

SECTION 6. VOLUME RETENTION REQUIREMENT AND WATER QUALITY VOLUME/WATER QUALITY FLOW

6.1. Introduction

The City's approach to minimize potential water quality impacts from stormwater runoff is implementing a volume retention requirement. By retaining a portion of stormwater runoff, the City expects to reduce and/or eliminate the pollutant loads, which are typically higher during the beginning of storm events, from reaching the receiving waters. Volume retention at a site depends on a number of factors including: type of potential pollutants in stormwater runoff, quantity of stormwater runoff, project site conditions, and receiving water conditions. Land area requirements and costs to design, construct, and maintain facilities to retain the design stormwater runoff volume will vary.

6.2. Volume Retention Requirement

The volume retention requirement is a new requirement developed in response to 2008 Municipal Stormwater Permit requirements specifying the use of LID and a combination of non-structural and structural control measures. The volume retention requirement specifies that the first 0.50 inch, which is the average 85th percentile, 24-hour storm depth for the Modesto area estimated by Caltrans, of a storm event must be retained and treated on-site. This calculated stormwater runoff volume for retention and treatment is different from the flood control retention requirements. The retention and treatment requirements are for water quality purposes, while the flood control retention requirements are for flood control purposes. The procedures for calculating the volume of stormwater runoff that must be retained on-site is presented in Fact Sheet C-1.

C-1: Volume Retention Requirement Calculation

Purpose

The purpose of this fact sheet is to provide details for calculating the volume of stormwater runoff that must be retained on-site at a project location. Effective tributary area credits are available depending on the types of LID control measures selected to reduce the volume of stormwater runoff that must be retained on-site.

Calculating the Retention Volume

The volume of stormwater runoff that must be retained at a project site is calculated using the following equation:

$$V_{ret} = C \times R \times A$$

Where:

V_{ret} = stormwater runoff volume to be retained (ft³);
C = site-specific stormwater runoff coefficient (see Fact Sheet C-2 for calculation procedures);
R = design rainfall depth (in) = 0.50 in = 0.042 ft; and
A = effective site area (ft²).

Priority significant redevelopment/infill projects must also comply with the volume retention requirement, but incentives in the form of credits maybe applied based on the type of redevelopment. A credit of 0.05 inch from the 0.50 inch volume retention requirement may be applied to any of the following types of redevelopment/infill projects:

- Significant redevelopment (as defined in Section 2.1);
- Brownfield redevelopment;
- High density (22 or more units per acre);
- Vertical density (two or more stories); and
- Mixed use and transit-oriented development (within ½ mile of public transit).

Example Calculation

For a new development or redevelopment (that does not meet the type of redevelopment/infill project that qualifies for a credit) priority project, the volume retention requirement with the following project site conditions: A = 75,000 ft²; C = 0.90

$$V_{ret} = 0.90 \times 0.50 \times 75,000 = 33,750 \text{ ft}^3$$

For a priority redevelopment project that meets the vertical density and mixed use and transit-oriented development credits with the proposed site conditions listed above, the volume retention requirement is calculated as the following:

$$V_{ret} = 0.90 \times (0.50 - 2 \times 0.05) \times 75,000 = 27,000 \text{ ft}^3$$

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C-2: Water Quality Flow /Water Quality Volume Calculation

Purpose

The primary stormwater runoff control strategy for all treatment control measures specified in Section 8 is to treat the water quality flow (WQF) or water quality volume (WQV). This fact sheet presents calculation procedures and design criteria necessary to calculate the WQF and WQV, which are distinct parameters from the volume retention requirement that is discussed in Fact Sheet C-1. The WQF and WQV are required design parameters used to size treatment control measures. The volume retention requirement is a separate and independent requirement that must be met by application of a combination of LID and treatment control measures.

The treatment control measures specified in the 2010 Guidance Manual are listed in Table 6-1 along with the basis of design, WQF or WQV, to be used and the respective design drawdown periods. It should be noted that treatment control measures designated as R may be used solely or in combination to meet the volume retention requirement, while treatment control measures designated as C or P do not assist in meeting the volume retention requirement.

Table 6-1. Sizing Criteria for Treatment Control Measures

Treatment Control Measure	Design Basis	Design Drawdown
<i>Infiltration Control Measures</i>		
Infiltration Well (R-1)	WQV	48 hr
Water Quality Infiltration Basin (R-2)	WQV	48 hr
Water Quality Infiltration Trench (R-3)	WQV	48 hr
Bioretention without Underdrain (R-4)	WQV	12 hr
Dry Well (R-5)	WQV	12 hr
French Drain (R-6)	WQV	48 hr
Permeable Paving without an Underdrain (R-7)	WQV	12 hr
<i>Evapotranspiration and Biofiltration Control Measures</i>		
Bioretention with Underdrain (R-8)	WQV	12 hr
Permeable Paving with Underdrain (R-9)	WQV	12 hr
Stormwater Planter (R-10)	WQV	12 hr
Tree-well Filter (R-11)	WQV	12 hr
Vegetated Swale (R-12)	WQV	12 hr
Grassy Swale (R-13)	WQF	N/A
Vegetated Filter Strip (R-14)	WQF	N/A
<i>Other Public Domain Treatment Control Measures</i>		
Media Sand Filters (C-1)	WQV	40-48 hr
Constructed Wetland (C-2)	WQV	24 hr
Extended Detention Basin (C-3)	WQV	48 hr
Wet Pond (C-4)	WQV	12 hr
<i>Proprietary Treatment Control Measures</i>		
Proprietary Treatment Controls (P-1)	WQF or WQV	48 hr

Determining Design Imperviousness, Runoff Coefficient, and Effective Area

WQF and WQV calculations require following parameters associated with the drainage area tributary to the treatment control under design:

- Weighted stormwater runoff coefficient (C_r) (without application of impervious area credits); and
- Effective tributary area following application of impervious area credits (A_{eff}).

Weighted Imperviousness and Stormwater Runoff Coefficient Calculations

Projects typically comprise a variety of site elements that have variable values of imperviousness and associated stormwater runoff coefficients. The stormwater runoff coefficient is a function of imperviousness and permeability of the soil, if the stormwater runoff contacts the soil. Values of imperviousness and stormwater runoff coefficients that will be used for calculating WQF and WQV in the 2010 Guidance Manual are listed in Table 6-2 for typical site elements. The weighted stormwater runoff coefficient value for a particular drainage area is determined as follows:

- Determine area associated with each site element (A_{element}).
- Determine sum of site element areas (A_{site}).
- Determine fraction of total area associated with each site element ($A_{\text{element}}/A_{\text{site}}$).
- Determine the stormwater runoff coefficient (C_r) associated with each site element from Table 6-2.
- Calculate weighted imperviousness (I_a) or stormwater runoff coefficient (C_{ra}):

$$I_a = \sum_{i=1}^n \left(\frac{I_i \times A_{\text{element},i}}{A_{\text{site}}} \right)$$

$$C_{ra} = \sum_{i=1}^n \left(\frac{C_r \times A_{\text{element},i}}{A_{\text{site}}} \right)$$

Table 6-2. Stormwater Runoff Coefficients for Typical Site Elements

Site Element	Stormwater Runoff Coefficient (C_r) ⁽¹⁾	
	Type A and B Soils	Type C and D Soils
Asphalt/concrete pavement	0.95	0.95
Roofs	0.95	0.95
Gravel pavement	0.35	0.35
Permeable pavement	Variable ⁽²⁾	Variable ⁽²⁾
Managed turf	0.18	0.25
Disturbed soils	0.18	0.25
Vegetated areas with amended Type A soil	0.03	N/A
Forest/undisturbed open space	0.03	0.05

(1) Adapted from Center for Watershed Protection, Ellicott City, MD.

(2) Variable with product type. Consult manufacturer for appropriate design values.

Example calculations for weighted stormwater runoff coefficients for a site with Type D soil are presented in Table 6-3.

Table 6-3. Example Calculation Table for Weighted Stormwater Runoff Coefficient

Site Element	Element Area (A_{element} , ft ²) ⁽¹⁾	Fraction of Total Area ($A_{\text{element}}/A_{\text{site}}$)	Element Stormwater Runoff Coefficient (C_r)	Weighted Stormwater Runoff Coefficient (C_{ra})
Asphalt/concrete pavement	40,000	0.40	0.95	0.38
Roofs	30,000	0.30	0.95	0.29
Permeable pavement	5,000	0.05	0.35	0.17
Managed turf	20,000	0.20	0.25	0.05
Forest/undisturbed open space	5,000	0.05	0.03	0.01
Total Site (A_{site})	100,000			0.90

(1) Actual area without adjustment for tributary impervious area credits from LID control measures.

Effective Tributary Area Calculations

The effective tributary area is defined as the effective area being used in WQF and WQV calculations for specific treatment control measures, and is determined by subtracting the tributary impervious area credits earned for LID control measures from the actual tributary drainage area served by the treatment control measure.

$$A_{\text{eff}} = A_{\text{tributary}} - A_{\text{credit}}$$

Note that a tributary impervious area credit for an LID control measure must be applied to a treatment control measure that serves the same tributary drainage area as the LID control measure for which the credit is earned. The credits cannot be greater than the total tributary drainage area of the treatment control measure to which they are applied. Example calculations for effective area are presented in Table 6-4.

Table 6-4. Example Calculation Table for Effective Tributary Area

Site Element	Element Area (ft ²)	Area Credit (A_{credit} , ft ²) ⁽¹⁾	Effective Area (A_{eff} , ft ²)
Asphalt/concrete pavement	40,000	10,000	30,000
Roofs	30,000	15,000	15,000
Permeable pavement ⁽²⁾	5,000	0	5,000
Managed turf	20,000	0	20,000
Forest/undisturbed open space	5,000	0	5,000

(1) Area credit from low impact development control measures.

(2) Credit for permeable pavement has already been provided in the form of a reduced stormwater runoff coefficient (see Table 6-2 and Table 6-3).

Water Quality Flow (WQF) Calculation

Hydrologic calculations for design of flow-based treatment control measures in Modesto shall be in accordance with the most current City of Modesto Standard Specifications. The WQF is defined to be equal to the maximum flow rate of stormwater runoff produced by the 85th percentile hourly rainfall intensity, as determined from the local historical rainfall record, multiplied by a factor of two. The 85th percentile hourly rainfall intensity in the Modesto area is estimated to be approximately 0.10 in/hr, based on California State University, Sacramento Office of Water Programs' *Basin Sizer, Version 1.45 (2007)*.

Calculation Procedure

The following procedure is used to calculate the WQF:

- Determine the 85th percentile hourly rainfall intensity for the Modesto area. Use 0.10 in/hr.
- Multiply the 85th percentile hourly rainfall intensity by a factor of two to obtain the design rainfall intensity (i). Use $i = 0.10 \times 2 = 0.20$ in/hr.
- Determine the weighted stormwater runoff coefficient for the project area using the procedure illustrated in Table 6-3.
- Determine the effective area (A_{eff}) of the drainage area using the procedure illustrated in Table 6-4.
- Calculate WQF using the following equation:

$$WQF = i \times C_{ra} \times A_{eff} = 0.20 \times C_{ra} \times A_{eff}$$

Where:

WQF = Water quality flow (cfs);
i = Design rainfall intensity (0.20 in/hr);
 C_{ra} = Weighted stormwater runoff coefficient for project area; and
 A_{eff} = Effective project drainage area (acres) (Note: Area converted to acres for ease of calculation. Resulting conversion factor is approximately equal to 1.0).

Example Calculation

Project site conditions from previous example: $A_{eff} = 75,000 \text{ ft}^2$; $C_{ra} = 0.90$

$$WQF = 0.20 \times 0.90 \times \frac{75,000}{43,560} = 0.31 \text{ cfs}$$

Water Quality Volume (WQV) Calculation

Hydrologic calculations for design of volume-based treatment control measures in Modesto shall be in accordance with the procedures set forth herein.

The WQV is defined as the volume necessary to capture and treat 80 percent or more of the annual stormwater runoff volume from the site at the design drawdown period specified for each treatment control measure. The WQV should not be confused with the volume retention requirement, which is a separate requirement as defined previously.

Calculation Procedure

The following procedures are used to calculate the WQV:

- Review drainage area of the proposed treatment control measure. Determine the weighted stormwater runoff coefficient (C_{ra}) of the drainage area using the procedure presented in Table 6-3.
- A direct reading of the Unit Basin Storage Volumes (Figure 6-1) is required for 80% annual capture of stormwater runoff for values of C_{ra} determined in the previous step.
- Determine the effective area of the drainage area using the procedure outlined in Table 6-4.
- The WQV for the proposed treatment control measure is calculated by multiplying the Unit Basin Storage Volume by the effective drainage area. Due to the mixed units that result (e.g., acre-feet, acre-inches), it is recommended that the resulting volume be converted to cubic feet (ft^3) for use during design.

$$WQV = V_u \times A_{eff}$$

Where:

V_u = Unit basin storage volume (ft); and
 A_{eff} = Effective drainage area (acres).

Example Calculation

Project site conditions from previous example: $A_{eff} = 75,000 \text{ ft}^2$; $C_{ra} = 0.90$

- Determine design drawdown period for proposed control measure (see Table 6-1)
Example: Water Quality Infiltration Basin → drawdown period = 48 hours
- Determine Unit Basin Storage Volume for 80% annual capture, V_u , using Figure 6-1:
For $C_{ra} = 0.90$ and drawdown time = 48 hours → $V_u = 0.42 \text{ in}$

- Calculate WQV for basin:

$$WQV = V_u \times A_{eff} = (0.42 \text{ in}) \times (75,000 \text{ ft}^2) \times \left(\frac{1 \text{ ft}}{12 \text{ in}}\right) = 2,625 \text{ ft}^3$$

Figure 6-1. Unit Basin Storage Volume vs. Weighted Stormwater Runoff Coefficient

