW RATE

The peak rate of discharge for individual design storms is required for several different components of BMP design. While the primary design and sizing factor for most stormwater runoff reduction BMPs is the design Treatment Volume (*Tv*), several design elements will require a peak rate of discharge for specified design storms. The design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales and water quality swale geometry, etc., all require a peak rate of discharge in order to ensure non-erosive conditions and flow capacity.

The peak rate of discharge from a drainage area can be calculated from any one of several calculation methods. The two most commonly used methods of computing peak discharges for peak runoff calculations and drainage system design are NRCS TR-55 Curve Number (CN) methods (NRCS TR-55, 1986) and the Rational Formula. The Rational Formula is highly sensitive to the time of concentration and rainfall intensity, and therefore should only be used with reliable Intensity-Duration-Frequency (IDF) curves or tables for the rainfall depth and region of interest (Claytor and Schueler, 1996). Unfortunately, there are no IDF curves available at this time for the 1" rainfall depth.

The NRCS CN methods are very useful for characterizing complex sub-watersheds and drainage areas and estimating the peak discharge from large storms (greater than two inches), but can significantly under estimate the discharge from small storm events (Claytor and Schueler, 1996). Since the Tv is based on a one-inch rainfall, this underestimation of peak discharge can lead to undersized diversion and overflow structures, resulting in a significant volume of the design Tv potentially bypassing the runoff reduction practice. Undersized overflow structures and outlet channels can cause erosion of the BMP conveyance features which can lead to costly and frequent maintenance, gnashing of teeth, and unacceptable levels of misery and despair.

Since IDF Curves may not be available for all the regions of West Virginia for the one-inch rainfall, and in order to maintain consistency and accuracy, the following Modified CN Method is recommended to calculate the peak discharge for the one-inch rain event. The method utilizes the Small Storm Hydrology Method (Pitt, 1994) and NRCS Graphical Peak Discharge Method (USDA 1986) to provide an adjusted curve number that is more reflective of the runoff volume from impervious areas within the drainage area. The design rainfall is a NRCS type II distribution so the method incorporates the peak rainfall intensities common in the eastern United States, and the time of concentration is computed using the method outlined in TR-55.

The following provides a step by step procedure for calculating the Treatment Volume peak rate of discharge ($q_{pTv}$):

**Step 1**: Calculate the adjusted curve number for the site or contributing drainage area.

The following equation is derived from the NRCS CN Method and is described in detail in the National Engineering Handbook Chapter 4: Hydrology (NEH-4), and NRCS TR-55 Chapter 2: Estimating Runoff:

$$CN = \frac{1000}{[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{0.5}]}$$

Where:

$CN$ = Adjusted curve number

$P$ = Rainfall (inches), (1.0” in West Virginia)

$Q_a$ = Runoff volume (watershed inches), equal to $Tv \div drainage\ area$

**Note**: When using hydraulic/hydrologic model for sizing a runoff reduction BMP or calculating the Tv peak discharge ($q_{pTv}$), designers must use this modified CN for the drainage area to generate runoff equal to the Tv for the one-inch rainfall event.

**Step 2**: Compute the site or drainage area Time of Concentration (Tc).

TR-55 Chapter 3: Time of Concentration and Travel Time provides a detailed procedure for computing the Tc.

**Step 3**: Calculate the Treatment Volume peak discharge ($q_{pTv}$)

The $q_{pTv}$ is computed using the following equation and the procedures outlined in TR-55, Chapter 4: Graphical Peak Discharge Method. Designers can also use WinTR-55 or an equivalent TR-55 spreadsheet to compute $q_{pTv}$:

- Read initial abstraction ($I_a$) from TR-55 Table 4.1 or calculate using $I_a = 200/CN - 2$

- Compute $I_a/P$ ($P$ = 1.0);
- Read the Unit Peak Discharge ($q_u$) from exhibit 4-II using *Tc* and $I_a/P$;
- Compute the QTv peak discharge:

$$q_{pTv} = q_u \times A \times Q_a$$

Where:

$q_{pTv}$ = Treatment Volume peak discharge (cfs)

$q_u$ = unit peak discharge (cfs/mi$^2$/in)

$A$ = drainage area (mi$^2$)

$Q_a$ = runoff volume (watershed inches = $Tv/A$)

This procedure is for computing the peak flow rate for the one-inch rainfall event. All other calculations of peak discharge from larger storm events for the design of drainage systems, culverts, etc., should use published curve numbers and computational procedures.

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