



3.1.7 Water Quality Calculations

3.1.7.1 Water Quality Volume Calculation

In Knox County, the Water Quality Volume (WQv) is the treatment volume required to remove 80% of the average annual, post-development total suspended solids (TSS) load. This is achieved by intercepting and treating a portion of the runoff from all storms and all the runoff from 85% of the storms that occur on average during the course of a year. The water quality treatment volume is calculated using Equation 3-21.

$$\text{Equation 3-21} \quad WQv = \frac{1.1R_v A}{12}$$

where:

- WQv = water quality volume (acre-feet)
- 1.1 = the 85th percentile annual rainfall depth in Knox County (inches)
- Rv = volumetric runoff coefficient (see Equation 3-22)
- A = total drainage area (acres)

The volumetric runoff coefficient (Rv) is directly proportional to the percent impervious cover of the development or drainage area. Rv is calculated using Equation 3-22.

$$\text{Equation 3-22} \quad Rv = 0.015 + 0.0092(I)$$

where:

- I = percent of impervious cover (%)

3.1.7.2 Water Quality Peak Discharge Calculation

The peak rate of discharge for the water quality design storm (Q_{wq} , also called the water quality peak discharge) is needed to size off-line diversion structures, such as for sand filters and infiltration trenches. This method is utilized for the sizing of water quality treatment controls as opposed to more traditional peak discharge calculation methods which are not appropriate for this application. For example, the use of the Rational Method for sizing water quality controls would require the choosing of an arbitrary storm event. Further, conventional SCS methods have been found to underestimate the volume and rate of runoff for rainfall events of less than two inches. This discrepancy in estimating runoff and discharge rates can lead to situations where a significant amount of runoff bypasses the structural control due to an inadequately sized diversion structure and leads to the design of undersized bypass channels.

Equation 3-23 is utilized to calculate Q_{wq} .

$$\text{Equation 3-23} \quad Q_{wq} = q_u A Q_{wv}$$

where:

- Q_{wq} = the water quality flow rate (cfs)
- q_u = the unit peak discharge (cfs/mi²/inch)
- A = drainage area (mi²)
- Q_{wv} = runoff peak volume (water quality volume), in inches (1.1Rv)

The following procedure can be used to calculate Q_{wq} . This procedure relies on WQv and the simplified peak discharge calculation: WQv (water quality volume in acre-feet) = Q_{wv} (water quality runoff peak volume in inches) = 1.1Rv. An example calculation is provided in Example 3-7.

1. Using $Q_{wv}=1.1(Rv)$, a corresponding CN is computed utilizing a form of Equation 3-15:

$$CN = 1000/[10 + 5P + 10Q_{wv} - 10(Q_{wv}^2 + 1.25 Q_{wv}P)^{0.5}]$$



where:

$$P = 1.1 \text{ inches}$$

$$Q_{wv} = \text{water quality runoff peak volume (inches)}$$

2. Once a CN is computed, the time t_c is computed.
3. Using the computed CN, t_c and drainage area (A), in acres; the water quality peak discharge (Q_{wq}) is computed using a slight modification to the Simplified SCS Peak Runoff Rate Estimation technique discussed previously. The following steps will apply to the calculation.
 - a. read initial abstraction (I_a), compute I_a/P ;
 - b. read the unit peak discharge (q_u) for appropriate t_c ; and
 - c. using Q_{wv} , compute the water quality flow rate (Q_{wq}) using Equation 3-23.

Example 3-7. Calculation of Water Quality Volume and Water Quality Peak Flow

Using the data and information from Example 3-5, calculate the WQV and the Q_{wv} .

Step 1: Compute volumetric runoff coefficient, R_v :

$$R_v = 0.015 + (0.0092)(I) = 0.015 + (0.0092)(18/50)(100) = 0.35$$

Step 2: Compute water quality volume, WQV:

$$WQV = 1.1R_vA/12 = 1.1(0.35)(50)/12 = 1.6 \text{ ac-ft}$$

Step 3: Compute runoff peak in inches, Q_{wv} :

$$Q_{wv} = 1.1R_v = 1.1(0.35) = 0.39 \text{ inches}$$

Step 4: Compute curve number:

$$CN = 1000/[10 + 5(1.1) + 10(0.39) - 10[(0.39)^2 + 1.25(0.39)(1.1)]^{0.5}] = 90$$

$$S = 1000/(CN - 10) = 1000/(90 - 10) = 1.11 \text{ inches}$$

$$0.2S = I_a = 0.22 \text{ inches}$$

$$I_a/P = 0.22/1.1 = 0.20$$

Step 5: Find q_u , using $t_c = 0.35$ computed in Example 3-5 and from Figure 3-6 for $I_a/P = 0.20$

$$q_u = 580 \text{ cfs/mi}^2/\text{in}$$

Step 6: Compute water quality peak flow rate using Equation 3-23.

$$Q_{wq} = 580(50/640)(0.39) = 17.67 \text{ cfs}$$
