Austin Sand Filter – Earthen Type

Design Guidance

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California Department of Transportation
HQ Division of Design

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List of Abbreviations

AASHTO	American Association of State Highway Transportation Officials
ASF	Austin Sand Filter
BEES	Basic Engineering Estimating System
BMP	Best Management Practice
CF	cubic feet
CRZ	Clear Recovery Zone, (AASHTO Clear Zone)
DEA	Department of Environmental Analysis
DPPIA	Design Pollution Prevention Infiltration Area
EBASF	Earthen Berm Austin Sand Filter
fps	feet per second
ft	foot/feet
HDM	Highway Design Manual
HQ	Headquarters
LID	low impact development
NPDES	National Pollutant Discharge Elimination System
nSSP	Non-Standard Special Provision
OHSD	Office of Hydraulics and Stormwater Design
PA/ED	Project Approval/Environmental Document
PDT	Project Development Team
PE	Project Engineer
PECE	Preliminary Engineer's Cost Estimates
PID	Project Initiation Document
PPCE	Project Planning Cost Estimate
PPDG	Project Planning and Design Guide
PS&E	Plans, Specifications, and Estimates
SQFT	square foot
SSP	Standard Special Provision
SWDR	Stormwater Data Report
TBMP	Treatment Best Management practice
USEPA	United States Environmental Protection Agency
WQF	Water Quality Flow
WQV	Water Quality Volume

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Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating both Full and Partial Sedimentation, Rectangular Earthen Berm Austin Sand Filter (EBASF) Treatment Best Management Practices (TMBPs), herein referred to as EBASFs, into projects during the planning and design phases of Caltrans highways and facilities. This type of Austin Sand Filter is a Caltrans-Approved TBMP. The EBASF may also be known as an Earthen Austin or Media Filter. The primary functions of this document are to:

1. Describe an EBASF
2. Provide design guidance
3. Review the required elements for implementing an EBASF into Plans, Specifications, and Estimates (PS&E) packages
4. Provide a design example

It is assumed that the need for post construction TBMPs has already been determined in accordance with the guidelines and procedures presented in the Project Planning and Design Guide (PPDG; Caltrans 2019b).

The following guidance is provided based on Caltrans pilot studies and professional design experience. Designers may utilize alternatives to the calculation methodologies presented in this guidance. Alternative calculations and design decisions must be documented in the project Stormwater Data Report (SWDR) and the Project File. The SWDR template can be found in the PPDG.

1.1 Design Responsibility

The Project Engineer (PE) is responsible for the design of EBASF hydrology, hydraulics, grading, and traffic because they are part of the highway drainage system. The designer must consider the highway grading plans and the impacts stormwater infiltration may have on the roadway especially in consideration of the Clear Recovery Zone (CRZ). Coordinate with other functional experts to implement successful and functioning EBASFs.

Refer to Chapter 800 of the Highway Design Manual (HDM), the Headquarters (HQ) Office of Hydraulics and Stormwater Design (OHSD), and District Hydraulics for project drainage requirements. Contact the District Landscape Architect for appropriate plant selection based on the physiographic region and the purpose of the BMP. To achieve sustainability requirements, the Project Development Team (PDT) is encouraged to use native and climate appropriate vegetation that does not require irrigation and requires the least amount of maintenance.

1.2 Earthen Berm Austin Sand Filters

Sand filters are devices that are used to treat stormwater runoff. In the late 1980's, the City of Austin, Texas, developed a unique sand filter design that became known as the Austin Sand Filter (ASF). A typical ASF consists of the following key components (USEPA 1999):

- Inflow pipes or surface conveyance
- The sediment chamber, where 'floatables' and heavy sediments are removed
- The filtration chamber, where additional pollutants are removed by filtering the runoff through a sand bed
- An underdrain system beneath the filtration chamber, which collects the filtered runoff and discharges it to a downstream conveyance
- Overflow release/upstream flow splitter

The EBASF is configured using two chambers and is usually open and at grade with no permanent water pool. The EBASF is configured with earthen sides and invert. Stormwater is directed into the first chamber (sedimentation) where the larger sediments and particulates settle out, and the partially treated effluent is metered into the second chamber (filtration) to be filtered through a media.

There are two major ASF configurations: Full and Partial Sedimentation. For a Full Sedimentation design the first chamber is sized for the entire water quality volume (WQV) and for a Partial Sedimentation design the first chamber is sized for about 20 percent of the WQV. Both Full and Partial Sedimentation ASFs can utilize concrete walls, earthen berms, or gabion walls to create the two chambers. Other methods to separate the chambers may be acceptable and must be done in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR.

This guidance document covers both Full and Partial Sedimentation EBASFs (see Figures 1-1 and 1-2). Figures 1-3 and 1-4 show an isometric view of a Full and Partial Sedimentation EBASF, respectively.

The EBASF configurations and sizing calculations in this guidance are intended for standard inline designs under normal conditions with typical external loading requirements. It is preferred that EBASFs be placed offline with an upstream flow splitter to minimize the size of the BMP. See Section 6.6 for additional details. EBASFs in this guidance have prescriptive, rectangular configurations. Non-rectangular configurations may be considered, see Section 4.2. Additionally, the calculations in this guidance assume instantaneous runoff to the BMP (i.e., 'slug-flow') which is likely conservative. Alternative sizing calculations, like unsteady-flow storage routing, may be used to refine the BMP size, see Section 8.2. Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the CRZ.

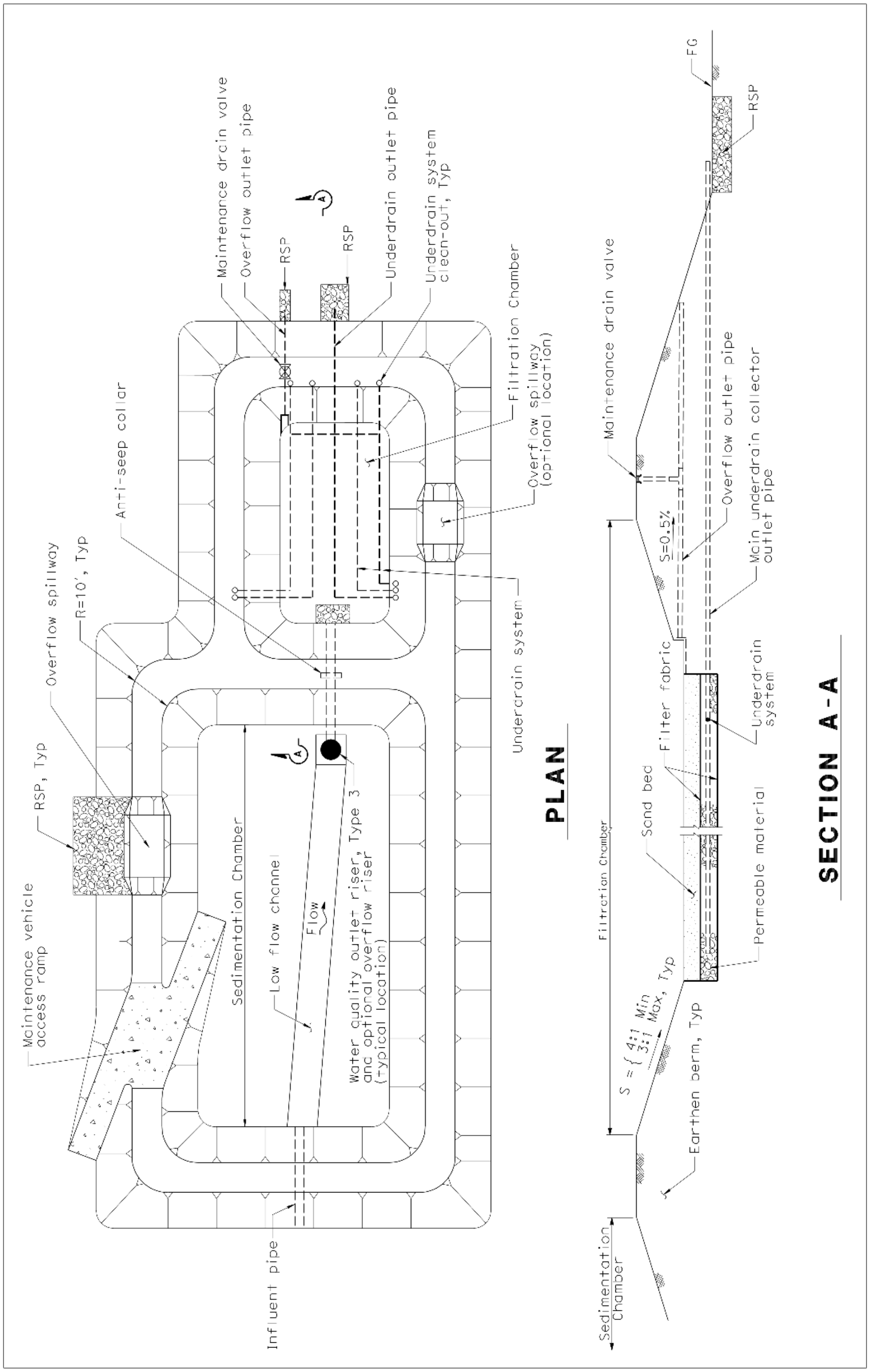

Figure 1-1: Full Sedimentation EBASF

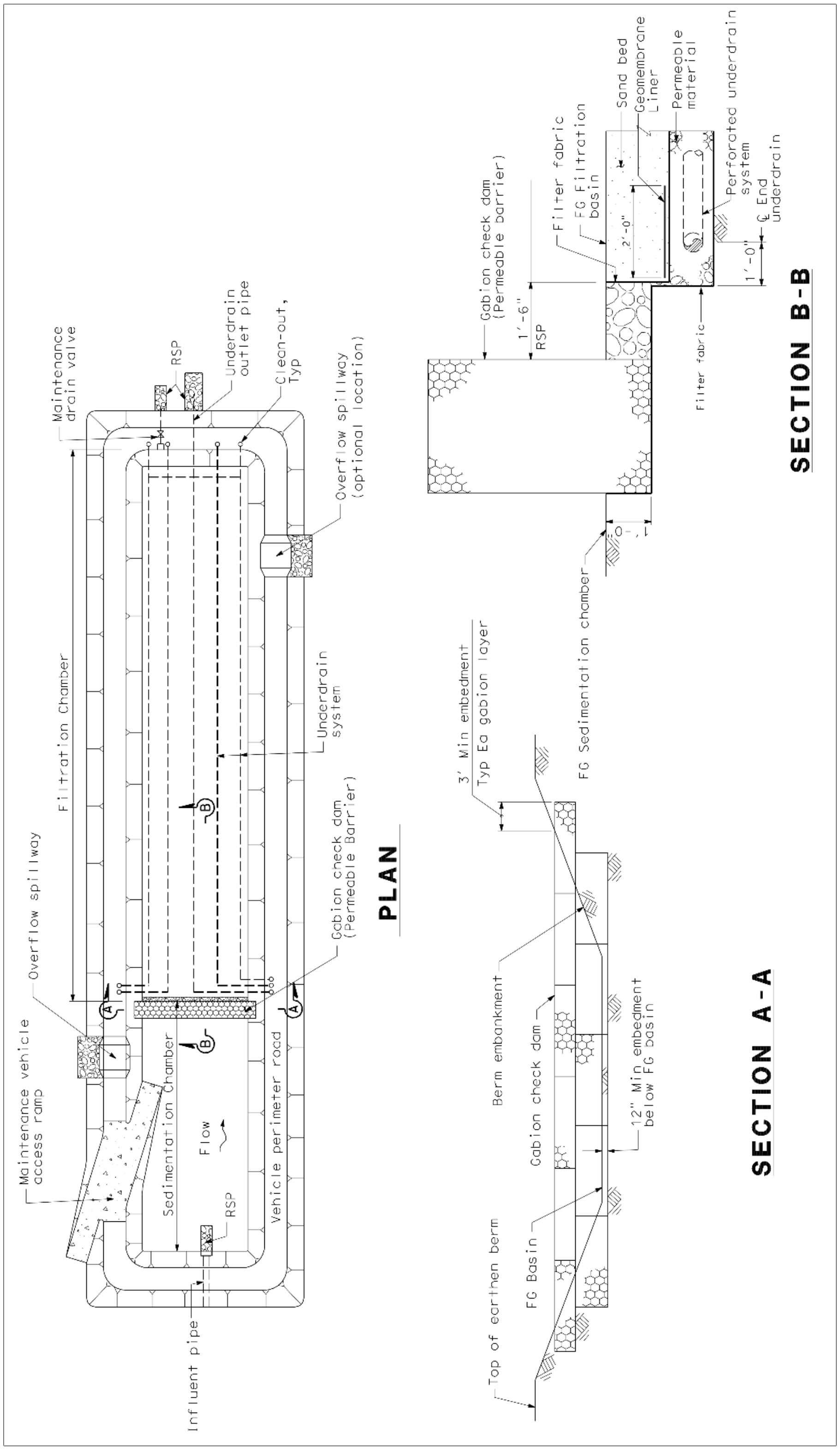

Figure 1-2: Partial Sedimentation EBASF

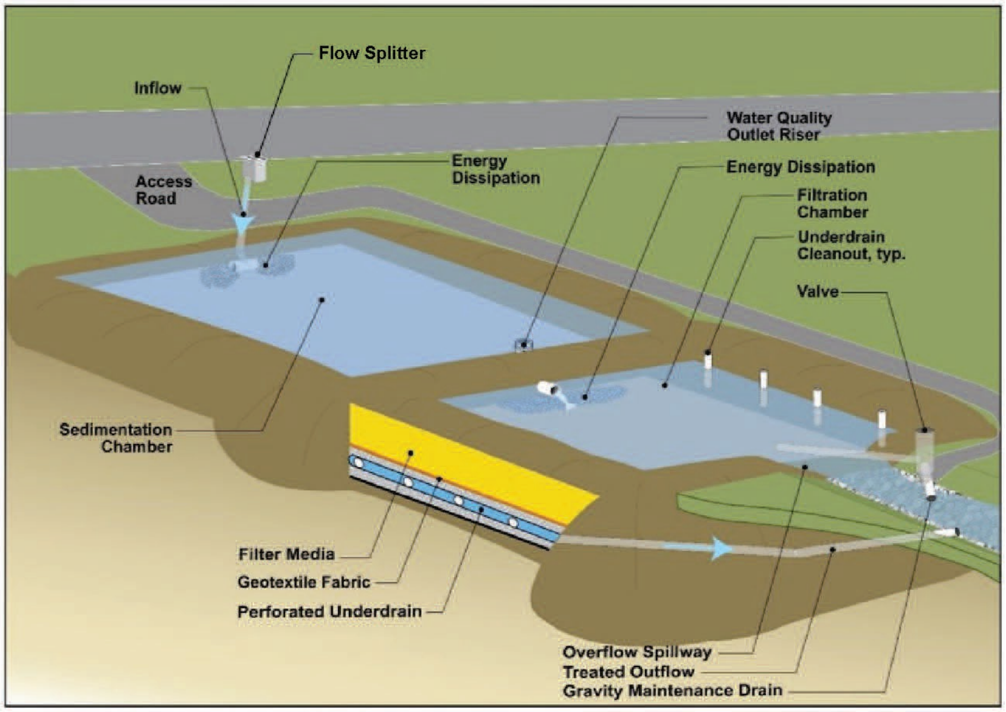

Figure 1-3: Full Sedimentation EBASF Isometric View

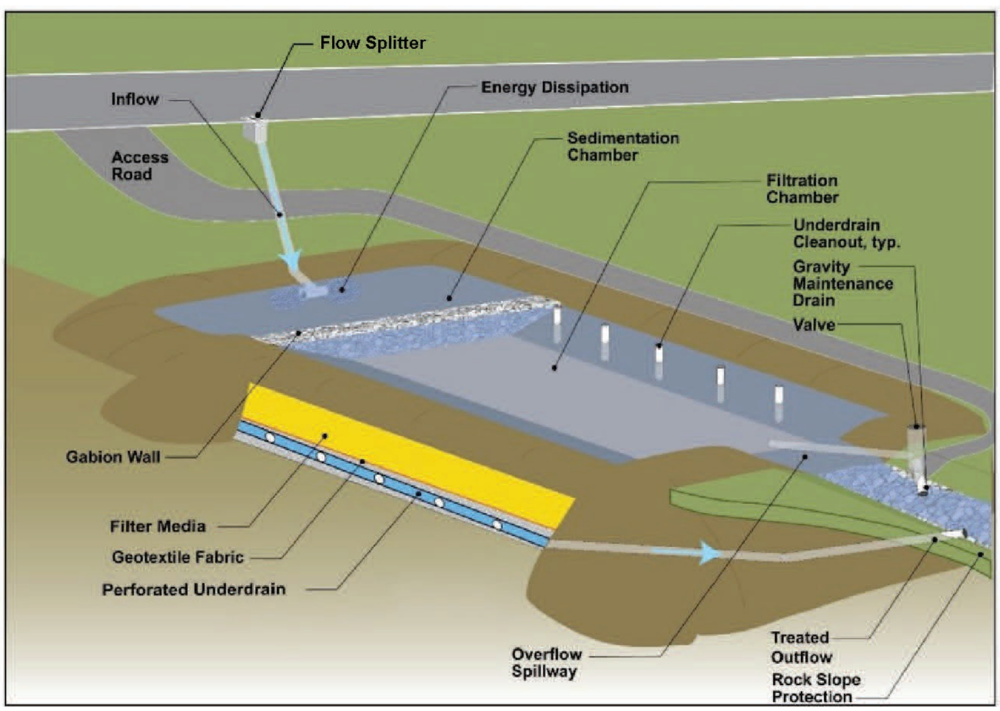

Figure 1-4: Partial Sedimentation EBASF Isometric View

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Section 2

Basis of EBASF Design

EBASFs should be considered for tributaries with a relatively high percentage of impervious area and low sediment loading. Additionally, the site must have sufficient hydraulic head for the filter to operate by gravity. EBASFs can benefit from pretreatment BMPs.

Checklist T-1, Part 8 in the PPDG, assists in evaluating the initial feasibility of EBASFs for a project. The checklist also identifies design elements that should be considered during the design of media filters. Once the feasibility of the device has been confirmed using Checklist T-1, Part 8 in the PPDG, use the following subsections to further understand the design elements of an EBASF for a given site.

2.1 Design Criteria

EBASFs must meet certain design criteria to perform as an effective TBMP. The primary factors to be incorporated in the design are found in Table 2-1. These standard design criteria were utilized for the development of Figures 1-1 and 1-2.

Table 2-1: Standard EBASF Design Criteria	
Parameter	**Value**
Sand media	Refer to Caltrans Permeable Material Non-Standard Special Provision (nSSP) Section 62, Class 5
Gravel media	Refer to Caltrans Permeable Material RSS Section 62, Class 4
Geotextile (filter) fabric material	Refer to Caltrans Filter Fabric RSS Section 62, Type D
Depth of sand layer[1]	1.5 ft min, varies
Depth of gravel layer	1 ft min, varies
Underdrain pipe diameter	6 inches - Refer to Caltrans Standards Section 64 Plastic Pipe and Section 68 Subsurface Drains
Longitudinal sediment chamber slope	2%
Longitudinal filtration chamber underdrain slope	1%
Side Slope Ratio (H:V)	3:1 (with District Maintenance concurrence) or flatter
Side Slope Stabilization	Rock or Vegetation
Inlet Velocity	8.0 fps max at gabion wall or design energy dissipator
Freeboard	1 ft[2]
Sedimentation Chamber Length-to-Width Ratio (Full Sedimentation)	2:1 as a goal
Minimum separation between groundwater and EBASF Invert (use a liner if separation is between 1 ft and 5 ft)	5 ft
Hydraulic Head	3 to 6 ft[3]

1. *A minimum sand layer depth of 1.5 ft should be used. Consider increasing sand layer depth to provide equivalent treatment in a smaller chamber.*
2. *A minimum freeboard of 1 ft should be provided between the water surface elevation during an overflow event and the lowest elevation of the confinement (e.g. the lowest elevation at the top of berm) in order to provide assurance of the physical integrity of the EBASF and downstream facilities.*
3. *Generally, 3 to 6 ft of head (or more, depending on total EBASF length) are required between the flow line elevation at the inlet of the sediment chamber to the flow line elevation at the outlet of the filtration chamber in order for an EBASF to operate properly. Some alternative configurations may support as little as 2 ft of head and must be done in consultation with the District/Regional Design Stormwater Coordinator.*

2.2 Special Designs

A Special Design will be required for sites or conditions that do not meet the standard design criteria listed in Table 2-1. For example, if an EBASFs requires side slopes steeper than 3:1 (H:V) retaining walls or gabion walls may be considered. Where inlet velocities exceed 8.0 fps at the gabion wall, either consider energy dissipaters or alternatives to the gabion wall. All Special Designs must be done in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR.

2.3 Inline vs. Offline Placement

An EBASF can be placed in an inline or offline configuration however, offline placement is preferred.

A. Inline Placement

An EBASF is placed in an inline configuration when an alternate route for the overflow events is not provided. Designing an EBASF in an inline configuration is not the preferred method but may be acceptable due to space restrictions.

Alternate means of safely conveying the events larger than the Water Quality Event must be provided. Additionally, the EBASF must be able to pass the runoff generated during the Design Storm (see Section 6.2) through the basin to downstream conveyance without objectionable backwater effects to upstream facilities or causing erosion in the basin. An overflow device shall be designed to convey the runoff from an overflow event in accordance with Section 6.3.

B. Offline Placement

An EBASF is placed in an offline configuration when an alternate route for the overflow events is provided. The excess runoff is diverted around the EBASF to avoid exposing the treatment facility to events larger than the Water Quality Event. Flow diversion structures typically consist of flow splitters, weirs, orifices, or pipes to bypass excess runoff as discussed in Section 6.6. Overflow devices must be considered for offline placement of the EBASF in accordance with Sections 6.4 and 6.5.

2.4 Safety Considerations

EBASFs should be located using the general roadway drainage considerations for safety and CRZ concept in the AASHTO manual (AASHTO 2011). Traffic safety is an important part of highway drainage facility design. The shape of a roadside EBASF section should minimize vehicular impact and provide a traversable section for errant traffic leaving the traveled way within the CRZ (HDM Topics 304, 309, and 861.4). Coordinate with other functional experts such as District Traffic Operations, District Maintenance, District Hydraulics, Geotechnical Design, Structure Design, and Traffic Safety, as applicable.

Consult with District Traffic Operations for all proposed placements to determine if guard railing is required. EBASFs should have detailing, such as fences, that preclude ready access by the public.

2.5 Restrictions/Coordination

Successful implementation and utilization of the EBASF will require proper siting by the PDT in coordination with District Hydraulics, District Maintenance, District Traffic Operations, District Landscape Architecture, Geotechnical Design, Structure Design, and Traffic Safety, as applicable. The EBASF design decisions and coordination must be documented in the SWDR.

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Section 3

Getting Started

This section presents the design parameters and calculations necessary to support the sizing and layout of an EBASF. It is assumed that the need for an EBASF has already been determined in accordance with the guidelines and procedures presented in Section 2 of this guidance and in the PPDG. It is furthermore assumed that the specific site for the BMP has been selected. As a result, no BMP selection or site selection guidelines are provided herein.

This guidance assumes that the EBASF is configured inline. Additionally, alternative sizing calculations may be used to refine the BMP size. When an offline configuration or alternative sizing calculations are used a Special Design may be necessary, see Section 8.

3.1 Preliminary Design Parameters

To properly select, size, and layout an EBASF, evaluate existing site conditions to obtain the following design parameters that are the basis of the EBASF:

- WQV: The WQV is calculated using the methodology in Section 3.1.1
- Hydraulic Head: Generally, three to six feet of head (or more, depending on total EBASF length) are required between the flow line elevation at the inlet of the sediment chamber to the flow line elevation at the outlet of the filtration chamber in order for an EBASF to operate properly.
- Design Water Depth (Hw): This parameter is defined as the maximum depth of the water above the sand layer (at the WQV depth) in the filtration chamber and will be determined by the elevation of the overflow device. H_w is not the same as the maximum water surface, which is only reached during an overflow event that exceeds the WQV. The total height of the berms will be equal to the maximum water depth during an overflow event plus the Freeboard (1 foot) above the maximum water surface.

3.1.1 Contributing Drainage Area and WQV

The WQV generated by the BMP CDA is calculated using the Small Storm Hydrology Method (PPDG Section 5.3). An explanation of CDA delineation and WQV calculation and example can be found in Section 3 of the DPPIA Design Guidance (Caltrans 2019a).

3.2 Preliminary Calculations

First calculate chamber sizing for both full and partial sedimentation design to accommodate the portion of the WQV not infiltrated as determined in Section 3.1.2. The PE will then select either full or partial sedimentation design based on available site dimensions. The footprint of a partial sedimentation configuration is usually around 80 to 90% of the full sedimentation configuration. Additionally, the efficiency of the partial sedimentation design is not greatly diminished from the full sedimentation design, and the overall maintenance is usually reduced because the release of stormwater from the partial sedimentation chamber to the filter chamber is usually done through a rock-filled gabion wall and not an outlet riser.

3.2.1 Full Sedimentation

Size the initial chamber to hold the WQV not infiltrated and use the equation for the outlet riser presented in the Supplemental Details Design Guidance (Caltrans 2020c) and in Section 3.2 of the Detention Basins Design Guidance (Caltrans 2020b) to determine the diameter of the orifices, using a 24-hour hold time.

The equation for sizing the filter bed in the second chamber is:

$A_{fc} = [C \times WQV \times d] / [k \times T \times (h + d)]$ (Eq. 1)

Where:

A_{fc} = area of 2nd chamber filter bed, full sedimentation basin; SQFT

C = conversion factor for units of permeability (12 for inches to ft)

WQV = Water Quality Volume; CF

d = depth of sand layer in the Austin-style filter bed, minimum 1.5 ft

k = coefficient of permeability of the filtering medium; US Customary units: 2 inches/hr

T = design drain time for WQV, equal to 24 hours

h = average water height above the surface of the media bed, taken as ½ the maximum head of the second chamber (distance to any overflow device from that chamber to the surface of the media bed); ft

3.2.2 Partial Sedimentation

Size the initial chamber to hold a minimum 20% of the WQV, subject to increase to meet the requirement that both chambers (including the void space in the filter chamber calculated using Eqn. 2 below) combine to hold the entire WQV.

$V_V = 0.35A_{fc} \times (d + d_g)$ (Eq. 2)

Where:

V_v = available storage volume of the filter chamber; CF

A_{fc} = area of the filter chamber; SQFT

d = depth of the filter (sand) layer; US Customary units: 1.5 ft

d_g = depth of the gravel layer(s); US Customary units: 1.0 ft

0.35 = assumed void ratio (dimensionless)

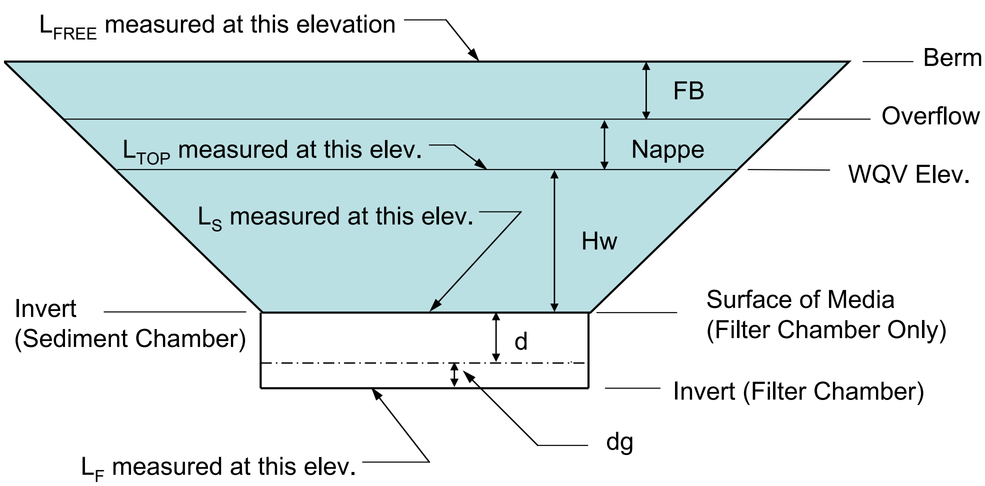


Figure 3-1: Cross-Section of EBASF and Key Dimensions

Size the filter bed in the second chamber using the following formula:

$A_{fp} = 1.8A_{fc}$ (Eq. 3)

Where:

A_{fp} = area of 2nd chamber filter bed for a partial sedimentation device

A_{fc} = value from equation 1.

Note that the filter area is larger in the partial sedimentation version than the full sedimentation version due to the less efficient capture of sediments in the partial sedimentation device. Sediment loads will vary based on project conditions.

3.2.3 Partial Sedimentation, Rectangular Basin Dimensions

Both a plan and section view of a typical, rectangular partial sedimentation installation are shown in Figure 3-2[1]. The basin is surrounded on all four sides by berms with slopes ranging from approximately 3:1 to 4:1 (H:V). A partial EBASF has five distinct zones as described below:

- Z1 (Drop Inlet Zone): This zone consists of the initial sloped entrance area to the sediment chamber
- Z2 (Sedimentation Zone): The zone where actual sedimentation and floatables capture occurs
- Z3 (Gabion Zone): The zone that is occupied by the gabion wall
- Z4 (Filtration Zone): This zone comprises the portion of runoff in the filtration chamber that is directly above the flat invert of the chamber (H_W volume), plus the volume of the sand bed
- Z5 (Filter End Zone): This zone consists of the sloped exit area at the end of the filtration chamber

The key dimensions are as follows:

- L_S: Length of the sediment chamber as measured across the 2% slope (Zone Z2)
- L_F: Length of the filtration chamber across the flat invert of the chamber (Zone Z4)
- $L_{TOP}S$: The length of the sediment chamber as measured at the WQV water surface (Zones Z1 and Z2)
- $L_{TOP}F$: The length of the filtration chamber as measured at the WQV water surface (Zones Z4 and Z5)
- $L_{FREE}S$: The length of the sediment chamber as measured inside the berms at the freeboard elevation
- $L_{FREE}F$: The length of the filtration chamber as measured inside the berms at the freeboard elevation
- L_{TOTAL}: The total length of the EBASF, including the outside edge of the sloped berms
- W_F: Width of the filtration chamber across the flat invert of the chamber
- $W_{TOP}S$: The width of the sediment chamber as measured at the water surface at WQV
- $W_{TOP}F$: The width of the filtration chamber as measured at the water surface at WQV
- $W_{FREE}S$: The width of the sediment chamber as measured inside the berms at the freeboard elevation

[1] In Figure 6, the side slopes on the width of the first chamber are exaggerated for effect.

- $W_{FREE}F$: The width of the filtration chamber as measured inside the berms at the freeboard elevation
- W_{TOTAL}: The total width of the EBASF, including the outside edge of the sloped berms
- H_W: Design Water Depth inside the EBASF at WQV elevation (as measured in Zone Z4 just downstream of Zone Z3)
- W_{AR}: The width of the access road (i.e. width of the berm crest)

3.2.4 Full Sedimentation, Rectangular Basin Dimensions

Both a plan and section view of a typical, rectangular full sedimentation installation are shown in Figure 3-3[2]. The basin is surrounded on all four sides by berms with slopes ranging from 3:1 to 4:1 (H:V). A full EBASF has four distinct zones as described below:

- Z1 (Drop Inlet Zone): This zone consists of the initial sloped entrance area to the sediment chamber
- Z2 (Sedimentation Zone): The zone where actual sedimentation and floatables capture occurs
- Z3 (Sedimentation End Zone): This zone consists of the sloped exit area of the sediment chamber
- Z4 (Filtration Zone): This zone comprises the portion of runoff in the filtration chamber that is directly above the flat invert of the chamber (H_w volume), plus the volume of the sand bed

The key dimensions are as follows:

- L_S: Length of sediment chamber as measured across the 2% slope (Zone Z2);
- W_S: Width of the sediment chamber as measured across the invert;
- $L_{TOP}S$: The overall length of the sediment chamber as measured across the water surface at WQV (including Zones Z1, Z2, and Z3);
- $L_{FREE}S$: The length of the sediment chamber as measured inside the berms at the freeboard elevation;
- $W_{TOP}S$: The overall width of the sediment chamber as measured at the water surface at WQV;
- $W_{FREE}S$: The width of the sediment chamber as measured inside the berms at the freeboard elevation;
- L_F: Length of filtration chamber across the flat invert of the chamber (Zone Z4);
- W_F: Width of the filtration chamber across the flat invert of the chamber;

[2] In Figure 3-5, the side slopes on the width of the first chamber are exaggerated for effect.

- $L_{TOP}F$: The overall length of the filtration chamber as measured across the water surface at WQV;
- $L_{FREE}F$: The length of the filtration chamber as measured inside the berms at the freeboard elevation;
- L_{TOTAL}: The total length of the EBASF, including the outside edge of the sloped berms;
- $W_{TOP}F$: The overall width of the filtration chamber as measured at the water surface at WQV;
- $W_{FREE}F$: The width of the filtration chamber as measured inside the berms at the freeboard elevation;
- W_{TOTAL}: The total width of the EBASF, including the outside edge of the sloped berms;
- H_W: Design Water Depth inside the EBASF at WQV elevation (as measured in Zone Z4 just downstream of Zone Z3);
- B_W: The width of the berm crest.

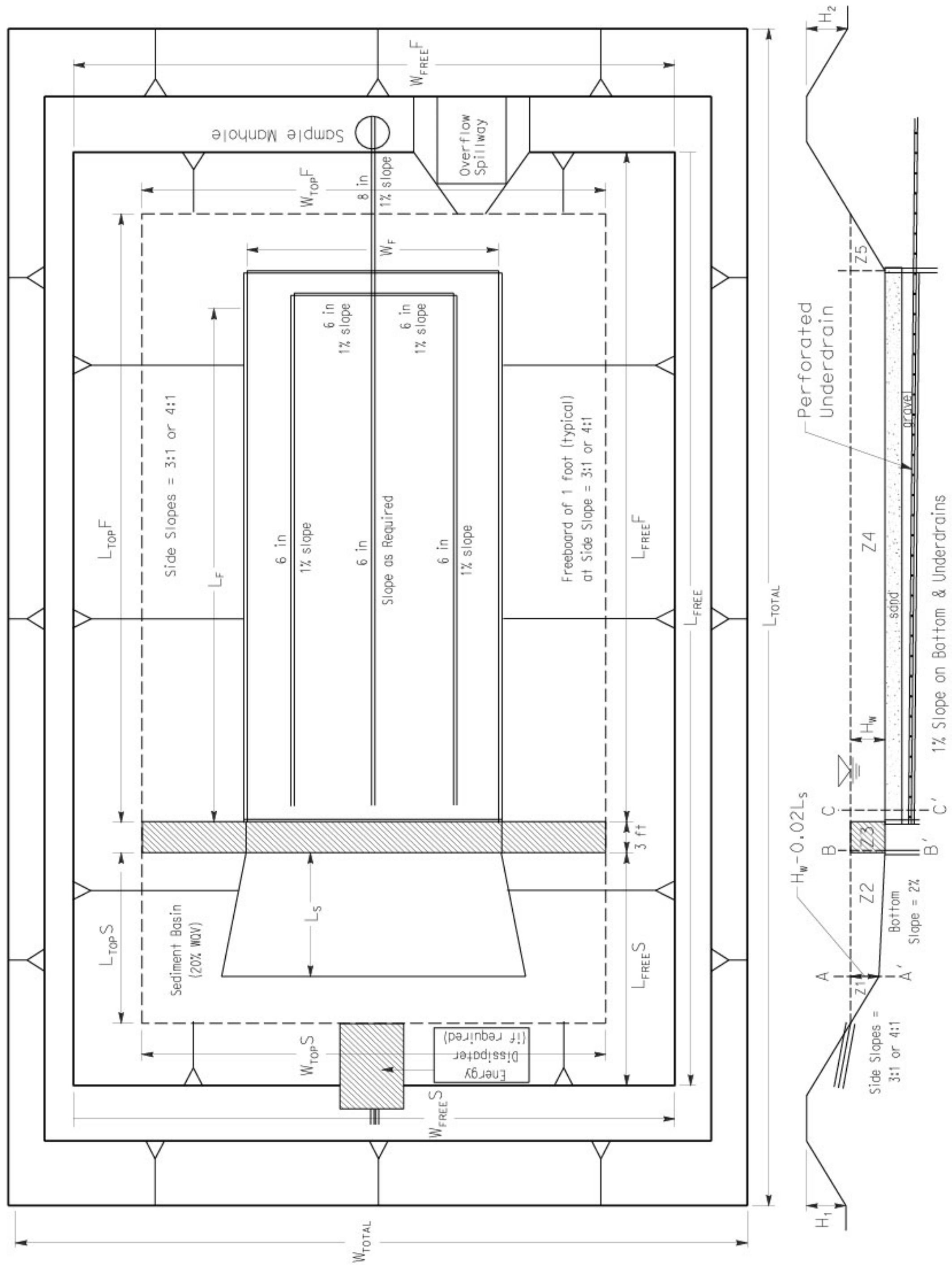


Figure 3-2: Partial Sedimentation EBASF Dimensions

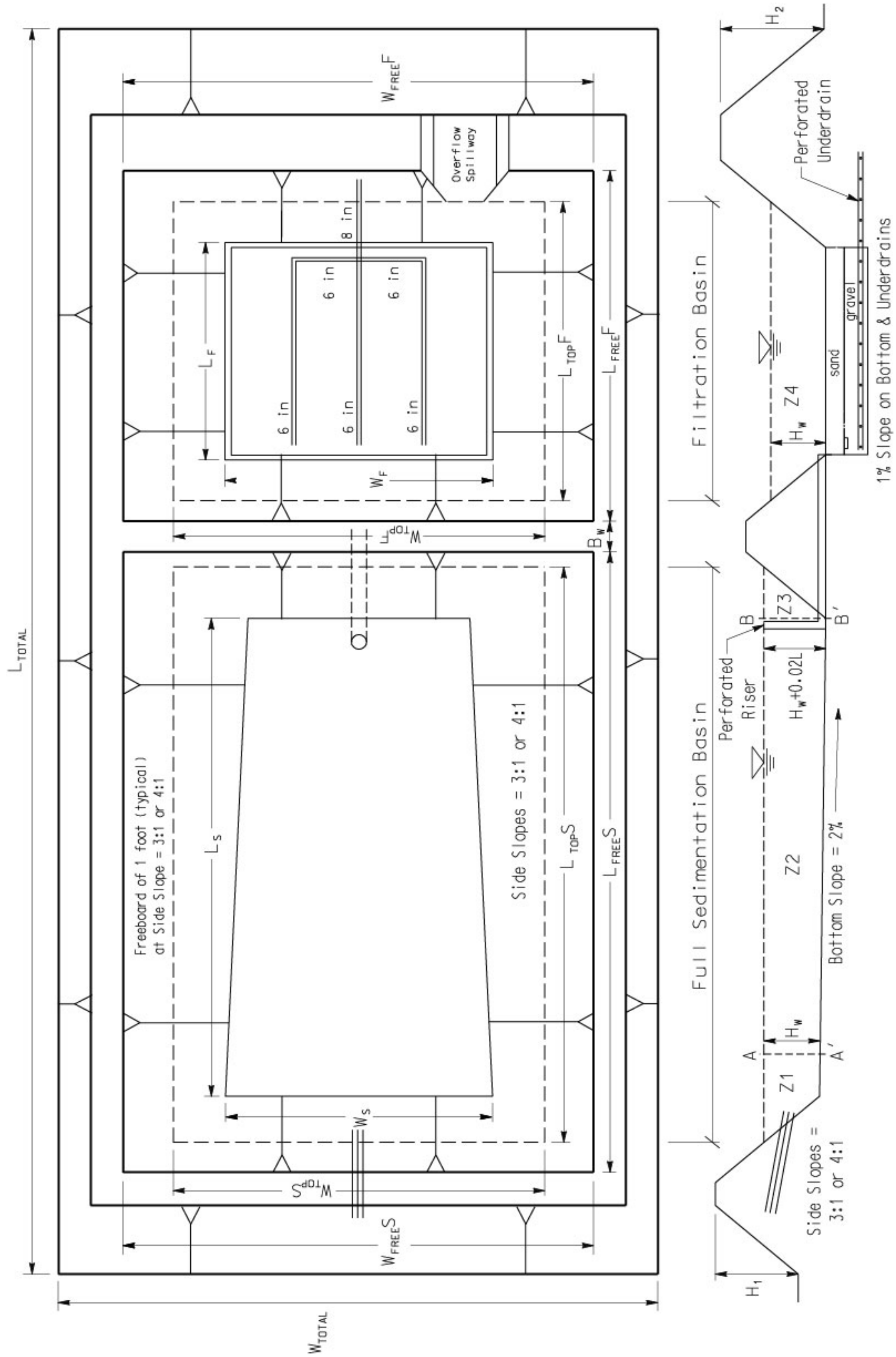


Figure 3-3: Full Sedimentation EBASF Dimensions

Section 4

BMP Selection

The method for selecting the most appropriate EBASF size and configuration for a given site will often be an iterative process where the design factors presented in Section 2 are evaluated together. Figure 4-1 presents the typical process flowchart for selecting the most appropriate EBASF size and configuration for a specific project. Selecting which rectangular EBASF to use for a particular project is a two-step process with each substep being discussed in detail below.

This guidance includes EBASFs configured with rectangular basins only. However, this BMP can utilize non-rectangular configurations to accommodate site conditions. Alternative sizing calculations (Section 8.2) and alternative configurations (Section 8.3) are a Special Design and must be done in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR.

Prior to proceeding with the steps below, the PE should first review the site conditions to ensure that none of the site restrictions discussed in Section 2 or in the PPDG are present, and to confirm that there is available unobstructed area for placement of the EBASF. For larger drainage areas, the PE may need to consider splitting the drainage area into sections and using additional EBASFs in series or parallel arrangements.

4.1 Chamber Dimensions

4.1.1 Background

For a Full Sedimentation EBASF, the sediment chamber volume should be set equal to the WQV. For a Partial Sedimentation EBASF, the sediment chamber volume should be set equal to 20% of the WQV.

The sediment and filtration chambers for most EBASFs will often be designed as trapezoidal basins. The equation for solving for the volume of a trapezoidal basin is:

$$Volume = (W \times L \times D) + (W + L) \times (Z) \times (D^2) + (4/3) \times (Z^2) \times (D^3)$$

Where:

W = width at basin invert

L = length at basin invert

Z = basin side slope (H:V)

D = depth of basin

For the sediment chamber of a Full Sedimentation EBASF, Volume = WQV, and the recommended length-to-width ratio at WQV is 2:1.[3]

For Full Sedimentation EBASFs, there is no storage volume requirement for the filtration chamber. The width of the sediment chamber (W_S) is typically assumed to be the same as the width of the filtration chamber at the surface of the media. Since the side slopes in the filtration chamber below the surface of the media are typically vertical, this means that the filtration chamber invert width (W_F) is equal to W_S.

For Partial Sedimentation EBASFs, the volume in the sediment chamber is ≥ 20% of the WQV, and the sum of the volume of the sediment chamber plus the total volume of the filtration chamber (including the void space within the media and gravel layers) is ≥ the WQV, as required by the *PPDG*. There are no length-to-width ratio requirements for either the sediment chamber or the filtration chamber for Partial Sedimentation EBASFs, so the chamber dimensions can be anything that meets the volumetric requirements and area of filter surface requirements.

The substeps required to determine the basin dimensions for Partial and Full Sedimentation EBASFs are as follows:

4.1.2 Partial EBASF

Substep A: Determine W_{TOTAL} and H_W based upon Site Conditions

Often, site conditions will limit the total width of a Partial EBASF, measured from toe of the outside berm to the toe of the opposite outside berm. Also, the depth of an EBASF may be limited by invert elevations of existing storm drains and/or depth-to-groundwater. The seasonally high groundwater should be at least 5 ft below the invert of the EBASF unless arrangements are made with the Regional Water Quality Control Board. In cases where there is hazardous waste or ground water contamination, or geotechnical issues related to highway then a liner is used. Groundwater clearance from the bottom of the liner should be a minimum of 1 foot.

Thus, the Design Water Depth and total width are often known when beginning the design of a Partial EBASF. The terms are defined as follows:

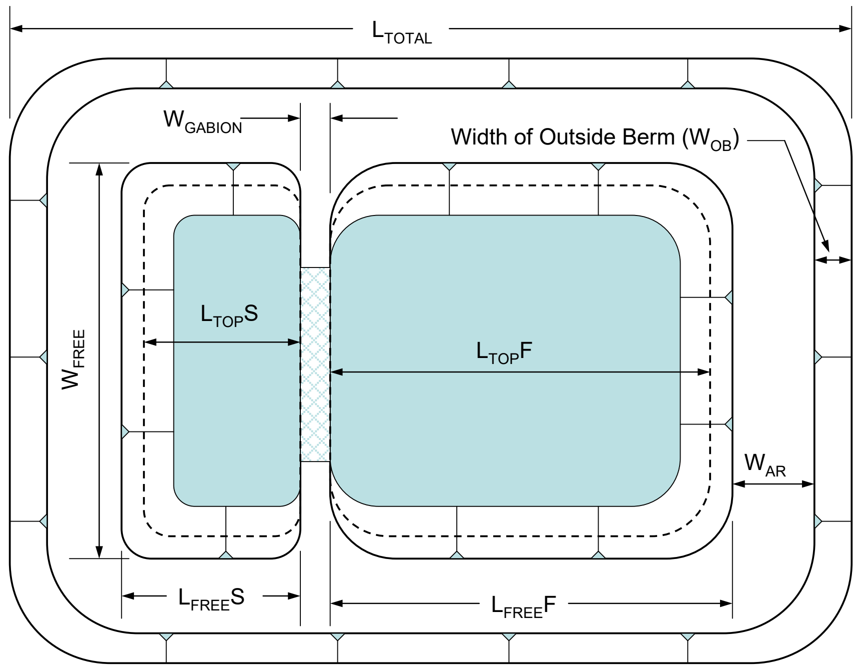
W_{TOTAL} = total width of EBASF from edge of outside berm to edge of outside berm

H_W = Design Water Depth inside the EBASF, from invert of sediment chamber to WQV elevation

[3] Because an EBASF often has an irregularly shaped volume, the calculation of the dimensions and volumes typically requires design software or an iterative trial-and-error process. However, for the purposes of this Design Guidance document, the design procedure will assume a regularly shaped, trapezoidal basin. For initial sizing, estimation to within 10% of actual volume is considered adequate for design purposes.

Substep B: Determine $W_{FREE}S$

Determine outside berm slope width (W_{OB}) and choose width of access road (W_{AR}). Subtract the horizontal width of the outside berm and the width of the access road to determine W_{FREE}.



W_{FREE} may be calculated using the following equation:

$$W_{FREE}S = W_{TOTAL} - 2 \times W_{OB} - 2 \times W_{AR}$$

Where:

$W_{FREE}S$	=	width across the invert of the sediment chamber
W_{TOTAL}	=	total width of EBASF from edge of outside berm to edge of outside berm
W_{OB}	=	width across the outer berm
W_{AR}	=	width across the access road

Substep C: Determine $W_{TOP}S$

Next, calculate the width across the WQV minus the water surface elevation of the sediment chamber:

$$W_{TOP}S = W_{FREE} - 2 \times Z \times (FB + N)$$

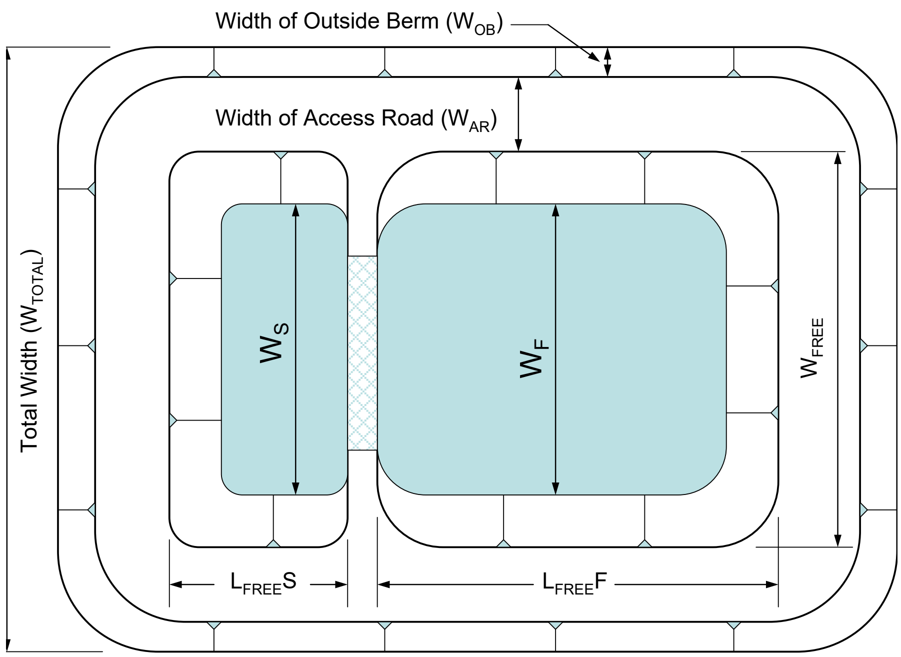
Where:

$W_{TOP}S$ = width across the sediment chamber at the WQV minus water surface elevation

Z = slope of the interior berm (H:V)

FB = Freeboard, typically 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), typically 1 foot for the purpose of this document



Substep D: Determine W_S

Determine the invert width of the sediment chamber (W_S):

$$W_S = W_{TOP}S - 2 \times Z \times H_W$$

Where:

W_S = width across the invert of the sediment chamber

$W_{TOP}S$ = width across the sediment chamber at the WQV - water surface elevation

Z = slope of the interior berm (H:V)

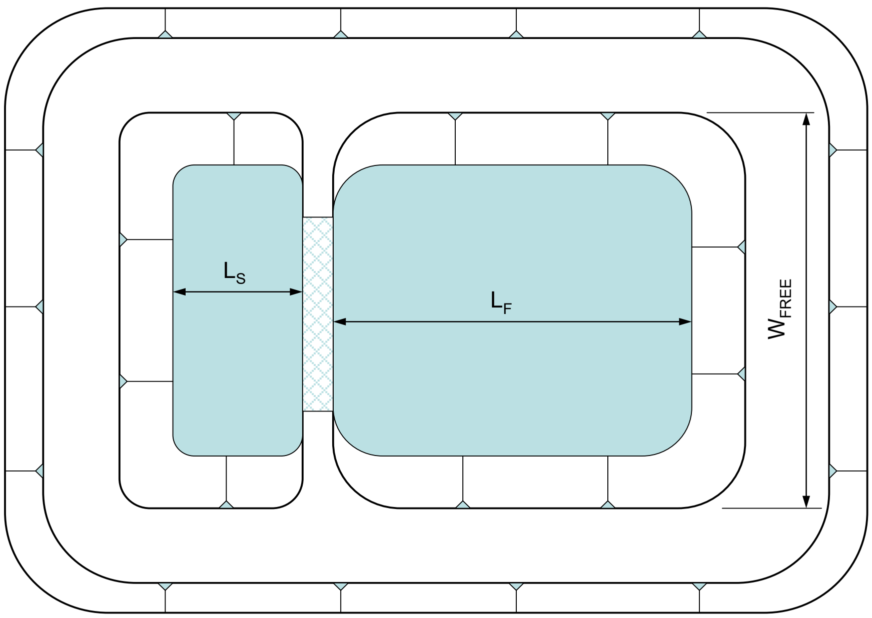
H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation

Substep E: Determine W_F

Determine the width of the filtration chamber. Unless site conditions require a different configuration, W_F is typically equal to W_S.

Substep F: Determine L_S

Determine the length across the invert of the sediment chamber, noting that one end of the chamber has a slope (Z), while the other end is the vertical face of the gabion wall.



L_S may be calculated directly using the following formula:

$$L_S = \frac{0.2 \times WQV - 0.5 \times W_S \times Z \times H_W{}^2 - 0.67 \times Z^2 \times H_W{}^3}{(W_S \times H_W) + (Z \times H_W{}^2)}$$

Where:

L_S = length across the invert of the sediment chamber

WQV = Water Quality Volume

W_S = width across the invert of the sediment chamber

Z = slope of the interior berm (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation.

Substep G: Determine L_F

Determine the length across the invert of the filtration chamber, noting that one end of the filtration chamber has a slope (Z), while the other end is the vertical face of the gabion wall.

L_F may be calculated directly using the following formula:

$$L_F = \frac{0.8 \times WQV - 0.5 \times W_F \times Z \times H_W^{\ 2} - 0.67 \times Z^2 \times H_W^{\ 3}}{[0.35 \times W_F \times (d + dg)] + (W_F \times H_W) + (Z \times H_W^{\ 2})}$$

Where the variables are as listed for L_S and:

d	=	depth of filter media (i.e. sand, typically 1.5 ft)
dg	=	depth of collector (i.e. gravel) layer, typically 1 foot

Substep H: Check Filtration Chamber Surface Area, A_{fp}

The surface area of the filter media will be equal to $L_F \times W_F$. However, the filtration chamber surface area also needs to meet the following requirement:

$$Afp = 1.8Afc = \frac{1.8 \times C \times WQV \times d}{[k \times T \times (h + d)]}$$

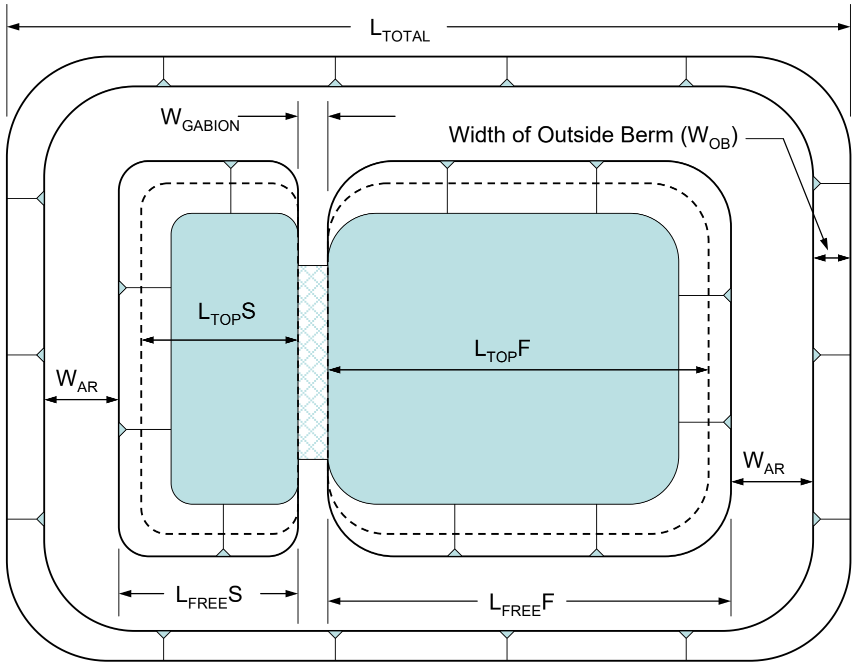
Where:

Afp	=	area of filter bed in the filtration chamber, SQFT
C	=	conversion factor for units of permeability (12 inches to ft)
WQV	=	Water Quality Volume
d	=	depth of filter bed, typically about 1.5 ft
k	=	coefficient of permeability of the filtering medium, typically 2 inches/hour
T	=	design drain time for WQV, typically 24 hours
h	=	average water height above the surface of the media bed, taken as half the maximum head of the filtration chamber (i.e. 0.5 x H_w)

If $L_F \times W_F$ is less than A_{fp} calculated using the preceding equation, then L_F must be increased such that $L_F \times W_F > A_{fp}$.

Substep I: Determine W_{TOP} and L_{TOP}

Determine the overall lengths of the two chambers as measured across the water surface at WQV, and the width of the filtration chamber at WQV (W_{TOP} and L_{TOP}). Note that $W_{TOP}S$ was calculated in Step C.



$$L_{TOP}S = L_S + Z \times H_W$$

Where:

$L_{TOP}S$	=	length of the sediment chamber as measured across the water surface at WQV
L_S	=	length across the invert of the sediment chamber
Z	=	slope of the interior berm (H:V)
H_W	=	Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation

Similarly:

$$L_{TOP}F = L_F + Z \times H_W$$

Where:

LTOPF	=	length of the filtration chamber as measured across the water surface at WQV
LF	=	length across the invert of the filtration chamber
Z	=	slope of the interior berm (H:V)
HW	=	Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation

The width at the filtration chamber WQV surface elevation may also be calculated as follows:

$$W_{TOP}F = W_F + 2 \times Z \times H_W$$

Where:

$W_{TOP}F$ = width of the filtration chamber as measured across the water surface at WQV

WF = width across the invert of the filtration chamber

Z = slope of the interior berm (H:V)

HW = Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation

Substep J: Determine $L_{FREE}S$ and $L_{FREE}F$:

Determine the length of the sediment and filtration chambers as measured across the freeboard elevation. The equation for calculating $L_{FREE}S$ is:

$$L_{FREE}S = L_{TOP}S + Z \times (FB + N)$$

Where:

$L_{FREE}S$ = length across the filtration chamber as measured across the water surface at the freeboard elevation, ft

LTOPS = length of the filtration chamber as measured across the water surface at WQV

Z = slope of the interior berm (H:V)

FB = freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), typically 1 foot for the purpose of this document

Similarly, the equation for calculating $L_{FREE}F$ is:

$$L_{FREE}F = L_{TOP}F + Z \times (FB + N)$$

Where:

$L_{FREE}F$ = length across the filtration chamber as measured across the water surface at the freeboard elevation, ft

LTOPF = length of the filtration chamber as measured across the water surface at WQV

Z = slope of the interior berm (H:V)

FB = freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), typically 1 foot for the purpose of this document

Substep K: Determine L_{TOTAL}

Determine the overall length of the EBASF as measured from toe of outside berm to toe of outside berm.

$$L_{TOTAL} = L_{FREE}F + L_{FREE}S + 2 \times W_{OB} + 2 \times W_{AR} + W_{GABION}$$

4.1.3 Full EBASF

Substep A: Determine W_S and L_S based upon WQV

Refer to Tables 4-1 through 4-2 of this document to choose the appropriate invert width and length of the sediment chamber for the calculated WQV.

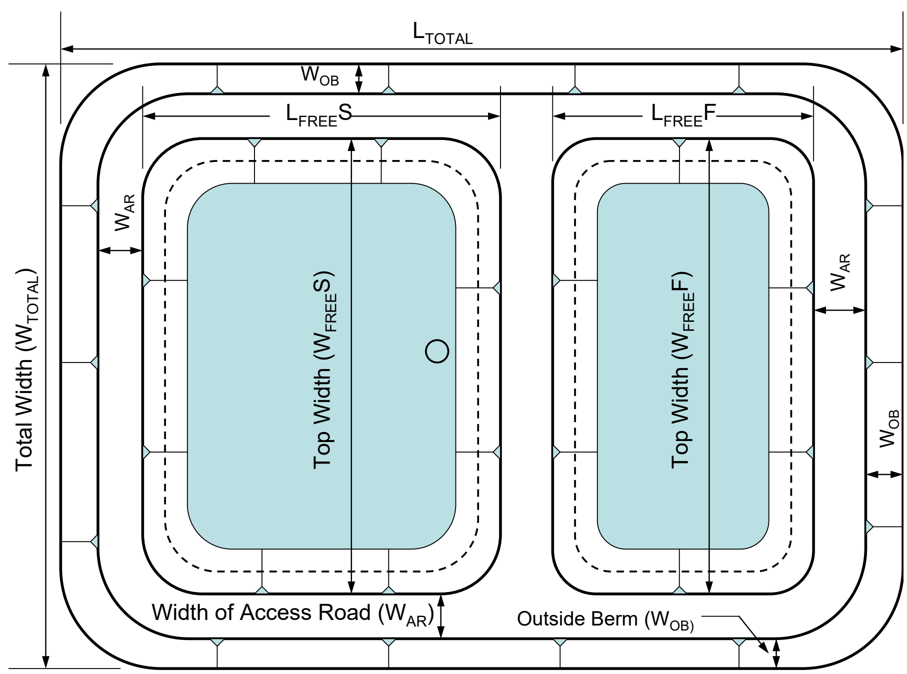


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Table 4-1: Sediment Chamber Invert Length (L_S), Width (W_S), and Area (A_S) For Full Sedimentation, Rectangular EBASFs with 3:1 Side Slopes (Z=3)															
Sediment Chamber Volume	HW =3 ft			HW =3.5 ft			HW =4 ft			HW =4.5 ft			HW =5 ft		
(CF)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)
4,356	50	16	800	47	13	611	44	10	440	41	7	287	38	4	152
5,000	53	18	954	50	15	750	47	12	564	44	9	396	41	6	246
10,000	77	30	2310	74	27	1998	71	24	1704	68	21	1428	65	18	1170
15,000	96	39	3744	93	36	3348	90	33	2970	87	30	2610	84	27	2268
20,000	111	47	5217	108	44	4752	105	41	4305	102	38	3876	99	35	3465
25,000	125	54	6750	122	51	6222	119	48	5712	116	45	5220	113	42	4746
30,000	137	60	8220	134	57	7638	131	54	7074	128	51	6528	125	48	6000
35,000	149	66	9834	146	63	9198	143	60	8580	140	57	7980	137	54	7398
40,000	159	71	11289	156	68	10608	153	65	9945	150	62	9300	147	59	8673
45,000	169	76	12844	166	73	12118	163	70	11410	160	67	10720	157	64	10048
50,000	178	80	14240	175	77	13475	172	74	12728	169	71	11999	166	68	11288
55,000	187	85	15895	184	82	15088	181	79	14299	178	76	13528	175	73	12775
60,000	196	89	17444	193	86	16598	190	83	15770	187	80	14960	184	77	14168
65,000	204	93	18972	201	90	18090	198	87	17226	195	84	16380	192	81	15552
70,000	212	97	20564	209	94	19646	206	91	18746	203	88	17864	200	85	17000
75,000	220	101	22220	217	98	21266	214	95	20330	211	92	19412	208	89	18512
80,000	227	105	23835	224	102	22848	221	99	21879	218	96	20928	215	93	19995
85,000	234	108	25272	231	105	24255	228	102	23256	225	99	22275	222	96	21312
90,000	241	112	26992	238	109	25942	235	106	24910	232	103	23896	229	100	22900
95,000	248	115	28520	245	112	27440	242	109	26378	239	106	25334	236	103	24308
100,000	254	118	29972	251	115	28865	248	112	27776	245	109	26705	242	106	25652
105,000	261	122	31842	258	119	30702	255	116	29580	252	113	28476	249	110	27390
110,000	267	125	33375	264	122	32208	261	119	31059	258	116	29928	255	113	28815
115,000	273	128	34944	270	125	33750	267	122	32574	264	119	31416	261	116	30276
120,000	279	131	36549	276	128	35328	273	125	34125	270	122	32940	267	119	31773

Table 4-2: Sediment Chamber Invert Length (L_S), Width (W_S), and Area (A_S) For Full Sedimentation, Rectangular EBASFs with 4:1 Side Slopes (Z=4)															
Sediment Chamber Volume	HW = 3 ft			HW = 3.5 ft			HW = 4 ft			HW = 4.5 ft			HW = 5 ft		
(CF)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)	LS (ft)	WS (ft)	AS (SQFT)
4,356	48	12	576	44	8	352	40	4	160	NA	NA	NA	NA	NA	NA
5,000	52	14	728	48	10	480	44	6	264	40	2	80	NA	NA	NA
10,000	76	26	1976	72	22	1584	68	18	1224	64	14	896	60	10	600
15,000	94	35	3290	90	31	2790	86	27	2322	82	23	1886	78	19	1482
20,000	110	43	4730	106	39	4134	102	35	3570	98	31	3038	94	27	2538
25,000	123	50	6150	119	46	5474	115	42	4830	111	38	4218	107	34	3638
30,000	136	56	7616	132	52	6864	128	48	6144	124	44	5456	120	40	4800
35,000	147	62	9114	143	58	8294	139	54	7506	135	50	6750	131	46	6026
40,000	158	67	10586	154	63	9702	150	59	8850	146	55	8030	142	51	7242
45,000	168	72	12096	164	68	11152	160	64	10240	156	60	9360	152	56	8512
50,000	177	77	13629	173	73	12629	169	69	11661	165	65	10725	161	61	9821
55,000	186	81	15066	182	77	14014	178	73	12994	174	69	12006	170	65	11050
60,000	194	85	16490	190	81	15390	186	77	14322	182	73	13286	178	69	12282
65,000	203	90	18270	199	86	17114	195	82	15990	191	78	14898	187	74	13838
70,000	210	93	19530	206	89	18334	202	85	17170	198	81	16038	194	77	14938
75,000	218	97	21146	214	93	19902	210	89	18690	206	85	17510	202	81	16362
80,000	225	101	22725	221	97	21437	217	93	20181	213	89	18957	209	85	17765
85,000	232	104	24128	228	100	22800	224	96	21504	220	92	20240	216	88	19008
90,000	239	108	25812	235	104	24440	231	100	23100	227	96	21792	223	92	20516
95,000	246	111	27306	242	107	25894	238	103	24514	234	99	23166	230	95	21850
100,000	253	115	29095	249	111	27639	245	107	26215	241	103	24823	237	99	23463
105,000	259	118	30562	255	114	29070	251	110	27610	247	106	26182	243	102	24786
110,000	265	121	32065	261	117	30537	257	113	29041	253	109	27577	249	105	26145
115,000	271	124	33604	267	120	32040	263	116	30508	259	112	29008	255	108	27540
120,000	277	127	35179	273	123	33579	269	119	32011	265	115	30475	261	111	28971

Note: The term "NA" indicates that the depth will not work for the given volume and side slope.

Table 4-3: Typical Filter Invert Length (L_F), Width (W_F), and Area (A_{fc}) For Full Sedimentation, Rectangular EBASF Assuming Z=3:1 (H:V), T=24 hours, k=2 inches/hour, d=1.5 ft															
WQV	HW = 3 ft			HW = 3.5 ft			HW = 4 ft			HW = 4.5 ft			HW = 5 ft		
(CF)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)
4,356	543	34	16	502	39	13	466	47	10	435	62	7	408	102	4
5,000	634	35	18	576	38	15	535	45	12	499	55	9	468	78	6
10,000	1,248	42	30	1,152	43	27	1,069	45	24	998	48	21	936	52	18
15,000	1,871	48	39	1,727	48	36	1,604	49	33	1,497	50	30	1,403	52	27
20,000	2,495	53	47	2,303	52	44	2,139	52	41	1,996	53	38	1,871	53	35
25,000	3,119	58	54	2,879	56	51	2,673	56	48	2,495	55	45	2,339	56	42
30,000	3,743	62	60	3,455	61	57	3,208	59	54	2,994	59	51	2,807	58	48
35,000	4,366	66	66	4,030	64	63	3,743	62	60	3,493	61	57	3,275	61	54
40,000	4,990	70	71	4,606	68	68	4,277	666	65	3,992	64	62	3,743	63	59
45,000	5,614	74	76	5,182	71	73	4,812	69	70	4,491	67	67	4,210	66	64
50,000	6,238	78	80	5,758	75	77	5,346	72	74	4,990	70	71	4,678	69	68
55,000	6,861	81	85	6,333	77	82	5,881	74	79	5,489	72	76	5,146	70	73
60,000	7,485	84	89	6,909	80	86	6,416	77	83	5,988	75	80	5,614	73	77
65,000	8,109	87	93	7,485	83	90	6,950	80	87	6,487	77	84	6,082	75	81
70,000	8,733	90	97	8,061	86	94	7,485	82	91	6,986	79	88	6,549	77	85
75,000	9,356	93	101	8,637	88	98	8,020	84	95	7,485	81	92	7,017	79	89
80,000	9,980	95	105	9,212	90	102	8,554	86	99	7,984	83	96	7,485	80	93
85,000	10,604	98	108	9,788	93	105	9,089	89	102	8,483	86	99	7,953	83	96
90,000	11,228	100	112	10,364	95	109	9,624	91	106	8,982	87	103	8,421	84	100
95,000	11,851	103	115	10,940	98	112	10,158	93	109	9,481	89	106	8,888	86	103
100,000	12,475	106	118	11,515	100	115	10,693	95	112	9,980	92	109	9,356	88	106
105,000	13,099	107	122	12,091	102	119	11,228	97	116	10,479	93	113	9,824	89	110
110,000	13,723	110	125	12,667	104	122	11,762	99	119	10,978	95	116	10,292	91	113
115,000	14,346	112	128	13,243	106	125	12,297	101	122	11,477	96	119	10,760	93	116
120,000	14,970	114	131	13,819	108	128	12,831	103	125	11,976	98	122	11,228	94	119

Table 4-4: Typical Filter Invert Length (L_F), Width (W_F), and Area (A_{fc}) For Full Sedimentation, Rectangular EBASF Assuming Z=4:1 (H:V), T=24 hours, k=2 inches/hour, d=1.5 ft															
WQV	Hw= 3 ft			Hw= 3.5 ft			Hw= 4 ft			Hw= 4.5 ft			Hw= 5 ft		
(CF)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)	Afc (SQFT)	LF (ft)	WF (ft)
4,356	543	45	12	502	63	8	466	116	4	435	NA	NA	408	NA	NA
5,000	624	45	14	576	58	10	535	89	6	499	250	2	468	NA	NA
10,000	1,248	48	26	1,152	52	22	1,069	59	18	998	71	14	936	94	10
15,000	1,871	53	35	1,727	56	331	4,604	59	27	1,497	65	23	1,403	74	19
2,0000	2,495	58	43	2,303	59	39	2,139	61	35	1,996	64	31	1,871	69	27
25,000	23,319	62	50	2,879	63	43	2,673	64	42	2,495	66	38	2,339	69	34
30,000	3,743	67	56	3,455	66	52	3,208	67	48	2,994	68	44	2,807	70	40
35,000	4,366	70	62	4,030	69	58	3,743	69	54	3,493	70	50	3,275	71	46
40,000	4,990	74	67	4,606	73	63	4,277	72	59	3,992	73	55	3,743	73	51
45,000	5,614	78	72	5,182	76	68	4,812	75	64	4,491	75	60	4,210	75	56
50,000	6,238	81	77	5,758	79	73	5,346	77	69	4,990	77	65	4,678	77	61
55,000	6,861	85	81	6,333	82	77	5,881	81	73	5,489	80	69	5,146	79	95
60,000	7,485	88	85	6,909	85	81	6,416	83	77	5,988	82	73	5,614	81	69
65,000	8,109	9	90	7,485	87	86	6,950	85	82	6,487	83	78	6,082	82	74
70,000	8,733	94	93	8,061	91	89	7,485	88	85	6,986	86	81	6,549	85	77
75,000	9,356	96	97	8,637	93	93	8,020	90	89	7,485	88	85	7,017	87	81
80,000	9,980	99	101	9,212	95	97	8,554	92	93	7,984	90	89	7,485	88	85
85,000	10,604	102	104	9,788	98	100	9,089	95	96	8,483	92	92	7,953	90	88
90,000	11,228	104	108	10,364	100	104	9,624	96	100	8,982	94	96	8,421	92	92
95,000	11,951	107	111	10,940	102	107	10,158	99	103	9,481	96	99	8,888	94	95
100,000	12,475	108	115	11,515	104	111	10,693	100	107	9,980	97	103	9,356	95	99
105,000	13,099	111	118	12,091	106	114	11,228	102	110	10,479	99	106	9,824	96	102
110,000	13,723	113	121	12,667	108	117	11,762	104	113	10,978	101	109	10,292	98	105
115,000	14,346	116	124	13,243	110	120	12,297	106	116	11,477	102	112	10,760	100	108
120,000	14,970	118	127	13,819	112	123	12,831	108	119	11,976	104	115	11,228	101	111

If the desired WQV is not listed in Table 4-1, then W_S and L_S must be determined using the volume equation for trapezoidal basins:

$$Volume = (W \times L \times D) + (W + L) \times (Z) \times (D^2) + (4/3) \times (Z^2) \times (D^3)$$

However, Volume = WQV, W = W_S, L = L_S, and D = H_W

Also, $L_{TOP}S = 2 \times W_{TOP}S = 2 \times (W_S + 2 \times Z \times H_W) = L_S + 2 \times Z \times H_W$

Rearranging:

$$W_S(2 \times W_S + 2 \times Z \times H_W)H_W + (W_S + (2 \times W_S + 2 \times Z \times H_W)) \times Z \times H_W{}^2 + [(4/3) \times Z^2 \times H_W{}^3] - WQV = 0$$

This is in the form of a quadratic equation, and the designer can enter in the known values and solve directly for W_S. Once W_S has been calculated, L_S can be calculated using the following equation:

$$L_S = 2 \times (W_S + 2 \times Z \times H_W)$$

Substep B: Determine W_F and L_F based upon WQV

Refer to Tables 4-3 and 4-4 of this document to choose the appropriate invert width and length of the filtration chamber for the calculated WQV. If the permeability of the media, side slope of the berm, or drawdown time differs from the assumptions made for Tables 4-3 and 4-4, calculate the surface area of the filtration chamber (A_{fc}), W_F, and L_F as follows:

$$Afc = \frac{C \times WQV \times d}{[k \times T \times (h + d)]}$$

Where:

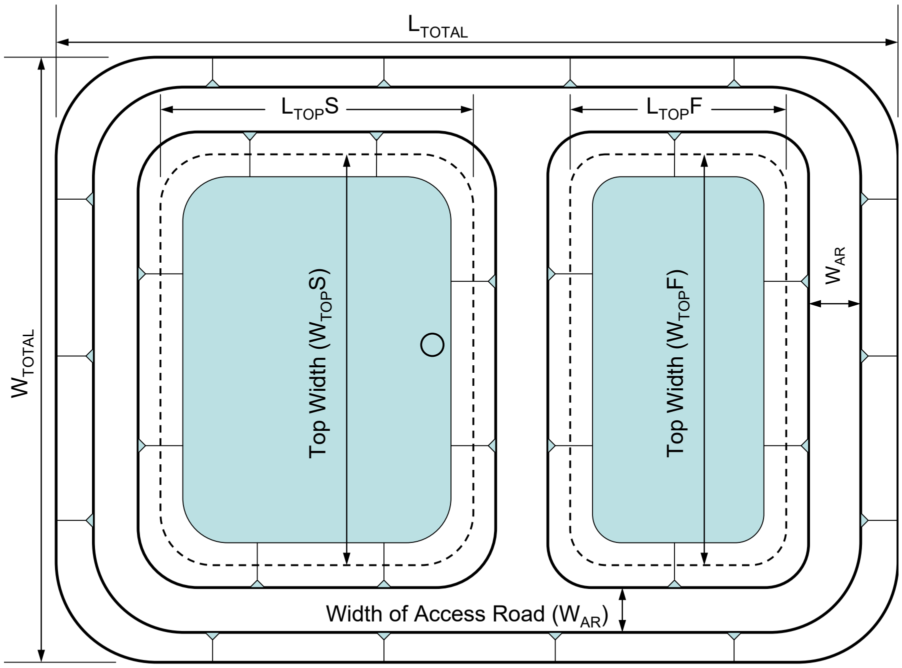
A_{fc}	=	area of filter bed in the filtration chamber, SQFT
C	=	conversion factor for units of permeability (12 inches to ft)
WQV	=	Water Quality Volume
d	=	depth of filter bed, typically about 1.5 ft
k	=	coefficient of permeability of the filtering medium, typically 2 inches/hour
T	=	design drain time for WQV, typically 24 hours
h	=	average water height above the surface of the media bed, taken as half the maximum head of the filtration chamber (i.e. 0.5 x Hw)

Since W_F = W_S, and W_S is known, the designer can now solve for L_F as follows:

$$L_F = A_{fc} / W_F = A_{fc} / W_S$$

Substep C: Determine W_{TOP} and L_{TOP}

Determine the overall lengths and widths of the two chambers as measured across the water surface at WQV (W_{TOP} and L_{TOP}).



$$L_{TOP}S = L_S + 2 \times Z \times H_W$$

Where:

$L_{TOP}S$ = length of the sediment chamber as measured across the water surface at WQV

L_S = length across the invert of the sediment chamber

Z = slope of the interior berm (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation

Similarly:

$$L_{TOP}F = L_F + 2 \times Z \times H_W$$

Where:

$L_{TOP}F$ = length of the filtration chamber as measured across the water surface at WQV

L_F = length across the invert of the filtration chamber

Z = slope of the interior berm (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation

The widths at the WQV surface elevation may also be calculated as follows:

$$W_{TOP}S = W_S + 2 \times Z \times H_W$$

Where:

$W_{TOP}S$ = width of the sediment chamber as measured across the water surface at WQV

W_S = width across the invert of the sediment chamber

Z = slope of the interior berm (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation

And:

$$W_{TOP}F = W_F + 2 \times Z \times H_W$$

Where:

$W_{TOP}F$ = width of the filtration chamber as measured across the water surface at WQV

W_F = width across the invert of the filtration chamber

Z = slope of the interior berm (H:V)

H_W = Design Water Depth inside the EBASF from surface of media material in filtration chamber to WQV elevation

Substep D: Determine W_{FREE} and L_{FREE}

Determine the lengths and widths of the two chambers as measured across the freeboard elevation.

$$L_{FREE}S = L_{TOP}S + 2 \times Z \times (FB + N)$$

Where:

$L_{FREE}S$ = length of the sediment chamber as measured across the water surface at the freeboard elevation

LTOPS = length across the sediment chamber at the WQV elevation

Z = slope of the interior berm (H:V)

FB = Freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), typically 1 foot for the purpose of this document

Similarly:

$$L_{FREE}F = L_{TOP}F + Z \times (FB + N)$$

Where:

$L_{FREE}F$ = length of the filtration chamber as measured across the water surface at the freeboard elevation

$L_{TOP}F$ = length across the filtration chamber at the WQV elevation

Z = slope of the interior berm (H:V)

FB = freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), typically 1 foot for the purpose of this document

The widths at the freeboard elevation may also be calculated as follows:

$$W_{FREE}S = W_{TOP}S + 2 \times Z \times (FB + N)$$

Where variables are as defined above plus:

$W_{FREE}S$ = width of the sediment chamber as measured across the water surface at the freeboard elevation

$W_{TOP}S$ = width of the sediment chamber as measured across the water surface at WQV

And for the filtration chamber:

$$W_{FREE}F = W_{TOP}F + 2 \times Z \times (FB + N)$$

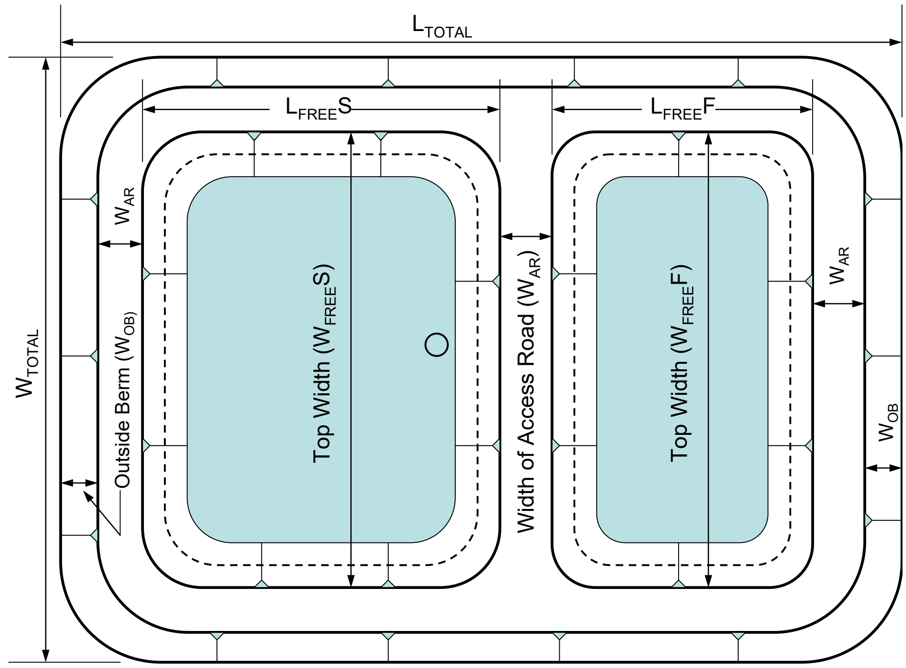
Where variables are as defined above plus:

$W_{FREE}F$ = width of the filtration chamber as measured across the water surface at the freeboard elevation

$W_{TOP}F$ = width of the filtration chamber as measured across the water surface at WQV

Substep E: Determine W_{TOTAL} and L_{TOTAL}

Determine the overall length of the EBASF as measured from toe of outside berm to toe of outside berm.



$$L_{TOTAL} = L_{FREE}F + L_{FREE}S + 2 \times W_{OB} + 3 \times W_{AR}$$

Where:

$L_{FREE}S$ = length of the sediment chamber as measured across the water surface at the freeboard elevation

$L_{FREE}F$ = length of the filtration chamber as measured across the water surface at the freeboard elevation

W_{OB} = width of the outside berm

W_{AR} = width of the access road

Similarly, the overall width of the EBASF as measured from toe of outside berm to toe of outside berm may be calculated using the following equation:

$$W_{TOTAL} = W_{FREE}F + 2 \times W_{OB} + 2 \times W_{AR}$$

Where:

$W_{FREE}F$ = length of the filtration chamber as measured across the water surface at the freeboard elevation

W_{OB} = width of the outside berm

W_{AR} = width of the access road

4.2 Non-Rectangular Configurations

The equations above are presented for standard, rectangular basin configurations. Non-rectangular configurations may be considered by the PE and one design option could be to use equivalent areas. Using equivalent areas, the non-rectangular design would provide a sediment chamber invert area (A_s) equivalent to the areas shown in Tables 4-1 and 4-2. The design would provide a filter area (A_{fs}) equivalent to the areas shown in Tables 4-3 and 4-4. For use of a non-rectangular design configuration, see Section 8.3.

4.3 Check EBASF Footprint

The footprint should be checked versus the site plan to verify that the size and placement are feasible.

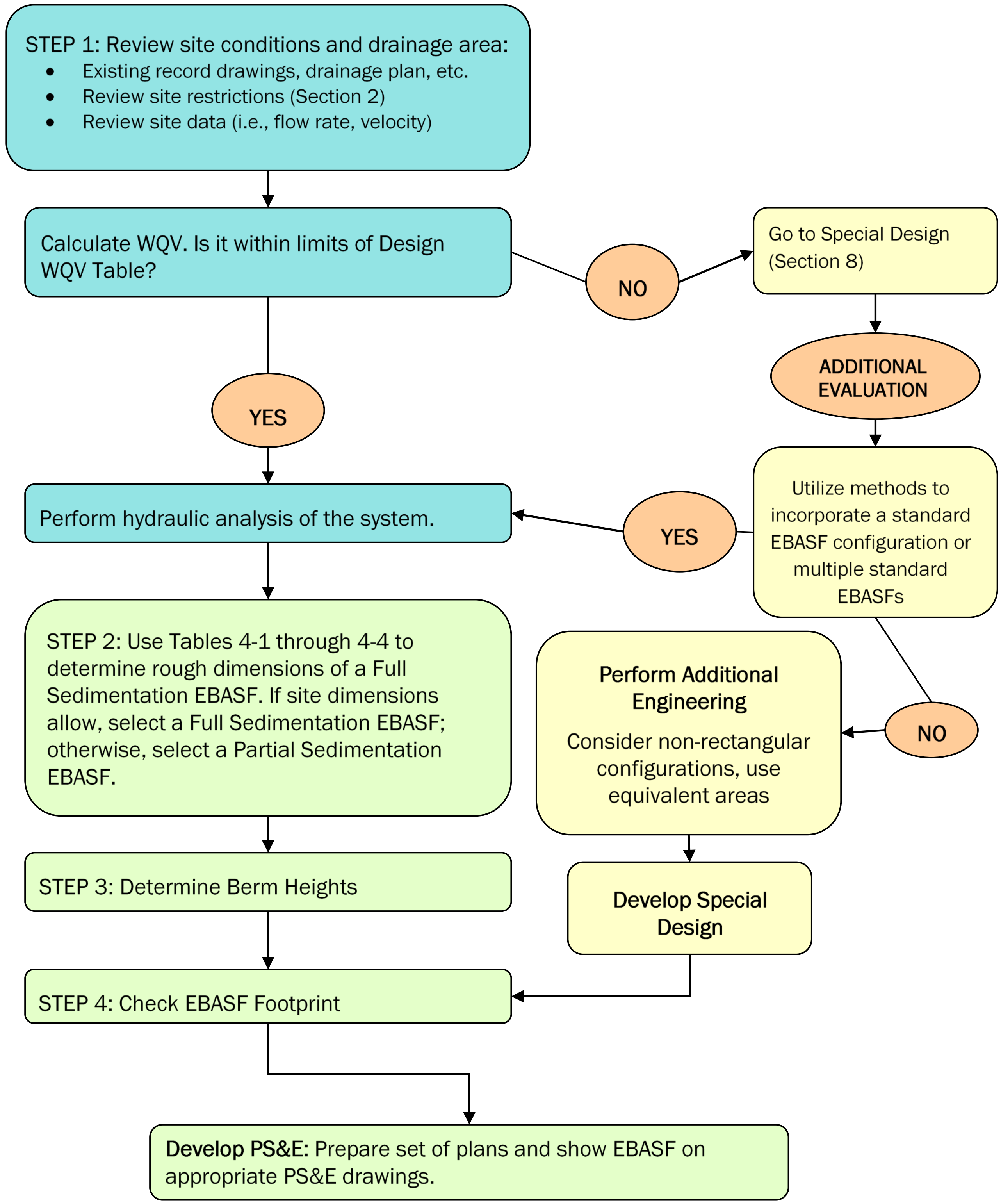


Figure 4-1: Typical EBASF Selection Flowchart

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Section 5

BMP Layout and Design

This section discusses various considerations needed to place an EBASF within the project, including layout, space and construction requirements, and detailing of the conveyances carrying runoff into and away from the devices.

5.1 Layout

The layout of the EBASF is set by positioning the device relative to the direction of the incoming flow, and by adhering to the limitations of the EBASF design. The layout of the EBASF must consider the structure's footprint "out-to-out" earthen berm dimensions compared to the available site footprint, as well as the existing inlet and outlet drain pipe layout compared to the EBASF requirements.

5.2 Space Considerations

EBASFs require sufficient space and access for maintenance and inspection, including the use of vacuum trucks and other equipment for cleaning and media replacement.

The site area must be able to accommodate the EBASF structure and should be verified by checking the structure dimensions using the "out-to-out" earthen berm dimensions. The proposed EBASF locations are to be verified with District Maintenance to confirm the space and access availability for maintenance and inspection of the structure.

The EBASF should be located outside the CRZ; otherwise consult with District Traffic Operations to determine if guard railing is required.

5.3 Site Requirements and Restrictions

Successful implementation and utilization of EBASFs will require coordination with District Hydraulics and will depend on proper siting of the devices. Therefore, it is important to take note of siting requirements and restrictions when designing the EBASF, particularly for retrofit applications. For conditions resulting in design criteria values outside the range of values presented in Table 2-1, see Section 8 of this document.

EBASFs should generally be sited in an unobstructed location that can be easily accessed by maintenance vehicles, and the entire structure should be above seasonally high groundwater. The footprints of the approved EBASFs and space considerations are discussed in Sections 3 and 5, respectively. The following three major restrictions listed in the following subsections should be considered during the EBASF selection, siting, and sizing process.

5.4 Inlet and Outlet Pipe Diameter Restrictions

In general, the inlet and outlet diameters of the EBASF should match those for the existing influent and effluent stormwater pipes for the site. However, if the existing influent stormwater pipe causes a velocity greater than 8.0 fps, which is high enough to overturn a gabion wall, the PE should consider reducing the velocity at the inlet by enlarging the pipe diameter or by installing energy dissipating baffles in the sediment chamber. Such devices are considered site-specific and would require additional detailing or possibly a Special Design.

5.5 Vegetation of Invert and Side Slopes

Vegetation should be placed in the first chamber to help capture sediment, to minimize erosion within the chamber, and for aesthetics purposes. As a guide, up to 10% of the area could be planted with bunch grasses while the remaining area planted with turf grasses, but the PE should consult with the District Landscape Architecture and District Maintenance for concurrence.

The filter media of the second chamber should not be vegetated, but the side slopes may be vegetated with turf grass. As research is on-going regarding allowed vegetation in TBMPs, the PE should contact OHSD if this option is under consideration.

5.6 Contaminants

An impermeable liner should be inserted below the gravel layer if there is a contaminant plume below the proposed site of the EBASF. Otherwise, no liner is required. Infiltration through the BMP invert is not considered when designing the underdrain system.

Section 6

Design Elements

Certain supplemental structures and devices may be required in the construction of EBASFs. The supplemental design elements are discussed in detail in the Supplemental Details Design Guidance. It is the PE's responsibility to determine which of the EBASF supplemental design elements are required for a specific site.

6.1 Maintenance

Discuss proposed EBASF location and access with the District Maintenance Stormwater Coordinator, as maintenance is critical to these devices. Coordinate with District Maintenance Stormwater Coordinator on maintenance access to the overflow spillway and around the entire perimeter of the EBASF. Additionally, a ramp to the basin invert and an alternative method of draining the EBASF should be considered.

6.2 Design Storm

Both storm volume and peak flow conditions must be considered in the evaluation of runoff conditions. The Design Storm is the event that generates runoff rates or volumes that the drainage facilities are designed to handle (see HDM, Topic 831). For this guidance manual, the term Design Storm is used in reference to designing drainage facilities and refers to the peak drainage facility design event as determined in accordance with the HDM[4].

6.3 Overflow Events

It is preferred that the EBASF be designed offline, where flows exceeding those associated with the WQV are diverted around the EBASF through an upstream flow splitter. When a flow splitter is not feasible, the EBASF may be designed inline, where flows are designed to travel through the EBASF with release through an overflow device.

Even in an offline configuration, all EBASFs must be equipped with an overflow device sized to accommodate the Design Storm flows in case clogging of the upstream flow splitter or other unusual condition occur. The overflow structure may be in the form of an overflow spillway or riser, located at the downstream end of

[4] For convenience in this document, the Design Storm flow is referred to as Q_{25}. However, other recurrence intervals may have been used for the roadway drainage design, as described in HDM Chapter 830, Transportation Facility Drainage; confer with District Hydraulics.

the filtration chamber. The overflow event used in the design of the spillway must be consistent with the intensity, duration, and frequency of the Design Storm used for the roadway drainage design for that CDA generating runoff to the EBASF. The overflow device shall meet the design criteria and be accompanied with downstream conveyance engineered to handle the Design Storm flow. In addition, a minimum freeboard of 12 inches should be provided between the surface water elevation during the overflow event and the lowest elevation of the confinement in order to provide assurance of the physical integrity of the TBMP and downstream facilities.

6.4 Overflow Spillways

EBASFs may be equipped with an overflow spillway, located in either chamber, designed to safely handle flows associated with the Design Storm flow (see Section 6.2). Overflow spillways are broad-crested weirs intended to control the location where the flows would overtop the basin perimeter in order to avoid structural damage to the embankment, and to direct the flows into the downstream conveyance system or other applicable discharge point. Minimum spillway length is 3 ft and is measured perpendicular to flow. Details of overflow spillways and their design parameters can be found in Section 5 of the Supplemental Details Design Guidance.

6.5 Overflow Risers

Overflow risers are vertical pipes that act as sharp-crested weirs designed to pass flows in excess of the WQV and are similar in structure to water quality outlet risers except that the flow is not regulated. Minimum riser pipe diameter should be 3 ft (for maintenance reasons). Overflow risers are used when overflow spillways are not practical and can be placed in either chamber of the EBASF. Details of overflow risers can be found in Section 8 of the Supplemental Details Design Guidance.

6.6 Flow Splitters

Flow splitters are upstream drainage bifurcation structures designed to direct water quality flows to EBASFs and to divert peak flows. Using a flow splitter minimizes scouring of previously deposited materials within the basin. Possible conditions requiring the implementation of a flow splitter in conjunction with an EBASF are listed below:

- Backwater effect in the EBASF
- Large peak storm effects
- Inlet pipe elevation constraints
- Available capacity of overflow discharge pipe connection
- Downstream effects of an overflow spillway

A detailed hydraulic analysis will be required to properly size and design the flow splitter structure, which is covered in the Flow Splitters Design Guidance (Caltrans 2020d).

6.7 Excessive Flows

In addition to implementing flow splitters as described above, in cases where the WQV of a drainage area would require an EBASF footprint larger than what is available, consider either requesting a smaller WQV event depth from the Regional Water Quality Control Board or splitting a large drainage area into sections and using additional EBASFs in series or in parallel arrangements. However, this may result in operational issues, and the preferred method would be the placement of a single EBASF to serve an entire tributary area.

6.8 Upstream Effects

While EBASF are placed for water quality purposes, they must also operate safely and effectively as part of the overall highway drainage system. Hydraulic design issues must be carefully evaluated during the design process. The BMP placement and design must consider the design of the roadway drainage system. The Design Storm must be determined and the associated hydraulic grade lines calculated to ensure that placement of the device does not impede the effective drainage of the roadway. Additional discussion of those analyses is beyond the scope of this document. Consult with District Hydraulics.

6.9 Potential Downstream Impacts

Potential downstream impacts must be considered. Placement of this or any other TBMP must not cause objectionable headwater or violate requirements of Chapter 800 of the HDM. Specific consideration of the overall placement within a particular drainage system is beyond the scope of this document and should be coordinated with District Hydraulics.

6.10 Underdrain System

Typical underdrain systems consist of perforated underdrain pipe, surrounded by permeable material, and covered by a geotextile material. The underdrain system conveys treated runoff to the downstream discharge while allowing infiltration through native soil, as applicable.

6.11 Litter and Trash Considerations

Caltrans has developed a Statewide Trash Implementation Plan (Plan; Caltrans 2019c) to prevent the discharge of trash to surface waters through stormwater discharges. The Plan identifies statewide Significant Trash Generating Areas (STGAs) requiring consideration of full trash capture BMPs.

Full trash capture should be included in the design of an AVSF within a watershed where any of the following exists:

1. A Total Maximum Daily Load (TMDL) restriction for trash
2. Discharges to a 303(d) listed waterway for trash
3. Has been identified as an STGA
4. Required by a Regional Basin Plan

The AVSF is a Caltrans approved treatment device that can be certified as a multi benefit full trash capture BMP. The full-capture volume is calculated using the 1-year, 1-hour storm event depth. Refer to the Multi Benefit Treatment BMP Trash Full Capture Requirements Design Guide (Caltrans 2018) for specifics on design details.

Additionally, the PE may include a pretreatment device to capture the gross solids (e.g., paper, plastics, glass) and naturally occurring debris that may be conveyed by stormwater to the AVSF. The device should be designed to remove all litter and solids 5 mm and larger. This pretreatment can be provided by the Caltrans approved Gross Solids Removal Devices (GSRDs) TBMP or other devices that meet the requirements for full trash capture.

Use of other devices requires a detailed design by the PE and must be coordinated with the District/Regional Design Stormwater Coordinator, District Hydraulics, Traffic Safety, District Maintenance Stormwater Coordinator, and OHSD, as appropriate. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required. Design decisions and coordination on the trash device must be documented in the SWDR.

6.12 Sediment Forebays

A sediment forebay is a pretreatment device for EBASFs that is located in areas where moderate to high sediment and/or debris loads are anticipated. It provides a separate area where larger particles settle out before they accumulate in the EBASF. By isolating the sediment and debris, EBASF maintenance is facilitated, and the longevity of the EBASF is extended. The PE should coordinate the design and installation of sediment forebays with Maintenance and the District/Regional Design Stormwater Coordinator. Details of sediment forebays can be found in Section 11 of the Supplemental Details Design Guidance.

6.13 Anti-Seep Collars

Anti-seep collars prevent water from seeping around the outside of an underground pipe, and thus effectively protect the pipe from failure due to loss of bedding caused by subsurface water flow. Anti-seep collars are generally recommended for use in and around detention basins and berms holding stormwater and when pipe slopes exceed 10%. Collars are installed along pipes at the recommended size and spacing. Connections between the pipe and the collars should be watertight, specifically in areas of high groundwater, and the collars should be constructed against undisturbed or compacted embankment material. Details of anti-seep collars can be found in Section 2 of the Supplemental Details Design Guidance.

6.14 Water Quality Outlet Risers

For Full Sedimentation EBASFs, the water quality outlet riser is the primary outlet structure for discharging flows from the sediment chamber to the filtration chamber. Design the riser to allow for complete drawdown of the accumulated WQV in no more than 24 hours. The discharge is regulated by orifices with a minimum size of 0.5 inch. Orifice sizing should be accomplished using the procedures outlined in Section 3.2 of the Detention Basins Design Guidance.

The structure should have a debris rack or other acceptable means of preventing clogging at the entrance of the outflow pipes. Details of this rack, and all views and details of water quality outlet risers can be found in Section 9 of the Supplemental Details Design Guidance.

6.15 Low Flow Channels

Low flow channels are hard surface channels (e.g., concrete) constructed along the bottom of EBASFs to convey low flow runoff and/or base flow directly from the inlet to the outlet without erosion. The low flow channel also prevents standing water from accumulating within the device after a storm event. Channel cross sections can be trapezoidal or triangular (i.e., V-ditch). Low flow channels are designed to be mounted and crossed by maintenance equipment and vehicles. Details of low flow channels can be found in Section 7 of the Supplemental Details Design Guidance.

6.16 Maintenance Drain Valves

Maintenance drain valves are outlet mechanisms for draining an EBASF in the event that the outlet pipe becomes clogged. The maintenance drain valve should be accessible from a location outside the EBASF to allow for maintenance personnel to operate the valve in wet conditions without having to enter into the water storage area. If there is a pipe between the basin and the drain valve, the slope of the pipe should be a minimum of 2% to minimize sediment buildup at the valve. The valve-pipe connections should be watertight, and the valve box containing the valve operator should be designed to support traffic loads. Maintenance drain valve details can be found in Section 4 of the Supplemental Details Design Guidance.

6.17 Maintenance Access Ramps

Vehicle access should be provided around the EBASF to adequately and safely allow access to all structures and devices located within the basin area. Maintenance access ramps must be located within Caltrans right-of-way or within a maintenance easement and must be able to accommodate vehicles of various types and sizes to cover routine visits; maintenance access ramps must also allow for trash and debris removal, possibly using a backhoe and a truck. Details of maintenance access ramps can be found in Section 10 of the Supplemental Details Design Guidance.

Section 7

PS&E Preparation

This section provides guidance for incorporating EBASFs into the PS&E package, discusses typical specifications that may be required, and presents information about estimating the construction costs.

While every effort has been made to provide accurate information here, the PE is responsible for incorporating all design aspects of EBASFs into the PS&E in accordance with the requirements of Section 2 of the Construction Contract Development Guide (Caltrans 2019d).

7.1 PS&E Drawings

Standard drawings and details have not been developed by OHSD for an EBASF, so the PE is responsible for incorporating the design into the PS&E in accordance with the procedures typically followed when developing a PS&E package. For example, the applicable layout, grading, drainage, and detail sheets should be updated to reflect the required design features of the EBASF.

The PS&E drawings for most projects having EBASF may include:

- Layout(s): Show location(s) of the EBASF. This is a recommended option, as its use will aid in recognizing, both within and outside Caltrans, that EBASF were placed within the project limits.
- Grading or Contour Grading Plan(s): As EBASFs are primarily earthwork features they should be shown on Contour Grading sheets or grading plans. Other associated grading surrounding the EBASF should be shown on these sheet(s).
- Drainage Plan(s), Profiles, Details, and Quantities:
  - Drainage Plan sheets should show each EBASF in plan view, along with other existing and proposed drainage conveyance devices that direct the runoff into the device and overflow from the device.
  - Drainage Profile sheets should show the EBASF in profile within the drainage conveyance system. These sheets should also call out the specific EBASF inlet and outlet flow line (surface) elevations and invert elevation.
  - Drainage Detail sheets should show inflow and outflow detailing, including the overflow release device, and any other detailing needed for the construction of the EBASF not provided elsewhere in the contract plans (e.g., under Construction Details).
  - Drainage Quantity sheets should include all pay and non-pay items associated with the construction of the EBASF, except for those items that will be placed on the Summary of Quantities sheets.

- Planting Plans/Erosion Control Plans: These sheets are used to show vegetative portion of the BMP if needed. Planting quantities (e.g., hydroseed) for each EBASF should be provided.
- Temporary Water Pollution Control Plans: These sheets are used to show the temporary BMPs used to establish the EBASF BMPs and compliance with the Construction General Permit.

7.2 Specifications

Contract specifications for projects that include EBASFs will include a combination of Standard Specifications, Standard Special Provisions (SSPs), and may include non-Standard Special Provisions (nSSPs). In some cases, specific nSSPs have been developed by OHSD.

Special provisions for the various items of work needed to construct the EBASF could be organized under an umbrella 'EBASF' nSSP with the required items listed as subheadings. Payment would be made for by 'each' EBASF.

Optionally, separate listings could be made for each contract item of work, with separate measurements and payments. The PE and the District Office Engineer should consider which method would better serve the project.

7.2.1 Standard Specifications

Standard Specifications are to be used for a project that constructs an EBASF. Consider the construction of the EBASF in the context of the entire project to determine what Standard Specifications are applicable. Within the Standard Specifications, these are the sections that will typically be applicable:

13 Water Pollution Control

15 Existing Facilities

17 General (Earthwork and Landscape)

19 Earthwork

20 Landscape

21 Erosion Control

26 Aggregate Bases

39 Asphalt Concrete

40 Concrete Pavement

61 Drainage Facilities- General

64 Plastic Pipe

65 Concrete Pipe

66 Corrugated Metal Pipe

68 Subsurface Drains

70 Miscellaneous Drainage Facilities

71 Existing Drainage Facilities

72 Slope Protection

73 Concrete Curbs and Sidewalks

80 Fences

96 Geosynthetics

7.2.2 Standard Special Provisions

SSPs may be included for a project that constructs an EBASF. Additional SSPs may be required depending on the types of appurtenant facilities and materials proposed for the project. The listed SSP section numbers are presented to assist in preparing the Contract Special Provisions. Consult the current index of SSPs available on the Office of Construction Contract Standards section of the Caltrans website. Each SSP topic should also be examined in the context of the entire project to determine if other SSPs are needed to completely specify the proposed work.

7.2.3 Non-Standard Special Provisions

A project that constructs an EBASF may require nSSPs so the PE can assure the design assumptions are constructed properly in the drainage system. The PE and PDT should decide the most appropriate specifications for the site-specific conditions to meet other goals in the HDM for safety. OHSD can provide nSSPs to support the design. nSSPs may be required when standard specifications are insufficient to address all the design and construction needs for the project.

7.3 Project Cost Estimates

Project Cost Estimates are required at every phase of the project – Project Initiation Document (PID), Project Approval/Environmental Document (PA/ED), and PS&E. The Caltrans Division of Design, Office of Project Support has developed the following website to assist in the development of cost estimates:

http://www.dot.ca.gov/design/pjs/index.html

This website includes links to Chapter 20 Project Development Cost Estimates of the Project Development Procedures Manual and Caltrans Cost Estimating Guidelines. In addition to Chapter 20, this website includes other useful cost estimating information on project cost escalation, contingency and supplemental work, and cost estimating templates for the planning and design phases of the project. These templates may be used to track estimates relating to costs for incorporating TBMPs.

7.3.1 PID and PA/ED Phases

A preliminary cost estimate, Project Planning Cost Estimate (PPCE), is required as an attachment of the SWDR during PID phase of the project. A refined version of the PPCE is developed in PA/ED phase. For details on what needs to be included in PPCE, refer to PPDG Section 6.4.9 and Appendix F. This estimate will need to be modified as the project progresses. If some design is conducted during the PA/ED phase of the project, it is possible that a more refined estimate could be made using the methods in Section 7.3.2. A cost escalation should be added for projects that are anticipated to advertise more than a year after the date of the estimate.

7.3.2 PS&E Phase

Preliminary Engineer's Cost Estimates (PECE) are initiated at the beginning of PS&E and are updated until the completion of PS&E phase of the project. PECEs focus on the construction costs of the project and the permanent BMPs and are inputs to the Basic Engineering Estimating System (BEES). Verify the quantities for inclusion in the project cost estimate to identify which should be considered Final Pay items, and to determine appropriate unit prices for each. Develop all necessary earthwork quantities for each specific EBASF location.

7.4 Developing EBASF Cost Estimates

Develop a quantity-based cost estimate, regardless of availability of specific unit cost or quantity data. As the design process proceeds, the project cost estimate should be updated as new data becomes available. Identify the contract items required to construct the EBASF. A challenging aspect of developing a cost estimate is determining the BMP limits of work. Only costs for work exclusively used to construct the TBMP should be included in the estimate.

It may not be necessary to include costs for items that support the TBMP. For example, utility relocation, maintenance vehicle pullouts, traffic safety items, drainage systems, or other site design elements that are required for the project even if the TBMP was not needed. Include the costs for these items when they are exclusively required for the TBMP.

Table 7-1 includes typical contract items that may be included in the unit cost (CY and FT) estimate if they are required for the EBASF. Table 7-1 is not a complete list and must be modified on a project specific basis to accommodate all aspects of design.

Table 7-1: Example EBASF Estimate					
Contract Item	Type	Unit	Quantity	Price	Amount
Clearing and Grubbing		LS			
Roadway Excavation		CY			
Gabion		CY			
Permeable Material		CY			
Class D Filter Fabric		SQYD			
Miscellaneous Metal		LB			
6" Perforated Plastic Pipe Underdrain		LF			
6" Non-perforated Plastic Pipe Underdrain		LF			
Storage Cell Media		SQFT			
Joint Seal (Type AL)		LF			
Erosion Control (Dry Seed)		SQFT			

When developing costs based on unit quantities, the unit costs should be based upon the most recent Caltrans Contract Cost Data Book, and District 8 Cost Data Base for current similar projects.

https://sv08data.dot.ca.gov/contractcost/

Use the project specifications, SSPs, and nSSPs to develop a list of items for which unit costs should be supplied. Carefully check that all items of work are accounted for either as pay or non-pay items.

Estimate the total cost of each EBASF used on the project for tracking TBMP costs at PS&E. Document all BMP costs in the project SWDR at PS&E.

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Section 8

Special Designs

This section provides guidance for situations where the specific project requirements do not meet the design parameters specified in Sections 2 and 3. The following recommendations are provided as alternatives to expand the applicability of the EBASFs beyond the range of the standard design criteria. Note that any of the following design approaches may require additional engineering, such as a structural and hydraulic analysis.

8.1 Alternative Filter Media

If alternative filter bed media, such as sand and peat, is being proposed, consult with DEA and OHSD for approval or to determine if a Special Design or pilot is required.

8.2 Alternative BMP Sizing

The EBASF sizing calculations in this guidance are intended for standard designs under normal conditions with typical external loading requirements, and have prescriptive, rectangular configurations. Alternative calculations may be generated by the PE for a specific project to refine the BMP size. One alternative may be to use the California Stormwater Quality Association (CASQA) TC-40 methodology (CASQA 2003). The TC-40 includes the following rule-of-thumb for sizing the filter area (A_{fc}):

If the filter is preceded by a sedimentation basin that releases the WQV to the filter over 24-hours, then the minimum average surface area for the sand filter is:

$$A_{fc} = WQV/18$$

If no pretreatment is provided, then the minimum average surface area for the sand filter is:

$$A_{fc} = WQV/10$$

Additionally, the calculations in this guidance assume instantaneous runoff to the BMP (i.e., 'slug-flow') which does not consider active treatment during the event, leading to conservative sizing designs. A sizing alternative to account for timing of runoff is to perform rainfall-runoff and unsteady-flow storage routing computations for the BMP. When the runoff is distributed over the duration of an event, early-event runoff can be treated and released before the peak runoff arrives. Using these calculations, the BMP does not need to be sized to store the entire runoff volume at once (i.e., 'slug-flow'), leading to smaller designs. By accounting for active treatment occurring during the event, an increase in the treated WQV listed in Tables 4-1 to 4-4 is possible depending on media filter area available. For the example shown in Figure 8-1, with a media filter area of 1,500 ft^2 a 72 percent increase of treated WQV was observed.

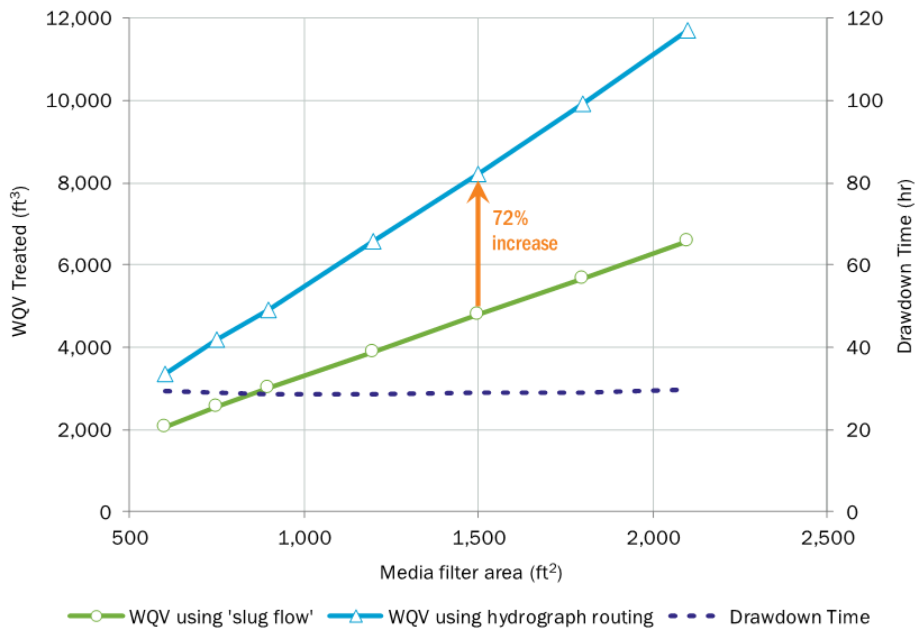


Figure 8-1. Maximum WQV Treated

Figure 8-1 shows an example calculation comparing treated WQV using the 'slug flow' method vs the hydrograph routing method. The WQV increase is the additional WQV treated by the same size BMP using an unsteady-flow routing method. Figure 8-1 also shows the drawdown time which remained relatively constant because the filter area increased proportionally with increasing volume, and the percolation rate was held constant. Details of this methodology and findings are discussed in the Review of Design Guidance for Sizing Media Filters for Stormwater Quality Treatment (Caltrans 2019e).

Additionally, when an infiltrative BMP is installed in a Type A or Type B soil the BMP footprint can be reduced while treating the same WQV. The following figure shows an example of how accounting for active treatment and native soil type using the Caltrans Infiltration Tool IT4 tool impacts BMP size. The example shows that in a Type A soil a BMP can be 60% smaller than if it were installed in Type C or Type D soils.

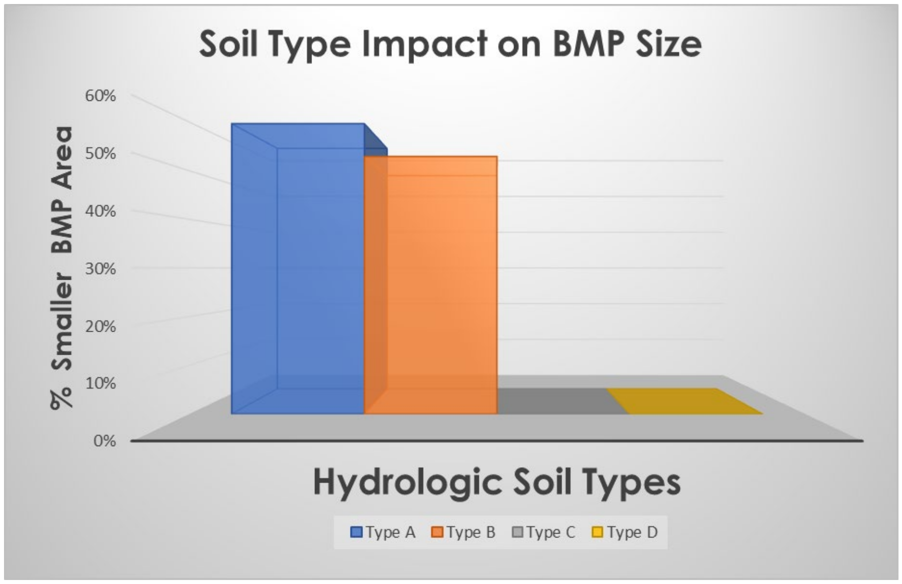


Figure 8-2. BMP Size Reduction Based on Soil Type

Alternative calculations may be used by the PE for a specific project and must be developed by a qualified professional in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required.

8.3 Alternative Configuration

The EBASF configurations in this guidance are intended for standard designs under normal conditions with typical external loading requirements, and have prescriptive, rectangular configurations. This BMP can utilize non-rectangular configurations to accommodate site conditions provided that other design criteria are met. When non-rectangular configurations are used, the PE can consider sizing the BMP using an equivalent filter bed invert area and equivalent chamber invert area. Alternative configurations must be designed by a qualified professional in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required.

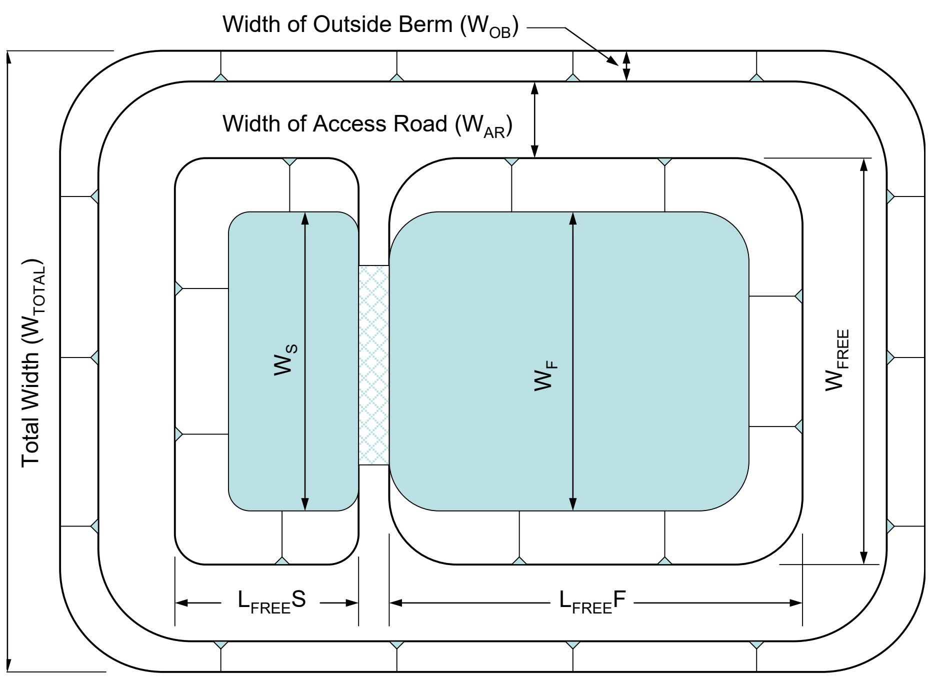
8.4 Corrosive Environments

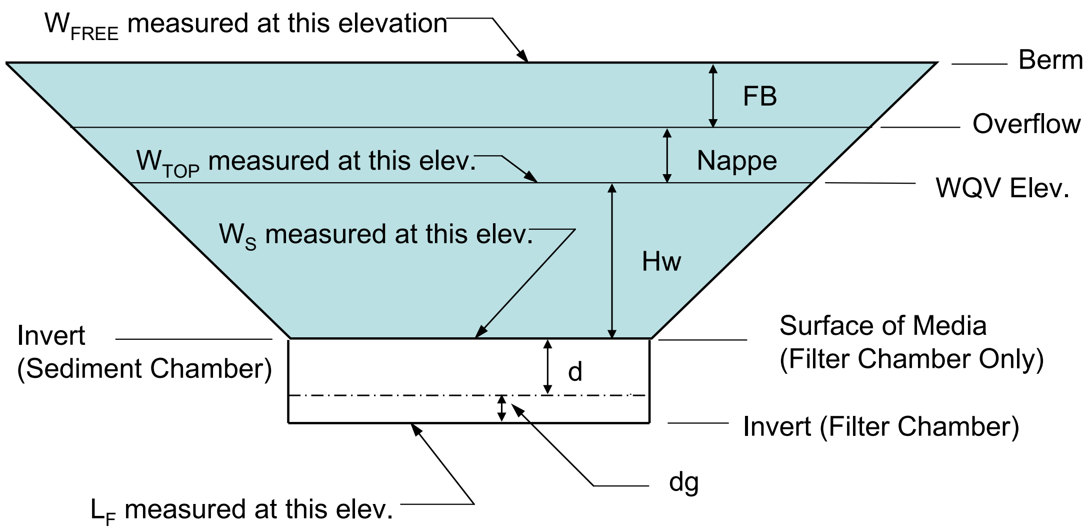
Per Chapter 850, Topic 852 of the HDM, metal pipes and arches, reinforced concrete pipe, box, and arch culverts, non-reinforced concrete pipe culverts, and plastic pipes all have a design service life with respect to corrosion. Design service life is defined as the expected maintenance free service life of each installation. When siting an EBASF, if the location is determined to be in a corrosive environment, a Special Design is required to protect the components of an EBASF that consist of any of the materials above, and to assure that maintenance free service life is achieved.

Section 9

Design Example – Partial Sedimentation

This section presents an example on how to implement the procedure presented in Section 4 for a Partial Sedimentation, Rectangular EBASF design. The sample layout and section view shown below applies to the calculations presented in this section.





The design parameters for this site are as follows:

- WQV = 10,000 CF;
- The footprint of the available site adjacent to the highway is 132 ft wide by 300 ft long;
- Depth-to-groundwater is 15.5 ft from original ground (OG);
- Top of berm is at OG.

9.1 Chamber Dimensions

Step A: Review Site Conditions and Restrictions, Determine W_{TOTAL} and H_W:

Review the site conditions to ensure that none of the site restrictions that are discussed in Section 2.2 are present, and to confirm that there is available unobstructed area for placement of the EBASF. The maximum available width has been determined to be 132 ft, and the following dimensions need to be subtracted from the maximum available width to determine W_{TOTAL}:

- 30-ft CRZ (unless guard rail installed)
- 10-ft setback from back boundary line[5]

Subtracting these two dimensions:

$$W_{TOTAL} = 132 - 30 - 10$$ **W_{TOTAL} = 92 ft**

Since depth-to-groundwater is 15.5 ft, and the minimum separation from invert of the sediment chamber to groundwater is 5 ft for an EBASF, allowing for 1 foot of

[5] Per HDM Topic 304.2, when feasible, at least 15 ft should be provided as a setback.

freeboard and a 1-foot overflow depth results in a maximum H_w of 15.5 – 5 – 1 – 1 = 8.5 ft. Choose **H_w = 3 ft** to match proposed storm drain flow lines.

Step B: Determine W_{FREE} for the Sedimentation Chamber, $W_{FREE}S$:

Determine outside berm slope width (W_{OB}) and choose width of access road (W_{AR}). Subtract the horizontal width of the outside berm and the width of the access road to determine W_{FREE}. Set height of outside berm to be 1 foot above O.G.[6], and use a 3:1 (H:V) slope. W_{OB} would then be:

$$1.0(ft) \times 3(ft/ft) = 3 \text{ ft}$$

Maintenance preference is to have the width of access roads, W_{AR}, to be 12 ft[7]. Therefore, W_{FREE} may be calculated as:

$$W_{FREE}S = W_{TOTAL} - 2 \times W_{OB} - 2 \times W_{AR} = 92 - (2 \times 3) - (2 \times 12)$$ **$W_{FREE}S$ = 62 ft**

Step C: Determine $W_{TOP}S$:

Calculate the width across the basin at the water surface elevation of the sediment chamber:

$$W_{TOP}S = W_{FREE} - 2 \times Z \times (FB + N)$$

Choose:

Z = 3:1 (H:V)

FB = Freeboard, 1 foot

N = nappe of flow over weir during overflow event, 1 foot

Therefore:

$$W_{TOP}S = 62 - 2 \times 3 \times (1 + 1)$$ **$W_{TOP}S$ = 50 ft**

Step D: Determine W_S:

Next, determine the invert width of the sediment chamber:

$$W_S = W_{TOP}S - 2 \times Z \times H_W$$

Known:

$W_{TOP}S$ = width across the basin at the water surface elevation of the sediment chamber, 50 ft

Z = 3:1 (H:V)

[6] If the EBASF is set entirely below ground, proceed to Step D.

[7] If right-of-way is limited, the use of an access road on only one side of the EBASF can be considered, if approved by District Maintenance.

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation, 3 ft

Therefore:

$$W_S = 50 - 2 \times 3 \times 3.0$$ **W_S = 32 ft**

Step E: Determine W_F:

Determine the width of the filtration chamber invert. Since there are no extenuating site conditions, W_F is set equal to W_S.

W_F = 32 ft

Step F: Determine L_S:

Determine the length across the invert of the sediment chamber using the formula provided in Section 4:

$$L_S = \frac{0.2 \times WQV - 0.5 \times W_S \times Z \times H_W{}^2 - 0.67 \times Z^2 \times H_W{}^3}{(W_S \times H_W) + (Z \times H_W{}^2)}$$

Where:

L_S = length across the invert of the sediment chamber, ft

WQV = Water Quality Volume, 10,000 CF

W_S = width across the invert of the sediment chamber, 32 ft

Z = slope of the interior berm, 3:1 (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation, 3 ft

$$L_S = \frac{0.2 \times 10{,}000 - 0.5 \times 32 \times 3 \times 3^2 - 0.67 \times 3^2 \times 3^3}{(32 \times 3) + (3 \times 3^2)}$$

Solving, L_S = 11.4 ft. Round up to 12 ft. **L_S = 12 ft**

Step G: Determine L_F:

Determine the length across the invert of the filtration chamber using the formula provided in Section 4 such that the EBASF meets the minimum volume requirement:

$$L_F = \frac{0.8 \times WQV - 0.5 \times W_F \times Z \times H_W{}^2 - 0.67 \times Z^2 \times H_W{}^3}{[0.35 \times W_F \times (d + dg)] + (W_F \times H_W) + (Z \times H_W{}^2)}$$

Where the variables are as listed for L_S and:

d = depth of filter media (i.e. sand, typically 1.5 ft)

dg = depth of collector (i.e. gravel) layer, typically 1 foot

Therefore:

$$L_F = \frac{0.8 \times 10{,}000 - 0.5 \times 32 \times 3 \times 3^2 - 0.67 \times 3^2 \times 3^3}{[0.35 \times 32 \times (1.5 + 1.0)] + (32 \times 3) + (3 \times 3^2)}$$

Solving, L_F = 49.04 ft. Round up to 50 ft. **L_F = 50 ft**

Step H: Check Filtration Chamber Surface Area, A_{fp}:

The surface area of the filter media will be equal to $L_F \times W_F$. However, the filtration chamber surface area also needs to meet the following requirement:

$$Afp = 1.8Afc = \frac{1.8 \times C \times WQV \times d}{[k \times T \times (h + d)]}$$

Where:

A_{fp} = area of filter bed in the filtration chamber, SQFT

C = conversion factor for units of permeability (12 for inches to ft)

WQV = Water Quality Volume, 10,000 CF

d = depth of filter bed, use 1.5 ft

k = coefficient of permeability of the filtering medium, use 2 inches/hour

T = design drain time for WQV, use 24 hours

h = average water height above the surface of the media bed, taken as half the maximum head of the filtration chamber (i.e. 0.5 x H_W), 1.5 ft

The equation then becomes:

$$Afp = \frac{1.8 \times 12 \times 10{,}000 \times 1.5}{[2 \times 24 \times (1.5 + 1.5)]}$$

A_{fp} = 2,250 SQFT

But $L_F \times W_F$ = $50 \times 32 =$ 1,600 << 2,250 SQFT

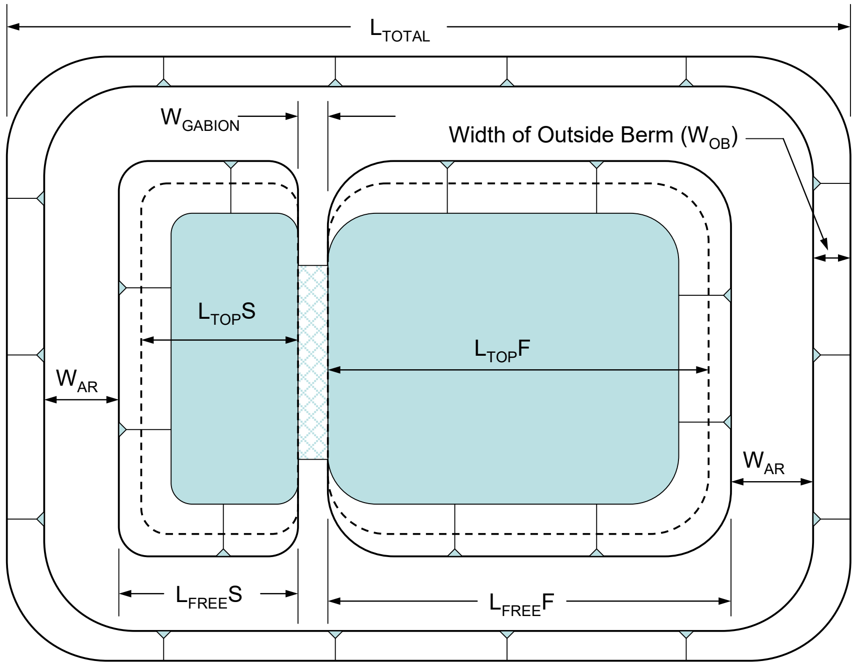
Therefore, L_F must be increased using the value for A_{fp} above. Solving for L_F results in:

$L_F = A_{fp}/W_F$ = 2,250/32 = 70.31 ft

Round up to 71 ft. **L_F = 71 ft**

Step I: Determine W_{TOP} and L_{TOP}:

Determine the overall lengths of the two chambers as measured across the water surface at WQV, and the width of the filtration chamber at WQV (W_{TOP} and L_{TOP}). Note that $W_{TOP}S$ was calculated in Step C.



$$L_{TOP}S = L_S + Z \times H_W$$

Where:

$L_{TOP}S$	=	length of the sediment chamber as measured across the water surface at WQV, ft
L_S	=	length across the invert of the sediment chamber, 12 ft
Z	=	slope of the interior berm, 3:1 (H:V)
H_W	=	Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation, 3 ft

$$L_{TOP}S = 12 + 3 \times 3$$ **$L_{TOP}S$ = 21 ft**

Similarly:

$$L_{TOP}F = L_F + Z \times H_W$$

Where:

$L_{TOP}F$	=	length of filtration chamber as measured across the water surface at WQV, ft
L_F	=	length across the invert of the filtration chamber, 71 ft
Z	=	slope of the interior berm, 3:1 (H:V)
H_W	=	Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation, 3 ft

Thus:

$$L_{TOP}F = 71 + 3 \times 3$$ **$L_{TOP}F$ = 80 ft**

The width at the filtration chamber WQV surface elevation may also be calculated as follows:

$$W_{TOP}F = W_F + 2 \times Z \times H_W$$

Where:

$W_{TOP}F$	=	width of filtration chamber as measured across the water surface at WQV, ft
W_F	=	width across the invert of the filtration chamber, 32 ft
Z	=	slope of the interior berm, 3:1 (H:V)
H_W	=	Design Water Depth inside the EBASF from media surface elevation within the filtration chamber to WQV elevation, 3 ft

Therefore:

$$W_{TOP}F = 32 + 2 \times 3 \times 3$$ **$W_{TOP}F$ = 50 ft**

Step J: Determine $L_{FREE}S$ and $L_{FREE}F$:

Determine the length of the sediment and filtration chambers as measured across the freeboard elevation. The equation for calculating $L_{FREE}S$ is:

$$L_{FREE}S = L_{TOP}S + Z \times (FB + N)$$

Where:

$L_{FREE}S$	=	length across the filtration chamber as measured across the water surface at the freeboard elevation, ft
$L_{TOP}S$	=	length of the filtration chamber as measured across the water surface at WQV, 21 ft
Z	=	slope of the interior berm, 3:1 (H:V)
FB	=	freeboard, defined by Section 2.1 as 1 foot
N	=	nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), use 1 foot

Inserting known values, we get:

$$L_{FREE}S = 21 + 3.0 \times (1.0 + 1.0)$$ **$L_{FREE}S$ = 27 ft**

Similarly, the equation for calculating $L_{FREE}F$ is:

$$L_{FREE}F = L_{TOP}F + Z \times (FB + N)$$

Where:

$L_{FREE}F$ = length across the filtration chamber as measured across the water surface at the freeboard elevation, ft

$L_{TOP}F$ = length of the filtration chamber as measured across the water surface at WQV, 80 ft

Z = slope of the interior berm, 3:1 (H:V)

FB = freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), use 1 foot

Thus:

$$L_{FREE}F = 80 + 3 \times (1.0 + 1.0)$$

$L_{FREE}F$ = 86 ft

Step K: Determine L_{TOTAL}:

Determine the overall length of the EBASF as measured from toe of outside berm to toe of outside berm.

$$L_{TOTAL} = L_{FREE}F + L_{FREE}S + 2 \times W_{OB} + 2 \times W_{AR} + W_{GABION}$$

Where all terms are as defined previously, and W_{GABION} is the width of the gabion wall (use 3 ft). Therefore:

$$L_{TOTAL} = 86 + 27 + 2 \times 3 + 2 \times 12 + 3$$

L_{TOTAL} = 146 ft

From Step A, W_{TOTAL} = 92 ft

Thus, the overall dimensions, 146 ft long by 92 ft wide, fit within the chosen site.

Section 10

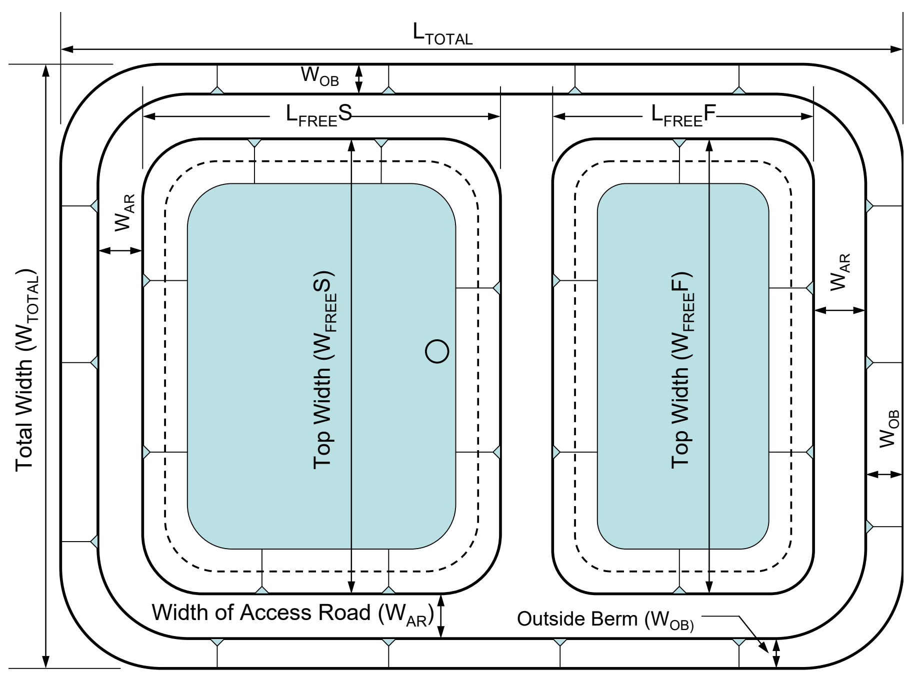
Design Example – Full Sedimentation

This section presents an example on how to implement the procedure that is presented in Section 4 for a Full Sedimentation, Rectangular EBASF design. The sample layout shown in the following figure applies to the calculations presented in this section. The design parameters for this site are as follows:

- WQV is 10,000 CF;
- The footprint of the available site adjacent to the highway is 132 ft wide by 300 ft long;
- Depth-to-groundwater is 15.5 ft from O.G.; use H_W = 3 ft to account for existing site conditions (refer to calculation of H_W in Step A of the Partial Sedimentation design example);
- Use side slopes = 3:1 (H:V).

Step A: Determine W_S and L_S based upon WQV:

Refer to Table 4-1 of this document to choose the appropriate invert width and length of the sediment chamber for the calculated WQV.



Selecting the row in Table 4-1 that corresponds to a WQV of 10,000 CF:

L_S = 77 ft

W_S = 30 ft

Step B: Determine W_F and L_F based upon WQV

Refer to Table 4-3 of this document to choose the appropriate invert width and length of the filtration chamber for the calculated WQV. Selecting the row in Table 4-3 that corresponds to a WQV of 10,000 CF:

L_F = 42 ft and W_F = 30 ft

If the permeability of the media, side slope of the berm, or drawdown time had differed from the assumptions made for Table 4-3, the designer could have calculated the surface area of the filtration chamber (A_{fc}), W_F, and L_F as follows:

$$Afc = \frac{C \times WQV \times d}{[k \times T \times (h + d)]}$$

Where:

A_{fc} = area of filter bed in the filtration chamber, SQFT

C = conversion factor for units of permeability (12 for inches to ft)

WQV = Water Quality Volume, 10,000 CF

d = depth of filter bed, use 1.5 ft

k = coefficient of permeability of the filtering medium, use 2 inches/hour

T = design drain time for WQV, use 24 hours

h = average water height above the surface of the media bed, taken as half the maximum head of the filtration chamber (i.e. 0.5 x H_W), 1.5 ft

Inserting known values, the equation becomes:

$$Afc = \frac{12 \times 10{,}000 \times 1.5}{[2 \times 24 \times (1.5 + 1.5)]}$$

A_{fc} = 1,250 SQFT

Since W_F = W_S, and W_S is known, the designer can now solve for L_F as follows:

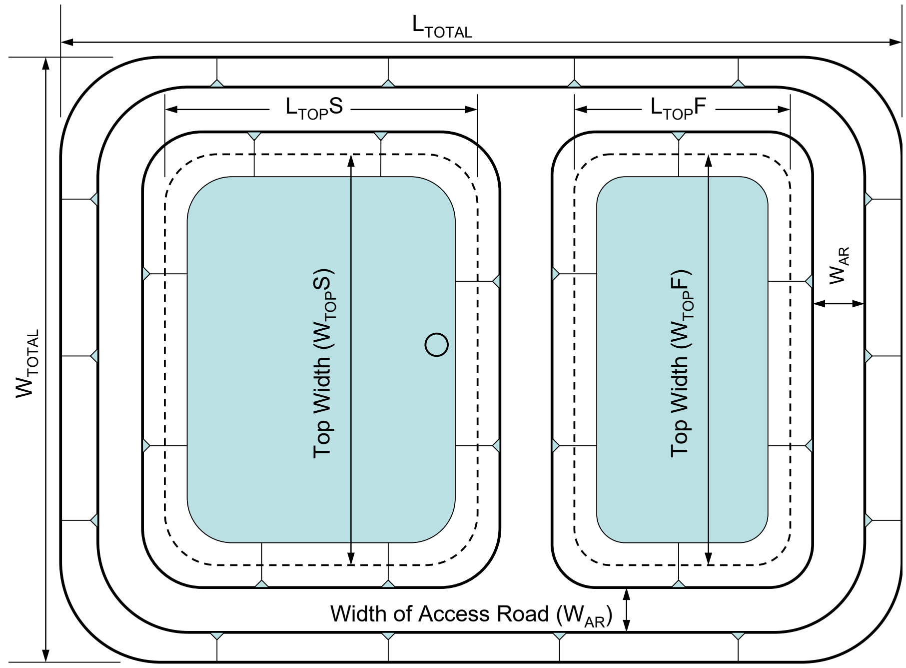
W_F = W_S W_F = 30 ft

$$L_F = A_{FC} / W_F = A_{FC} / W_S = 1{,}250 / 30$$

L_F = 42 ft

Step C: Determine W_{TOP} and L_{TOP}:

Determine the overall lengths and widths of the two chambers as measured across the water surface at WQV (W_{TOP} and L_{TOP}).



$$L_{TOP}S = L_S + 2 \times Z \times H_W$$

Where:

$L_{TOP}S$ = length of the sediment chamber as measured across the water surface at WQV, ft

L_S = length across the invert of the sediment chamber, 77 ft

Z = Slope of the interior berm, 3:1 (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation, 3 ft

Therefore:

$$L_{TOP}S = 77 + 2 \times 3 \times 3$$ **L_{TOP}S = 95 ft**

Similarly:

$$L_{TOP}F = L_F + 2 \times Z \times H_W$$

Where:

$L_{TOP}F$ = length of filtration chamber as measured across the water surface at WQV, ft

L_F = length across the invert of the filtration chamber, 42 ft

Z = slope of the interior berm, 3:1 (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation, 3 ft

Solving:

$L_{TOP}F = 42 + 2 \times 3 \times 3$ **$L_{TOP}F$ = 60 ft**

The widths at the WQV surface elevation may also be calculated as follows:

$$W_{TOP}S = W_S + 2 \times Z \times H_W$$

Where:

$W_{TOP}S$ = width of sediment chamber as measured across the water surface at WQV, ft

W_S = width across the invert of the sediment chamber, 30 ft

Z = slope of the interior berm, 3:1 (H:V)

H_W = Design Water Depth inside the EBASF from invert of sediment chamber to WQV elevation, 3 ft

Which solves to be:

$W_{TOP}S = 30 + 2 \times 3 \times 3$ **$W_{TOP}S$ = 48 ft**

Then:

$$W_{TOP}F = W_F + 2 \times Z \times H_W$$

Where:

$W_{TOP}F$ = width of filtration chamber as measured across the water surface at WQV, ft

W_F = width across the invert of the filtration chamber, 30 ft

Z = slope of the interior berm, 3:1 (H:V)

H_W = Design Water Depth inside the EBASF from surface of media material in filtration chamber to WQV elevation, 3 ft

Therefore:

$W_{TOP}F = 30 + 2 \times 3 \times 3$ **$W_{TOP}F$ = 48 ft**

Step D: Determine W_{FREE} and L_{FREE}:

Determine the lengths and widths of the two chambers as measured across the freeboard elevation.

$$L_{FREE}S = L_{TOP}S + 2 \times Z \times (FB + N)$$

Where:

$L_{FREE}S$ = length of the sediment chamber as measured across the water surface at the freeboard elevation, ft

$L_{TOP}S$ = length across the sediment chamber at the WQV elevation, 95 ft

Z = slope of the interior berm, 3:1 (H:V)

FB = Freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event (i.e. vertical distance between water surface elevation during overflow event and water surface elevation at WQV), use 1 foot

Solve as follows:

$$L_{FREE}S = 95 + 2 \times 3 \times (1.0 + 1.0)$$ **$L_{FREE}S$ = 107 ft**

Similarly:

$$L_{FREE}F = L_{TOP}F + Z \times (FB + N)$$

Where:

$L_{FREE}F$ = length of the filtration chamber as measured at the freeboard elevation, ft

$L_{TOP}F$ = length across the filtration chamber at the WQV elevation, 60 ft

Z = slope of the interior berm, 3:1 (H:V)

FB = freeboard, defined by Section 2.1 as 1 foot

N = nappe of flow over weir during overflow event, use 1 foot

Which solves as follows:

$$L_{FREE}F = 60 + 2 \times 3 \times (1.0 + 1.0)$$ **$L_{FREE}F$ = 72 ft**

The widths at the freeboard elevation may then be calculated as follows:

$$W_{FREE}S = W_{TOP}S + 2 \times Z \times (FB + N)$$

Where variables are as defined above plus:

$W_{FREE}S$ = width of the sediment chamber as measured across the water surface at the freeboard elevation, ft

$W_{TOP}S$ = width of the sediment chamber as measured across the water surface at WQV, 48 ft

Therefore:

$$W_{FREE}S = 48 + 2 \times 3 \times (1.0 + 1.0)$$ **$W_{FREE}S$ = 60 ft**

The width for the filtration chamber should be the same as that for the sediment chamber:

$$W_{FREE}F = W_{TOP}F + 2 \times Z \times (FB + N)$$

Where variables are as defined above plus:

$W_{FREE}F$ = width of the filtration chamber as measured across the water surface at the freeboard elevation, ft

$W_{TOP}F$ = width of the filtration chamber as measured across the water surface at WQV, 48 ft

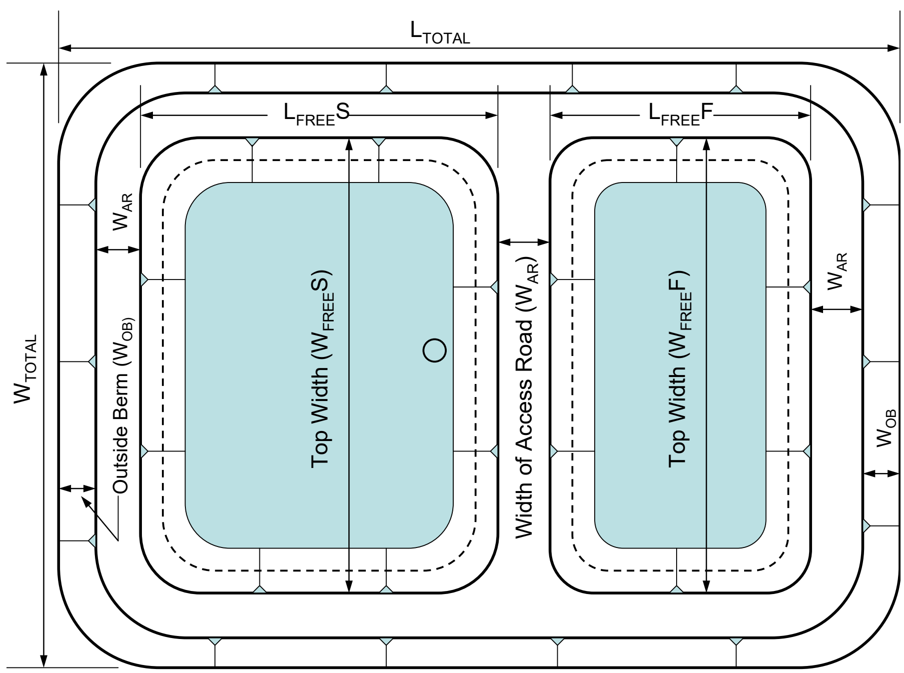
Inserting the known values as follows:

$W_{FREE}F = 48 + 2 \times 3 \times (1.0 + 1.0)$ **$W_{FREE}F$ = 60 ft**

Step E: Determine W_{TOTAL} and L_{TOTAL}:

Determine the overall length of the EBASF as measured from toe of outside berm to toe of outside berm.

$$L_{TOTAL} = L_{FREE}F + L_{FREE}S + 2 \times W_{OB} + 3 \times W_{AR}$$



Where:

$L_{FREE}S$ = length of the sediment chamber as measured across the water surface at the freeboard elevation, 107 ft

$L_{FREE}F$ = length of the filtration chamber as measured across the water surface at the freeboard elevation, 72 ft

W_{OB} = width of the outside berm, 3 ft

W_{AR} = width of the access road, 12 ft

$L_{TOTAL} = 72 + 107 + 2 \times 3 + 3 \times 12$ **L_{TOTAL} = 221 ft**

Similarly, the overall length of the EBASF as measured from toe of outside berm to toe of outside berm may be calculated using the following equation:

$$W_{TOTAL} = W_{FREE}F + 2 \times W_{OB} + 2 \times W_{AR}$$

Where:

$W_{FREE}F$= length of the filtration chamber as measured across the water surface at the freeboard elevation, 60 ft

W_{OB} = width of the outside berm, 3 ft

W_{AR} = width of the access road, 12 ft

$W_{TOTAL} = 60 + 2 \times 3 + 3 \times 12$ **W_{TOTAL} = 102 ft**

Thus, the overall dimensions, 209 ft long by 90 ft wide, fit within the chosen site.

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Section 11

References

American Association of State Highway and Transportation Officials (AASHTO), 2011. Roadside Design Guide; with errata published in 2015

California Department of Transportation (Caltrans), 2020a. Highway Design Manual 6th Edition, March 2020

California Department of Transportation (Caltrans), 2020b. Stormwater Quality Handbooks: Detention Basin Design Guidance

California Department of Transportation (Caltrans), 2020c. Stormwater Quality Handbooks: Supplemental Details Design Guidance

California Department of Transportation (Caltrans), 2020d. Stormwater Quality Handbooks: Flow Splitters Design Guidance

California Department of Transportation (Caltrans), April 2019a. Stormwater Quality Handbooks: Design Pollution Prevention Infiltration Area Design Guidance, April 2019

California Department of Transportation (Caltrans), 2019b. Stormwater Quality Handbooks: Project Planning and Design Guide (PPDG), April 2019

California Department of Transportation (Caltrans), 2019c. Statewide Trash Implementation Plan, April 2019

California Department of Transportation (Caltrans), 2019d. Construction Contract Development Guide, Version 5.0, July 2019

California Department of Transportation (Caltrans), 2019e. Review of Design Guidance for Sizing Media Filters for Stormwater Quality Treatment, CTSW-TM-16-314.17.1, January 24, 2017, Revised September 17, 2019

California Department of Transportation (Caltrans), 2018. Multi Benefit Treatment BMP Trash Full Capture Requirements – Design Guidance, October 2018

California State Water Resources Control Board ORDER 2012-0011-DWQ, NPDES NO. CAS000003 for State of California Department of Transportation Statewide Storm Water Permit, referred to as "NPDES Permit"

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment, January 2003

United States Environmental Protection Agency (USEPA), 1999. Storm Water Technology Fact Sheet: Sand filters, EPA 832-F-99-007, September 1999

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