MORENO VALLEY

Storm Water Quality Best Management Practice

Volume Based BMP Design Handbook
POA/HOA Maintained System

City of Moreno Valley, County of Riverside, California

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Volume Based BMPs

General

The largest concentrations of pollutants are found in runoff from small volume storms and from the first flush of larger storms. Therefore, volume based BMPs should be sized to capture and treat the initial and more frequent runoff surges that convey the greatest concentration of pollutants. To maximize treatment and avoid health hazards, volume-based BMPs must retain and release the runoff between a 24 and 72 hour period. This handbook typically recommends a draw down time of **48** hours, as recommended by the California BMP Handbook. The drawdown time refers to the minimum amount of time the design volume must be retained.

In order to meet RWQCB requirements, the method for determining the design volume is based on capturing 85 percent of the total annual runoff. These 85 percent capture values were determined throughout Riverside County using rain gages with the greatest periods of record. Key model assumptions are based on studies used in the *Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, (1998)* and *the California Best Management Practice Handbook*. This handbook gives a simple procedure for determining the design volume of a BMP based on the location of the project. The basin shall have an emergency overflow outlet design acceptable to the City Engineer. The basin shall include a hard surface access to the forebay for maintenance and the forebay shall be P.C.C. constructed material as approved by the City Engineer.

BMP Design Volume Calculations

Following is a step-by-step procedure for determining design volume for BMPs using Worksheet 1. Examples of the following procedure can be found in Appendix B.

1. Create Unit Storage Volume Graph:
   a) Locate the project site on the Slope of the Design Volume Curve contained in Appendix A.
   b) Read the slope value at this location. This value is the Unit Storage Volume for a runoff coefficient of 1.0.
   c) Plot this value as a point (corresponding to a coefficient of 1.0) on the Unit Storage Volume Graph shown on Figure 2.
   d) Draw a straight line from this point to the origin, to create the graph.

2. Determine the runoff coefficient (C) from Figure 1 or the following relationship:

$$C = .858i^3 - .78i^2 + .774i + .04$$

where i = impervious percentage

3. Using the runoff coefficient found in step 2, determine 85th percentile unit storage volume (V_u) using Figure 2 (created in step 1).

4. Determine the design storage volume (V_{BMP}). This is the volume to be used in the design of selected BMPs presented in this handbook.

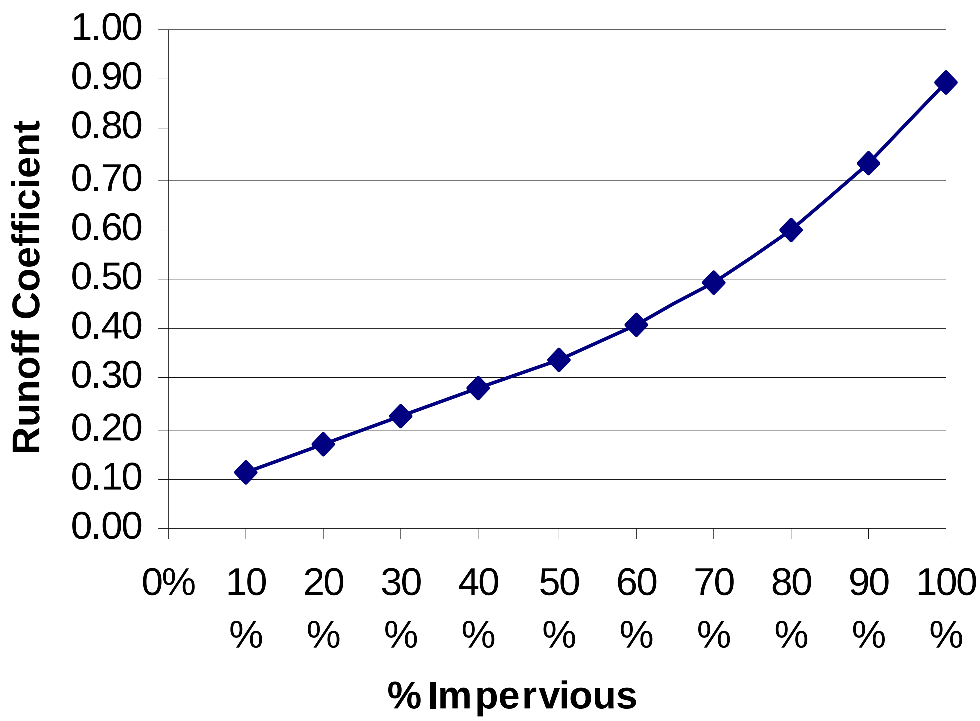

Figure 1. Impervious – Coefficient Curve (WEF/ASCE Method[1])

[1] Imperviousness is the decimal fraction of the total catchment covered by the sum of roads, parking lots, sidewalks, rooftops, and other impermeable surfaces of an urban landscape.

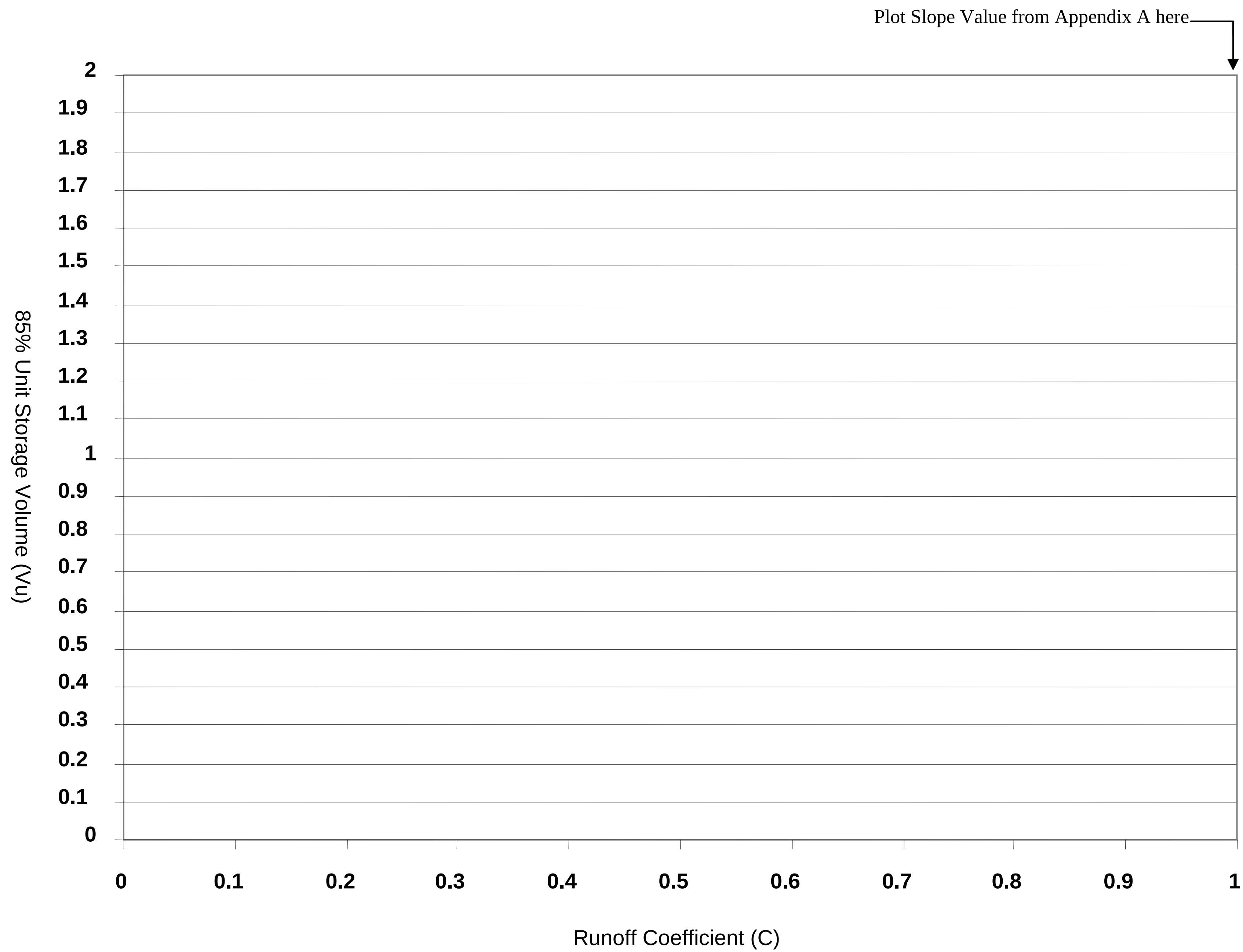

Figure 2 Unit Storage Volume Graph

Design Procedure for BMP Design Volume

85^{th} percentile runoff event

Designer: ______________________
Company: ______________________
Date: ______________________
Project: ______________________
Location: ______________________

1. Create Unit Storage Volume Graph		
a. Site location (Township, Range, and Section).	T ____ &R ____ Section ____	***(1)***
b. Slope value from the Design Volume Curve in **Appendix A**.	Slope = ____	***(2)***
c. Plot this value on the Unit Storage Volume Graph shown on **Figure 2.**		
d. Draw a straight line form this point to the origin, to create the graph	Is this graph attached? Yes ☐ No ☐	
2. Determine Runoff Coefficient		
a. Determine total impervious area	$A_{impervious}$ = ____ acres	***(5)***
b. Determine total tributary area	A_{total} = ____ acres	***(6)***
c. Determine Impervious fraction i = ***(5)*** / ***(6)***	i = ____	***(7)***
d. Use ***(7)*** in **Figure 1** to find Runoff OR $C = .858i^3 - .78i^2 + .774i + .04$	C = ____	***(8)***
3. Determine 85% Unit Storage Volume		
a. Use ***(8)*** in **Figure 2** Draw a Vertical line from ***(8)*** to the graph, then a Horizontal line to the desired V_u value.	V_u = ____ $\frac{\text{in-acre}}{\text{acre}}$	***(9)***
4. Determine Design Storage Volume		
a. V_{BMP} = ***(9)*** x ***(6)*** [in- acres]	V_{BMP} = ____ in-acre	***(10)***
b. V_{BMP} = ***(10)*** / 12 [ft- acres]	V_{BMP} = ____ ft-acre	***(11)***
c. V_{BMP} = ***(11)*** x 43560 [ft^3]	V_{BMP} = ____ ft^3	***(12)***

Notes: ______________________

Extended Detention Basins

General

An extended detention Basin is a permanent basin sized to detain and slowly release the design volume of stormwater, allowing particles and associated pollutants to settle out. An inlet forebay section and an inlet energy dissipater minimize erosion from entering flows, while erosion protection at the outlet prevents damage from exiting flows. The bottom of the basin slopes towards the outlet at an approximate grade of two (2) percent (may vary ±0.50%), and a low flow channel conveys incidental flows directly to the outlet end of the basin. **The basin should be vegetated earth in order to allow some infiltration to occur**, although highly pervious soils may require an impermeable liner to prevent groundwater contamination. Proper turf management is also required to ensure that the vegetation does not contribute to water pollution through pesticides, herbicides, or fertilizers. A permanent micropool should not be included due to vector concerns. See Figure 3 for a typical basin design and Figure 5 for several outlet options. Extended detention basins can also be used to reduce the peaks of storm events for flood control purposes. The basin design shall include an emergency overflow outlet acceptable to the City Engineer. The forebay shall have a P.C.C. access road for maintenance approved by the City Engineer.

The basin outlet is designed to release the design runoff over a 48-hour drawdown period. The drawdown time refers to the minimum amount of time the design volume must be retained. In order to avoid vector breeding problems, the design volume should always empty within **48** hours. To function properly, the outlet must also be sized to retain the first half of the design volume for a minimum of 24 hours.

Extended Detention Basin Design Criteria:

Design Parameter	Unit	Design Criteria
Design Volume	ft^3	V_{BMP}
Drawdown time (total)	hrs	48 hrs [3]
Drawdown time for 50% V_{BMP} (minimum)	hrs	24 hrs [3]
Minimum tributary area	acre	5 acres [3]
Inlet/outlet erosion control	-	Energy dissipater to reduce velocities [1]
Forebay volume	%	5 to 10 % of V_{BMP} [1]
Forebay drain time	min	Drain time < 45 minutes [1]
Low-flow channel depth	in	9 [1]
Low-flow chan. flow capacity	-	2 times the forebay outlet rate [1]
Bottom slope of upper stage	%	2.0 [1]
Length to width ratio (min.)	-	2:1 (larger preferred) [1]
Upper stage depth/width	ft	2’ depth / 30’ width [1]

(min.)		
Bottom stage volume	%	10 to 25 % of V_{BMP} [1]
Bottom stage depth	ft	1.5 to 3 ft deeper than top stage [1]
Freeboard (minimum)	ft	1.0 [1]
Embankment side slope (H:V)	-	≥ 3:1 inside / ≥ 4:1 outside (w/o retaining walls) [1]
Maintenance access ramp slope	%	10 % or flatter [1]
Maintenance access ramp width	ft	15' – approach paved with asphalt concrete [1]

1. Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures
2. City of Modesto's Guidance Manual for New Development Stormwater Quality Control Measures
3. CA Stormwater BMP Handbook for New Development and Significant Redevelopment
4. Riverside County DAMP Supplement A Attachment

Extended Detention Basin Design Procedure

1. Design Volume
   Use Worksheet 1- Design Procedure Form for Design Volume, V_{BMP}.

1. Basin Shape
   Whenever possible, shape the basin with a gradual expansion from the inlet toward the middle and a gradual contraction from middle toward the outlet. The length to width ratio should be a minimum of 2:1. Internal baffling with berms may be necessary to achieve this ratio.

2. Two-Stage Design
   Whenever feasible, provide a two-stage design with a pool that fills often with frequently occurring runoff. This minimizes standing water and sediment deposition in the remainder of the basin.

   a. Upper stage: The upper stage should be a minimum of 2 feet deep with the bottom sloped at 2 percent toward the low flow channel. Minimum width of the upper stage should be 30 feet.

   b. Bottom stage: The active storage basin of the bottom stage should be 1.5 to 3 feet deeper than the top stage and store 10 to 25 percent of the design volume.

3. Forebay Design
   The forebay provides a location for sedimentation of larger particles that has a solid bottom surface to facilitate mechanical removal of accumulated sediment. The forebay volume should be 5 to 10 percent of the V_{BMP}. A berm should separate the forebay from the upper stage of the basin. The outlet pipe from the forebay to the low-flow channel should be sized to drain

the forebay volume in 45 minutes. The outlet pipe entrance should be offset from the forebay inlet to prevent short circuiting.

4. Low-flow Channel
The low flow channel conveys flow from the forebay to the bottom stage. Erosion protection should be provided where the low-flow channel enters the bottom stage. Lining of the low flow channel with concrete is recommended. The depth of the channel should be at least 9 inches. The flow capacity of the channel should be twice the release capacity of the forebay outlet.

5. Trash Rack/Gravel Pack
A trash rack around perforated risers shall be provided to protect outlet orifices from clogging. Trash racks are better suited for use with perforated vertical plates for outlet control and allow easier access to outlet orifices for purposes of inspection and cleaning. Trash rack shall be sized to prevent clogging of the primary water quality outlet without restricting the hydraulic capacity of the outlet control orifices.

6. Basin Outlet
The basin outlet should be sized to release the design volume, V_{BMP} over a **48-hour period**, with no more than 50 percent released in 24 hours. The outflow structure should have a trash rack or other acceptable means to prevent clogging, and a valve that can stop discharge from being released in case of an accidental spill in the watershed (Figure 5). The discharge through a control orifice can be calculated using the following steps:

   a. Develop a Stage vs. Discharge curve for the outlet structure
   b. For example: If using an orifice, select the orifice size and use the following equation to develop a Stage vs. Discharge relationship for this outlet:

$$Q = CA[2g(H-H_o)]^{0.5}$$

   Where: Q = discharge (ft^3/s)
   C = orifice coefficient
   A = area of the orifice (ft)
   G = gravitational constant (32.2 ft^2/s)
   H = water surface elevation (ft)
   H_o = orifice elevation (ft)

   Recommended values for C are 0.66 for thin material (e.g. CMP riser) and 0.8 when the material is thicker than the orifice diameter (e.g. concrete riser). Alternative non-mechanical hydraulic control structures are acceptable (e.g. weirs, risers, etc).

c. Develop a Stage vs. Volume curve for the basin
   Based on the shape and size of the basin, develop a relationship between the stage and the volume of water in the basin.

d. Create an Inflow Hydrograph
   Create an inflow hydrograph that delivers the design volume V_{BMP} instantaneously to the basin. This can be approximated by creating a hydrograph with two 5-minute intervals that together convey the entire V_{BMP}.

e. Route the Volume through the Basin
   Route the volume of water through the basin using these curves. If this meets the hydraulic retention time requirements (50% of the volume empties in 24 hours, 100% of the volume empties in 48 hours and not more than 60 hours, time may vary by 5%) the outlet is correctly sized. If these requirements are not met, select a new outlet size or configuration and repeat the process.

7. Inlet/Outlet Design
   Basin inlet and outlet points should be provided with an energy dissipation structure and/or erosion protection.

8. Turf Management
   Basin vegetation provides erosion protection and improves sediment entrapment. Basin bottoms, berms, and side slopes may be planted with native grasses or with irrigated turf. Several BMPs must be implemented to ensure that this vegetation does not contribute to water pollution through pesticides, herbicides, or fertilizers. These BMPs shall include, at a minimum: (1) educational activities, permits, certifications, and other measures for local applicators and distributors; (2) integrated pest management measures that rely on non-chemical solutions; (3) the use of native vegetation; (4) schedules for irrigation and chemical application; and (5) the collection and proper disposal of unused pesticides, herbicides, and fertilizers.

9. Embankment
   Embankment designs must conform to requirements of the State of California Division of Safety of Dams, if the basin dimensions cause it to fall under that agency's jurisdiction. Interior slopes should be no steeper than 3:1 and exterior slopes no steeper than 4:1. Flatter slopes are preferable. Embankment fill is discouraged and should never be higher than three feet unless the basin is to be publicly maintained.

10. Access
   All-weather access P.C.C. material or other approved surface as specified by the City Engineer to the bottom, forebay, and outlet works shall be provided

for maintenance vehicles. Maximum grades of access ramps should be 10 percent and minimum width should be 15 feet.

11. Bypass
Provide for bypass or overflow of runoff volumes in excess of the design volume. Spillway and overflow structures should be designed in accordance with applicable standards of the Riverside County Flood Control District.

12. Geotextile Fabric
Non-woven geotextile fabric used in conjunction with gravel packs around perforated risers shall conform with the specifications located in Table 5.

Table 5. Non-woven Geotextile Fabric Specifications

Property	**Test Reference**	**Minimum Specification**
Grab Strength	ASTM D4632	90 lbs
Elongation at peak load	ASTM D4632	50 %
Puncture Strength	ASTM D3787	45 lbs
Permitivity	ASTM D4491	0.7 sec^{-1}
Burst Strength	ASTM D3786	180 psi
Toughness	% Elongation x Grab Strength	5,500 lbs
Ultraviolet Resistance (% strength retained at 500 Weatherometer hours)	ASTM D4355	70 %

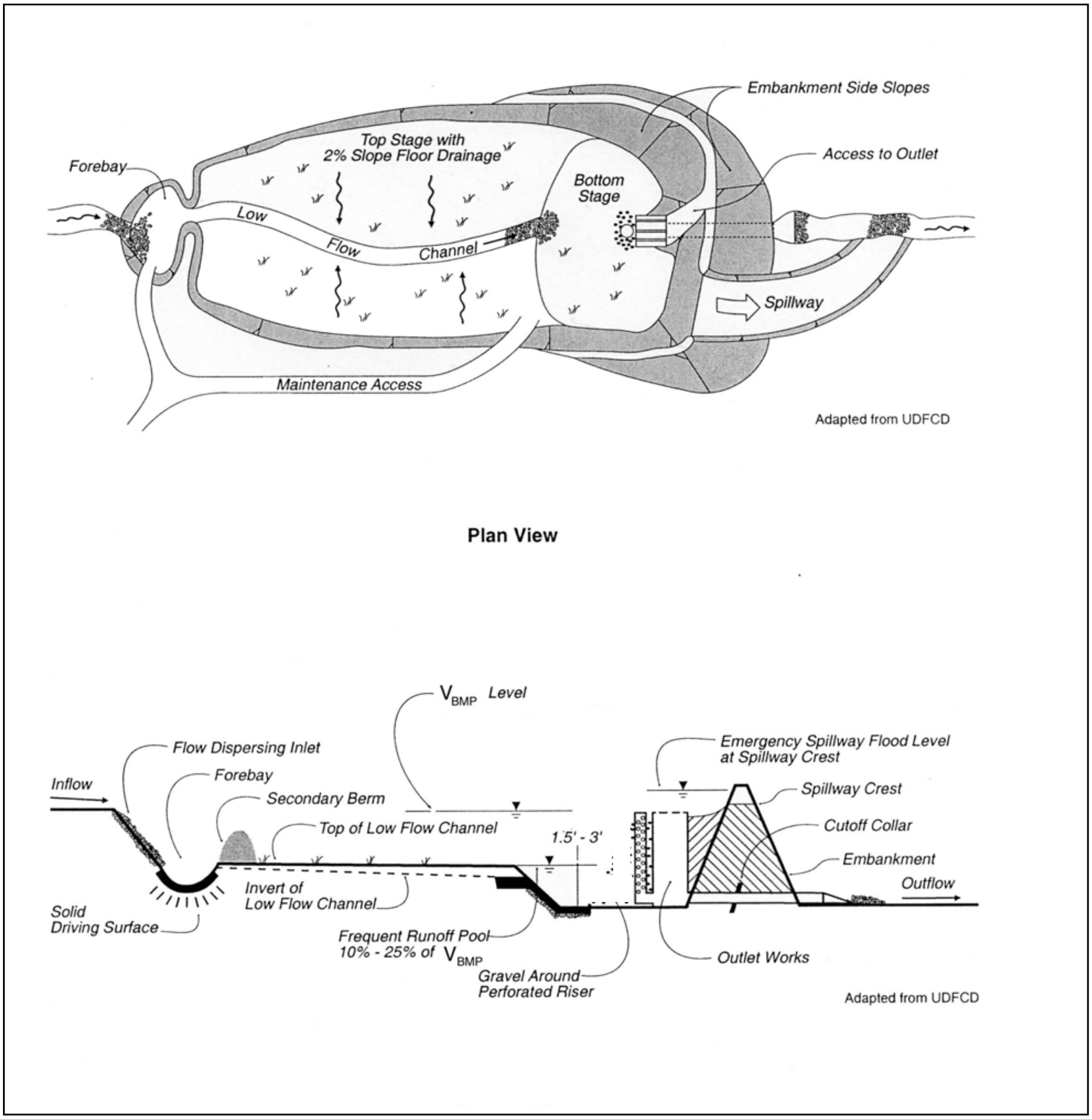

Figure 3: EXTENDED DETENTION BASIN

Source: Ventura County Guidance Manual

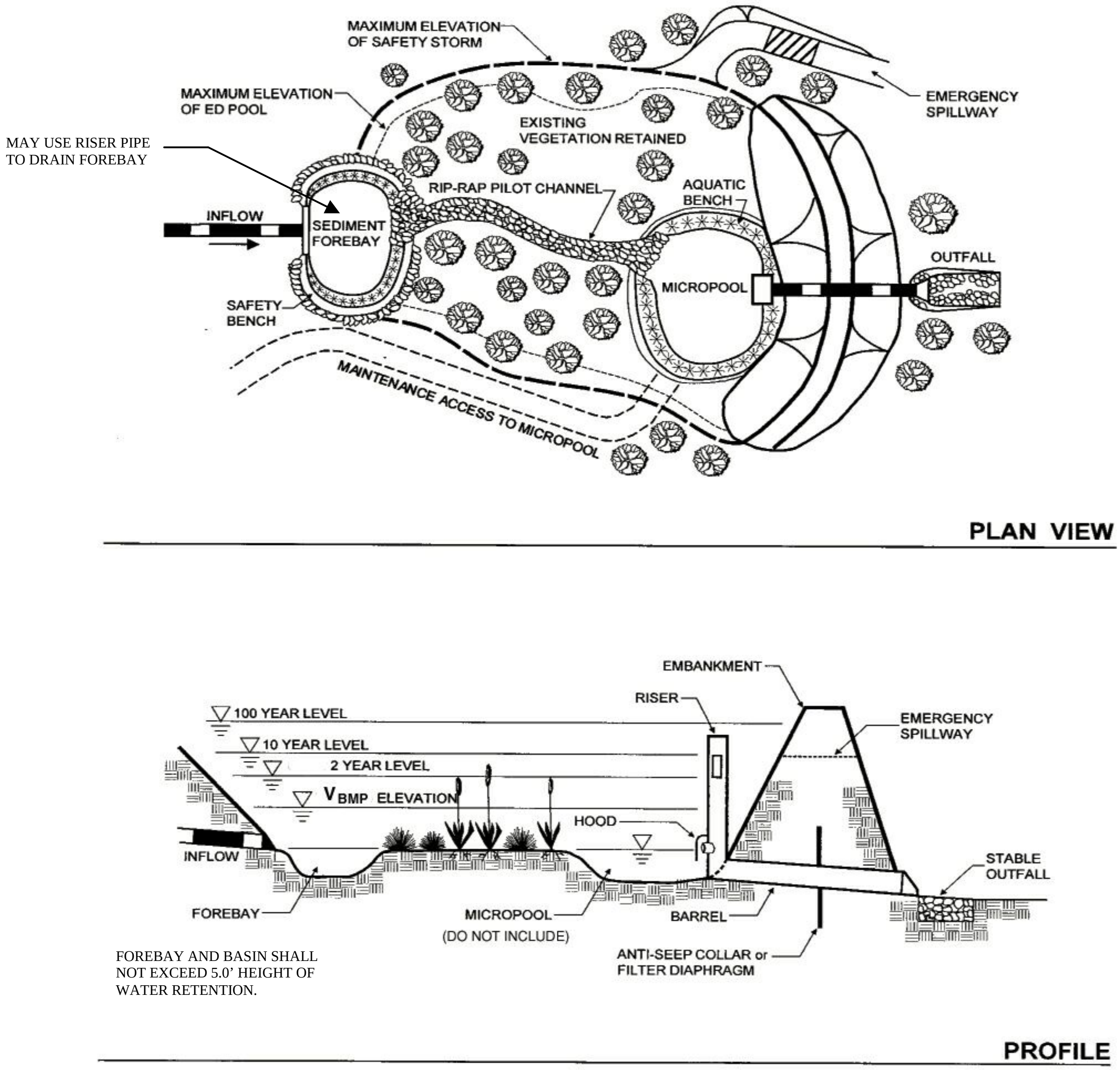

Figure 4: EXTENDED DETENTION / INCREASED RUNOFF BASIN

Source: CA BMP Handbook (2003)

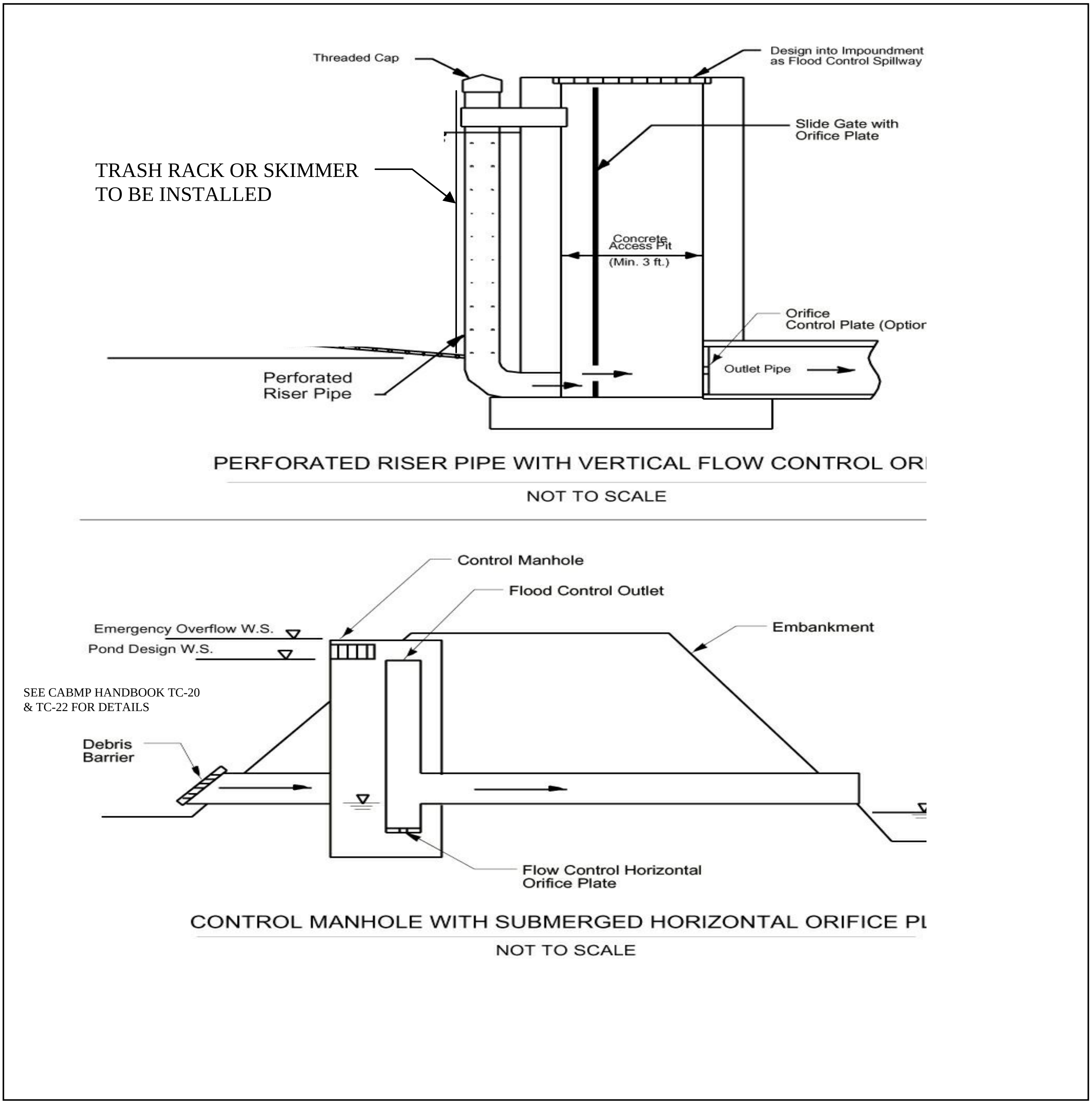

Figure 5: EXTENDED DETENTION BASIN TYPICAL OUTLETS

Source: Ventura County Guidance Manual

Worksheet 3

Design Procedure Form for Extended Detention Basin

Designer:____
Company:____
Date:____
Project:____
Location:____

1. Determine Design Volume (Use Worksheet 1) a. Total Tributary Area (minimum 5 ac.) b. Design Volume, V_{BMP}	A_{total} = __________ acres V_{BMP} = __________ ft^3
2. Basin Length to Width Ratio (2:1 min.)	Ratio = __________ L:W
3. Two-Stage Design a. Overall Design 1) Depth (3.5' min.) 2) Width (30' min.) 3) Length (60' min.) 4) Volume (must be ≥ V_{BMP}) b. Upper Stage 1) Depth (2' min.) 2) Bottom Slope (2% to low flow channel recommended) c. Bottom Stage 1) Depth (1.5' to 3') 2) Length 3) Volume (10 to 25% of V_{BMP})	Depth = __________ ft Width = __________ ft Length = __________ ft Volume = __________ ft^3 Depth = __________ ft Slope = __________ % Depth = __________ ft Length = __________ ft Volume = __________ ft^3
4. Forebay Design a. Forebay Volume (5 to 10% of V_{BMP}) b. Outlet pipe drainage time (≅ 45 min)	Volume = __________ ft^3 Drain time = __________ minutes
5. Low-flow Channel a. Depth (9" minimum) b. Flow Capacity (2 * Forebay Q_{OUT})	Depth = __________ ft $Q_{Low\ Flow}$ = __________ cfs
6. Trash Rack or Gravel Pack (check one)	Trash Rack ______ Gravel Pack ______

7. Basin Outlet a. Outlet type (check one)	Single orifice _____ Multi-orifice plate _____ Perforated Pipe _____ Other ____________________
b. Orifice Area c. Orifice Type d. Maximum Depth of water above bottom orifice e. Length of time for 50% V_{BMP} drainage (24 hour minimum) f. Length of time for 100% V_{BMP} drainage (between 48 and 60 hours) g. Attached Documents (all required) 1) Stage vs. Discharge 2) Stage vs. Volume 3) Inflow Hydrograph 4) Basin Routing	Area = __________ ft^2 Type ______________________ Depth = __________ ft Time 50% = __________ hrs Time 100% = __________ hrs Attached Documents (check) 1) __________ 2) __________ 3) __________ 4) __________
8. Increased Runoff (optional) Is this basin also mitigating increased runoff? Attached Documents (all required) for 2, 5, & 10-year storms: 1) Stage vs. Discharge 2) Stage vs. Volume 3) Inflow Hydrograph 4) Basin Routing	Yes ______ No ______ (if No, skip to #9) Attached Documents (check) 1) __________ 2) __________ 3) __________ 4) __________
9. Vegetation (check type)	____ Native Grasses ____ Irrigated Turf ____ Other ____________________________
10. Embankment a. Interior slope (4:1 max.) b. Exterior slope (3:1 max.)	Interior Slope = _________ % Exterior Slope = _________ %
11. Access a. Slope (10% max.) b. Width (16 feet min.)	Slope = __________ % Width = __________ ft

Notes:

Infiltration Basins

General

An infiltration basin is an earthen basin designed to capture the design volume of runoff and infiltrate that stormwater back into the pervious natural surrounding soil. These basins have only an emergency spillway, not a standard outlet, although a relief underdrain will drain the basin if standing water conditions occur. Flows that exceed the design volume should be diverted around the infiltration basin. The basin is designed to retain the design volume and allow it to percolate into the underlying soil over a period of 48 hours, which removes soluble and fine particulate pollutants. Sediment clogging can be avoided by including a settling basin near the inlet as well as the required energy dissipater. The sides and bottom of the basin include vegetation to protect the basin from erosion. Infiltration basins typically treat developments up to 50 acres in size.

Infiltration basins have select applications. Their use is often sharply restricted by concerns over ground water contamination, soils, and clogging at the site. These basins are not appropriate for the following site conditions: industrial sites or locations where spills occur, sites with C or D type soils, and sites with high infiltration rates where pollutants can affect ground water quality. The upstream tributary area must be completely stabilized before construction. In addition, some studies have shown relatively high failure rates compared with other management practices. Finally, infiltration basins are difficult to restore infiltration once the basin has been clogged.

Infiltration Basin Design Criteria:

Design Parameter	Unit	Design Criteria
Design Volume	ft^3	V_{BMP}
Drawdown time	hrs	48 hrs [3]
Maximum Tributary Area	acre	50 acres [4]
Minimum Infiltration Rate	in/hr	0.5 in/hr [4]
Bottom Basin elevation	ft	5 feet or more above seasonally high groundwater table [1]
Minimum Freeboard	ft	1.0 ft [1]
Setbacks	ft	100 feet from wells, tanks, fields, springs [1] 20 feet down slope of 100 feet up slope from foundations [1]
Inlet/outlet erosion control	-	Energy dissipater to reduce inlet/outlet velocity [1]
Embankment side slope (H:V)	-	4:1 or flatter inside slope/ 3:1 or flatter outside slope (without retaining walls) [1]
Maintenance access ramp slope (H:V)	-	10:1 or flatter [1]
Maintenance access	ft	16.0 – approach paved with asphalt

ramp width		concrete[1]
Vegetation	-	Side slopes and bottom (may require irrigation during summer) [1]
Relief Underdrain	-	A perforated PVC pipe with valve is to be installed to serve as a relief drain in the event of system failure. [2]

1 Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures
2 City of Modesto's Guidance Manual for New Development Stormwater Quality Control Measures
3 CA Stormwater BMP Handbook for New Development and Significant Redevelopment
4 Riverside County DAMP Supplement A Attachment

Infiltration Basin Design Procedure

1. Design Storage Volume
   Use Worksheet 1- Design Procedure Form for Design Storage Volume, V_{BMP}.

2. Basin Surface Area
   Calculate the minimum surface area:

$$A_m = V_{BMP} / D_m$$

Where A_m = minimum area required (ft^2)
V_{BMP} = volume of the infiltration basin (ft^3)
D_m = maximum allowable depth (ft)

$$D_m = [(t) \times (I)] / 12s$$

Where I = site infiltration rate (in/hr)
s = safety factor
t = minimum drawdown time (48 hours)

In the formula for maximum allowable depth, the safety factor accounts for the possibility of inaccuracy in the infiltration rate measurement. The less certain the infiltration rate the higher the safety factor shall be. Minimum safety factors shall be as follows:

- Without site-specific borings and percolation tests, use s = 10
- With borings (but no percolation test), use s = 6
- With percolation test (but no borings), use s = 5
- With borings and percolation test, use s = 3

It is recommended that the infiltration rate be determined through site-specific soils tests. The Infiltration rate can also be estimated by using the District's Hydrology Manual. To estimate the infiltration rate with the District's Hydrology Manual determine a RI number using plate D-5.5, then use plate E-6.2 to find the loss rate (keep in mind this loss rate is for pervious areas only).

3. Inline/Offline
   Basins may be on-line or off-line with flood control facilities. For on-line basins, the water quality outlet may be superimposed on the flood control outlet or may be constructed as a separate outlet.

4. Basin Inlet
   The inlet structure should dissipate energy of incoming flow to avoid scouring of the basin. If high sediment loads are anticipated a settling basin with a volume of 10 to 20 percent of the design volume should be placed at the inlet of the basin.

5. Vegetation
   Bottom vegetation provides erosion protection and sediment entrapment. Basin bottoms, berms, and side slopes may be planted with native grasses or with irrigated turf.

6. Embankments
   Design embankments to conform to requirements of State of California Division of Safety of Dams, if the basin dimensions cause it to fall under that agency’s jurisdiction. Interior slopes should be no steeper than 4:1 and exterior slopes no steeper than 3:1. Flatter slopes are preferable.

7. Access
   All-weather access to the bottom, forebay, and outlet works shall be provided for maintenance vehicles. Maximum grades of access ramps should be 10 percent and minimum width should be 16 feet. Ramps should be paved with concrete. Provide security fencing, except when used as a recreation area.

8. Bypass
   Provide for bypass or overflow of runoff volumes in excess of the design volume. Spillway and overflow structures should be designed in accordance with applicable standards of the Riverside County Flood Control District.

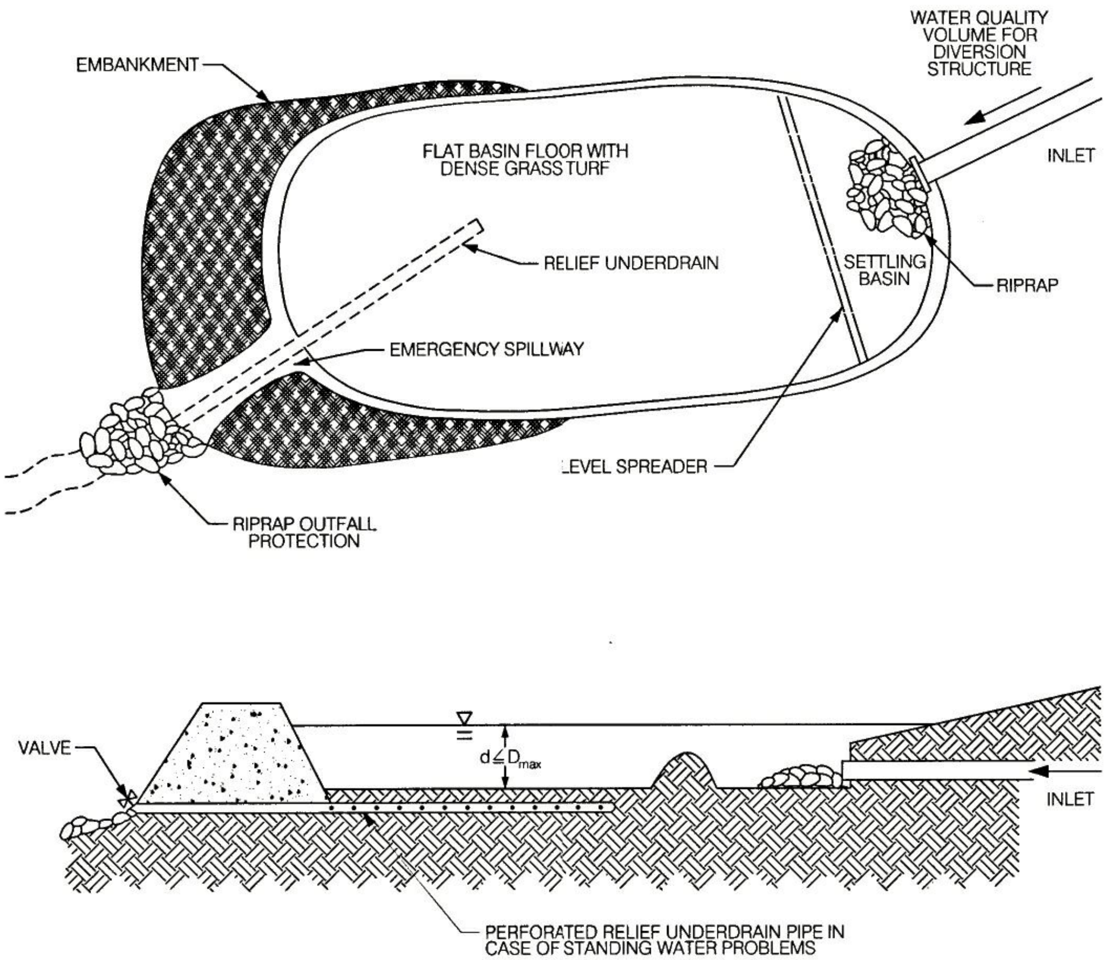

Figure 6: INFILTRATION BASIN

Source: City of Modesto Guidance Manual

Design Procedure Form for Infiltration Basin

Designer:____
Company:____
Date:____
Project:____
Location:____

1. Determine Design Storage Volume (Use Worksheet 1) a. Total Tributary Area (maximum 50) b. Design Storage Volume, V_{BMP}	A_{total} = __________ acres V_{BMP} = __________ ft^3
2. Maximum Allowable Depth (D_m) a. Site infiltration rate (I) b. Minimum drawdown time (48 hrs) c. Safety factor (s) d. $D_m = [(t) \times (I)]/[12s]$	I = __________ in/hr t = __________ hrs s = __________ D_m = __________ ft
3. Basin Surface Area $A_m = V_{BMP} / D_m$	A_m = __________ ft^2
4. Vegetation (check type used or describe "other")	_____ Native Grasses _____ Irrigated Turf Grass _____ Other ______________________________ __________________________

Notes:

Infiltration Trenches

General

An infiltration trench is an excavated trench that has been refilled with a gravel and sand bed capable of holding the design volume of stormwater runoff. The runoff is stored in the trench over a period of time (48 hours) during which it slowly infiltrates back into the naturally pervious surrounding soil. This infiltration process effectively removes soluble and particulate pollutants, however it is not intended to trap course sediments. It is recommended that an upstream control measure such as a grass swale or filter strip be combined with an infiltration trench to remove sediments that might clog the trench. These trenches also include a bypass system for volumes greater than the design capture volume, and a perforated pipe as an observation well to monitor water depth. An infiltration trench can typically treat developments up to 10 acres.

Infiltration Trench Design Criteria

Design Parameter	Unit	Design Criteria
Design Volume	ft^3	V_{BMP}
Drawdown time	hrs	48 hrs [3]
Maximum Tributary Area	acre	10 acres [2 & 3]
Minimum Infiltration Rate of Soil	in/hr	0.27 in/hr [4]
Trench bottom elevation	ft	5 feet or more above seasonally high groundwater table [1]
Maximum Trench depth (Dm)	ft	8.0 ft [1]
Gravel bed material	ft	Clean, washed aggregate 1 to 3 inches in diameter [1]
Trench lining material	-	Geotextile fabric [1] or 6" layer of sand [4]
Setbacks	ft	100 feet from wells, tanks, fields, or springs [1] 20 feet down slope or 100 feet up slope from foundations [1] Do not locate under tree drip-lines [1]

1 Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures
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4 Riverside County DAMP Supplement A Attachment

Infiltration Trench Design Procedure

1. Design Storage Volume
   Use Worksheet 1- Design Procedure Form for Design Storage Volume, V_{BMP}.

2. Trench Water Depth
   Calculate the maximum allowable depth of water in the trench, D_m, in feet. Maximum depth should not exceed 8 feet:

   $$D_m = [(t) \times (I)] / (12s)$$

   Where I = site infiltration rate (in/hr)
   s = safety factor
   t = minimum drawdown time (48 hours)

   In the formula for maximum allowable depth, the safety factor accounts for the possibility of inaccuracy in the infiltration rate measurement. The less certain the infiltration rate, the higher the safety factor should be. Minimum safety factors shall be as follows:
   - Without site-specific borings and percolation tests, use s = 10
   - With borings (but no percolation test), use s = 6
   - With percolation test (but no borings), use s = 5
   - With borings and percolation test, use s = 3

3. Trench Surface Area
   Calculate the minimum surface area of the trench bottom:

   $$A_m = V_{BMP} / D_m$$

   Where A_m = minimum area required (ft^2)
   V_{BMP} = Detention Volume (ft^3)
   D_m = maximum allowable depth (ft)

4. Observation Well
   Provide a vertical section of perforated PVC pipe, 4 to 6 inches in diameter, installed flush with top of trench on a foot-plate and with a locking, removable cap.

5. Bypass
   Provide for bypass or overflow of runoff volumes in excess of the SQDV by means of a screened overflow pipe connected to downstream storm drainage or grated overflow outlet.

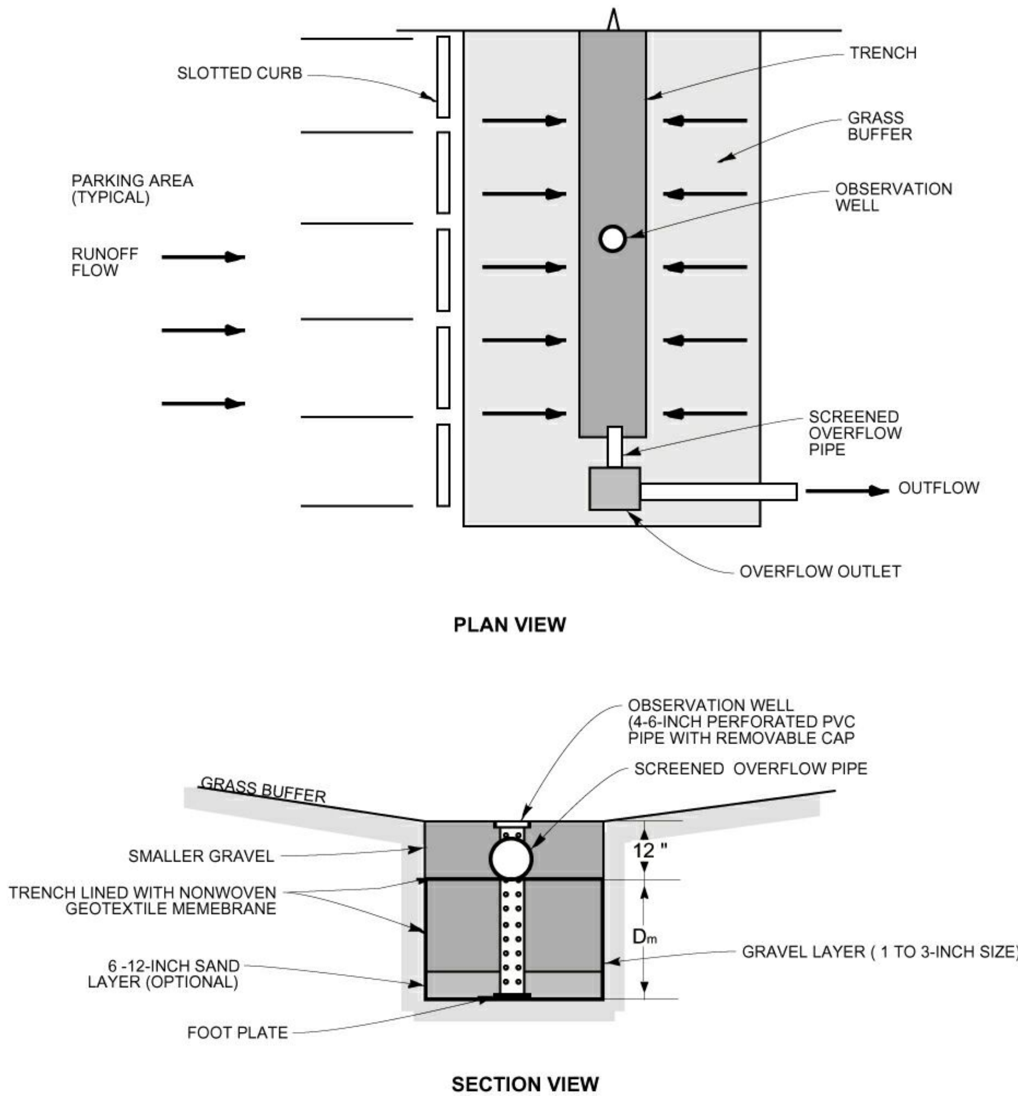

Figure 7: INFILTRATION TRENCH

Source: Ventura County Guidance Manual

Design Procedure Form for Infiltration Trench

Designer:____
Company:____
Date:____
Project:____
Location:____

1. Determine Design Storage Volume (Use worksheet 1) a. Total Tributary Area (maximum 10) b. Design Storage Volume, V_{BMP}	A_{total} = __________ acres V_{BMP} = __________ ft^3
2. Maximum Allowable Depth (D_m = tI/12s) a. Site infiltration rate (I) b. Minimum drawdown time (t = 48 hrs) c. Safety factor (s) d. D_m = tI/12s	I = __________ in/hr t = __________ hrs s = __________ D_m = __________ ft
3. Trench Bottom Surface Area $A_m = V_{BMP} / D_m$	A_m = __________ ft^2

Notes:

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Basin Functionality Test

This ***Functionality Test*** is for basins where there is a levee or berm between the forebay and aftbay. This test is to validate that the basin will function as designed and meet the requirements herein for basin drainage within 48 to 60 hours. This is a simple test in that the flooding of the aftbay should identify any low or bird bath spots that will need to be repaired. A City Construction Inspector shall be present during the test. The test shall be accomplished in the following sequence:

1. **Developer/Builder to Flood the Forebay.** Flood the forebay portion of the basin by completely blocking the outlet pipe from the forebay into the aftbay, not allowing water to escape the forebay area.

2. **Developer/Builder to Remove the Outlet Obstruction.** Once the water reaches the top of the forebay levee or berm the outlet pipe shall be cleared of any obstruction so the water will flow freely from the forebay into the aftbay and finally to the basin outlet. The inspector has the discretion as to determine the final water surface level required for this test other then note above.

3. **City Construction Inspector to Observe Outflow.** Call for a scheduled inspection. The Inspector shall be present during the test and observe the outflow released from the forebay to the aftbay to the basin outlet. Between 48 and 60 hours the inspector shall return to the basin to verify there is no standing surface water in either the forebay or aftbay, presence of or indications of birdbaths or other low spots deeper than the diameter of a quarter (1.0”) measured from a string line held at grade. Standing water and/or low spots measured to be deeper than the diameter of a quarter shall require those areas of the basin to be regraded followed by a repeat of the functionality test.

Upon successful completion of a functionality test, the line and grade certification for the basin shall be completed by the Civil Engineer of Record, submitted to and approved by the City Engineer. Upon approval of the Civil Engineering certifications, the City Engineer may approve commencement of the installation of the landscape and irrigation improvements.

Infiltration Rate Test

ASTM D3385 Double-Ring Infiltrometer

This ***Infiltration Rate Test*** is the accepted method allowed by the City of Moreno Valley for determining the percolation rate design and constructed within the City. The test is called the double-ring (also called the double-cylinder) infiltrometer. The test has been accepted by the USEPA (referenced document EPA/600/R-98/006, Appendix "C") in their design manual "*Storage/Sedimentation Facilities for Control of Storm and Combined Sewer Overflows*". The procedure for this test has been established by ASTM D3385.

Only **non-residential** developments that will be monitored and maintained by a private **Property Owners Association** are allowed to use percolation rates in the design to determine the Q-capacity of their WQMP basin.

There shall be five test locations within the basin for determining the percolation rate. Generally, there shall be one test at each corner of the basin and one in the middle of the basin for a square/rectangular basin. For long narrow rectangular basins, there shall be at lease one test per every 100 feet (starting with one at each end of the basin). The lowest value of all test locations will be used as the percolation rate use in calculating the allowable Q-capacity of the basin.

REFERENCES

California Stormwater Quality Association, January 2003. *Stormwater Best Management Practice Handbook for New Development and Redevelopment*, prepared by Camp Dresser & McKee and Larry Walker Associates

Attachment to Supplement "A" of the Riverside County Drainage Area Management Plans , April 1996. *Selection and Design of Stormwater Quality Controls*, prepared by Riverside County Flood Control and Water Conservation District

Ventura Countywide Stormwater Quality Management Program July 2002. *Technical Guidance Manual for Stormwater Quality Control Measures*

Environmental Protection Agency, Document EPA/600/R-98/006, Appendix "C": Design Manual -"*Storage/Sedimentation Facilities for Control of Storm and Combined Sewer Overflows*".