Calculating Treatment Volume Peak Discharge

Introduction

The water quality treatment volume (*Tv*) is defined as the amount of runoff from a contributing drainage area generated by the rainfall from the 90th percentile storm event, which has been established as the 1-inch storm for Virginia. In order to properly size water quality best management practices (BMPs), the water quality treatment volume must be calculated using the Virginia Runoff Reduction Method (VRRM). This treatment volume can then be converted into peak discharge (q_{pTv}) in order to ensure non-erosive conditions and BMP flow capacity. The peak discharge is further needed for the design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales, water quality swale geometry, and manufactured treatment devices (MTDs).

The Virginia Department of Environmental Quality (DEQ) has reviewed several methods for calculating peak discharge. **The Modified Curve Number Method is DEQ's preferred way to calculate the peak discharge for the water quality treatment volume associated with the BMP drainage area**. The method is based on the Small Storm Hydrology Method (Pitt, 1999) and Natural Resources Conservation Service (NRCS) Graphical Peak Discharge Method in *Technical Release 55* (TR-55; USDA, 1986).

The equation used for the Modified Curve Number Method is provided in DEQ's Draft 2013 Virginia Stormwater Management Handbook (Second Edition) and is provided below.

Equation 11.12 in DEQ, 2013 (Modified NRCS TR-55 Eq. 4-1)

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

Where:

q_{pTv} = treatment volume peak discharge (cfs)
q_u = unit peak discharge (cfs/mi^2/in)
A = BMP drainage area (mi^2)
Q_a = runoff volume (watershed inches = Tv_{BMP}/*BMP drainage area*)

Modified Curve Number Method

Follow the steps below to use the Modified Curve Number Method to compute the peak discharge of the BMP's treatment volume (q_{pTv}).

Step 1: Calculate the BMP treatment volume (Tv_{BMP}) using the VRRM (version 3.0). The VRRM spreadsheets for new development and redevelopment are available on the VRRM page of the Virginia Stormwater BMP Clearinghouse website (www.swbmp.vwrrc.vt.edu). The Tv_{BMP} is expressed in the VRRM spreadsheets in cubic feet (ft^3). The Tv_{BMP} is used to compute the runoff volume (Q_a).

Note: When using a treatment train, the designer should consult the VRRM spreadsheet to determine the total treatment volume from both the immediate contributing drainage area and any additional volume remaining from the upstream BMP.

Step 2: **Calculate the modified curve number (*CN*) for the BMP contributing drainage area.**

The *CN* is needed to compute the initial abstraction (I_a), which is used to determine the unit peak discharge (q_u) (**Step 4**).

The following equation is derived from the NRCS Curve Number Method, which is described in detail in Chapter 2 (Estimating Runoff) of TR-55 (USDA, 1986):

Equation: Derivation of NRCS Curve Number and Runoff Equation

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

Where:

CN = modified curve number
P = rainfall (inches), equal to 1.0 inch in Virginia
Q_a = runoff volume (watershed inches), equal to $Tv_{BMP} \div$ *BMP drainage area*

Note: When using a hydrologic/hydraulic model for sizing a runoff reduction BMP or calculating q_{pTv}, designers must use this modified curve number for the drainage area to generate runoff equal to the Tv_{BMP}.

Step 3: **Compute the time of concentration (T_c) for the site or drainage area.**

T_c influences the shape and peak of the runoff hydrograph. Chapter 3 of TR-55 (Time of Concentration and Travel Time; USDA, 1986) provides detailed procedures for computing the T_c.

Step 4: **Determine the unit peak discharge (q_u).**

The unit peak discharge (q_u) is described in Chapter 4 of TR-55 (Graphical Peak Discharge Method; USDA, 1986).

Note: The Virginia Stormwater Management Program (VSMP) regulations require that designers use updated rainfall data based upon the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 publication for stormwater management computations and modeling.

Note: Exhibit 4-II in TR-55 reports q_u in units of csm/in, which equals cubic feet per second (cfs) per square mile (mi^2) of drainage area per inch of runoff ($cfs/mi^2/in$).

Step 5: **Calculate the water quality treatment volume's peak discharge (q_{pTv}).**

The q_{pTv} is computed using equation 11.12 in DEQ's Draft 2013 Virginia Stormwater Management Handbook and is shown in the Introduction section of this document. The equation is a modified version of equation 4-1 in TR-55 (Chapter 4: Graphical Peak Discharge Method; USDA, 1986).

References

DEQ. 2013. Draft 2013 Virginia Stormwater Management Handbook, Second Ed. Available at https://www.swbmp.vwrrc.vt.edu/references-tools/ (accessed July 5, 2018).

NOAA. Atlas 14 Point Precipitation Frequency Estimates for Virginia. Available at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=va (accessed June 12, 2018).

Pitt, R. 1999. "Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices." In: *Advances in Modeling the Management of Stormwater Impacts, Volume 7*. (Edited by W. James). Computational Hydraulics International, Guelph, Ontario and Lewis Publishers/CRC Press.

USDA (United States Department of Agriculture). 1986. Urban Hydrology for Small Watersheds: TR-55. 210-VI-TR-55, Second Ed., June 1986. Natural Resources Conservation Service, Conservation Engineering Division.