Partial Sedimentation Austin Vault Sand Filters

Design Guidance

December 2020

California Department of Transportation
HQ Division of Design

For individuals with sensory disabilities, this document is available in alternate formats upon request. Please call or write to:

Caltrans Division of Design

Office of Hydraulics and Stormwater Design

P.O. Box 942874, Sacramento, CA 94274-0001

(916) 653-8896 Voice or dial 711 to use a relay service.

Table of Contents

List of Figures

List of Tables

This page intentionally left blank.

List of Abbreviations

ASF	Austin Sand Filter
AVSF	Austin Vault Sand Filter
BEES	Basic Engineering Estimating System
BMP	Best Management Practice
CF	cubic foot
CRZ	Clear Recovery Zone, (AASHTO Clear Zone)
DES	Division of Engineering Services
DPPIA	Design Pollution Prevention Infiltration Area
FE	footing elevation
FG	finished grade
fps	feet per second
ft	foot/feet
HDM	Highway Design Manual
HQ	Headquarters
H_W	Design Water Depth
L	length
L_F	length of filtration chamber
LID	Low Impact Development
LRFD	Load and Resistance Factor Design
L_S	length of sediment chamber
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
SSHM	Small Storm Hydrology Method
SSP	Standard Special Provision
SWDR	Stormwater Data Report
TBMP	Treatment Best Management Practice
USEPA	United States Environmental Protection Agency
W	width
WE	wall elevation
WQF	Water Quality Flow
WQV	Water Quality Volume

This page intentionally left blank.

Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating the Austin Vault Sand Filter (AVSF) Treatment Best Management Practices (TBMPs) and Detail Drawings into projects during the planning and design phases of Caltrans highways and facilities. AVSFs are a Caltrans-Approved Stormwater TBMP. The AVSF may also be known as an Austin Sand Filter (ASF) or Media Filter. The primary functions of this document are to:

1. Describe an AVSF
2. Provide design guidance
3. Review the required elements for implementing an AVSF 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).

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 AVSF 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 treatment may have on the roadway especially in consideration of the Clear Recovery Zone (CRZ). Coordinate with other functional experts to implement successful and functioning AVSFs.

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. 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 Austin Vault 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 ASF. A typical ASF consists of the following key components (United States Environmental Protection Agency [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 AVSF is configured using two chambers and is usually open and at grade with no permanent water pool. 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. In the Full Sedimentation ASF the first chamber is sized for the entire WQV, and for Partial Sedimentation ASF the first chamber is sized for approximately 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. Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the CRZ.

This guidance document covers only Partial Sedimentation ASFs utilizing concrete walls, hereafter referred to only as AVSFs (see Figure 1-1). Figure 1-2 shows an isometric view of a Partial Sedimentation AVSF. The ASFs – Earthen Type Design Guidance (Caltrans 2020c) covers both Full and Partial Sedimentation Earthen Berm ASFs. The area of the ASF - Partial Sedimentation device is usually about 80 to 90 percent of the ASF - Full Sedimentation device. However, the efficiency of the partial sedimentation design is not greatly different from the full sedimentation version, 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), and no hold time is assigned to the water in the initial (sedimentation) chamber.

The AVSF 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 AVSFs be placed offline with an upstream flow splitter to minimize the size of the BMP. See Section 6.5 for additional details.

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.

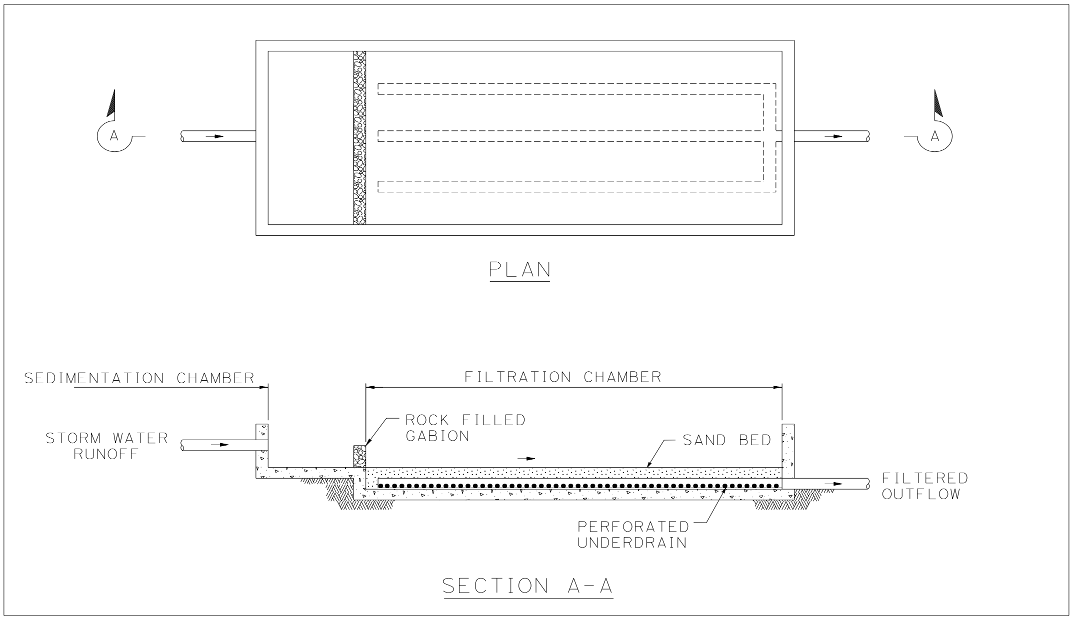


Figure 1-1. Partial Sedimentation AVSF

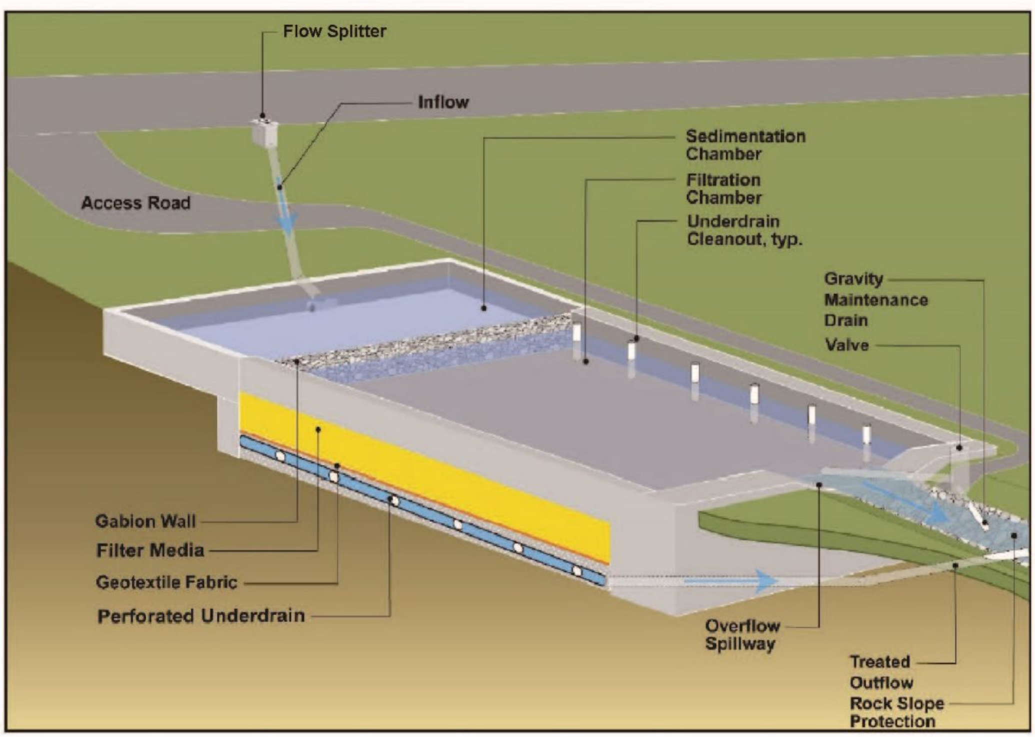


Figure 1-2. Partial Sedimentation AVSF Isometric View

This page intentionally left blank.

Section 2

Basis of BMP Detail Drawings

AVSFs 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. AVSFs can benefit from pretreatment BMPs.

Checklist T-1, Part 8 in the PPDG, assists in evaluating the initial feasibility of an AVSF for a project. The checklist 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 feasibility of an AVSF for a given site.

2.1 Design Basis

The primary design parameter for sizing an AVSF is the WQV, which is the volume of runoff to be treated as determined by methods listed in Section 3.1.1. Other sizing guidelines include:

- L_S: Length of the sediment chamber
- L_F: Length of the filtration chamber
- W: Width of both the sediment and filtration chambers
- H_W: Design water depth (H_w) inside the AVSF

Associated with an overflow event, a minimum freeboard of 1 foot (ft) should be provided between the water surface elevation during the overflow event and the lowest elevation of the confinement (e.g. the lowest elevation at the top of vault) in order to help protect the structural integrity of the AVSF.

2.2 Design Criteria

AVSFs must meet certain design criteria to perform as an effective TBMP. A set of AVSF Detail Drawings (Caltrans 2020b), have been developed for use in siting AVSFs and can be obtained from OHSD. Table 2-1 presents the primary factors of the standard design criteria utilized for the development of the AVSF Detail Drawings.

Table 2-1. Standard AVSF 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
Filter fabric between sand and gravel layers	Refer to Caltrans Filter Fabric RSS Section 62, Type D
Depth of sand layer	1.5 ft min, varies
Depth of gravel layer	1 ft min, varies
Underdrain pipe diameter	6 inches - Refer to Caltrans Standards Section 68 Subsurface Drains
Longitudinal sediment chamber slope	2%
Longitudinal filtration chamber underdrain slope	1%
Freeboard	1 ft[1]
Hydraulic Head	3 to 6 ft[2]

1. *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 AVSF and downstream facilities.*
2. *Generally, 3 to 6 ft of head (or more, depending on total AVSF 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 for an AVSF 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.*

The AVSF Detail Drawings can be renamed and/or revised as necessary by the PE in responsible charge of the project. The drawings are intended for standard configuration designs under normal conditions and typical external loading requirements, which are outlined in the "General Notes", "Design Notes", and "Detail of Design Loading Cases" sections on the Legend of the drawings.

2.3 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, such as:

- High ground water table (above the bottom of the concrete footing of the AVSF)
- Surcharge loads that exceed the Division of Engineering Services (DES) Underground Structures design criteria, which uses the Load and Resistance Factor Design (LRFD)
- Inadequate bearing capacity
- Inlet velocities which exceed 8.0 ft per second (fps) at the gabion wall
- Excessive settlement due to liquefaction

See Section 8 for more information on Special Designs.

2.4 Inline vs. Offline Placement

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

A. Inline Placement

A TBMP is placed in an inline configuration when an alternate route for flows greater than the Water Quality Event is not provided. Designing a TBMP 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 TBMP must be able to pass the runoff generated during the Design Storm (see Section 6.2) through the TBMP to downstream conveyance without objectionable backwater effects to upstream facilities or causing erosion. An overflow chamber or device is designed to convey the runoff from an overflow event (see Section 6.4).

B. Offline Placement

A TBMP is placed in an offline configuration when an alternate route for flows greater than the Water Quality Event is provided. The excess runoff is diverted around the TBMP 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 6.5. Even in an offline placement, overflow devices must be considered.

2.5 Safety Considerations

AVSFs 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 AVSF section should provide a barrier 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. AVSFs should have detailing, such as fences, that preclude ready access by the public.

2.6 Restrictions/Coordination

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

Section 3

Getting Started

This section presents the design parameters and calculations necessary to support the sizing and selection of the appropriate standard AVSF. It is assumed that the need for an AVSF has already been determined in accordance with the guidelines and procedures presented in Section 2 and in the PPDG. It is further 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 and the AVSF Detail Drawings assume that the AVSF 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 lay out an AVSF, evaluate existing site conditions to obtain the following design parameters that are the basis of the AVSF Detail Drawings:

- WQV: The WQV is calculated using the methodology in Section 3.1.1
- Hydraulic Head: Generally, three to six feet of head are required from the inlet to the outlet for an AVSF to operate properly. Constructing the AVSF with the dimensions shown in Table 3-1 below, and the dimensions shown on the AVSF Detail Drawings will provide adequate hydraulic head.
- Design Water Depth (H_W): This parameter is defined as the maximum depth of the water above the filter media in the filtration chamber for a specified WQV and should match the height of the gabion wall as closely as possible. H_W is <u>not</u> the same as the maximum water surface, which is only reached during an overflow event that exceeds the WQV. The total height of the walls will be equal to the maximum water depth during an overflow event plus the freeboard (1 ft) 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 current DPPIA Design Guidance (Caltrans 2019a).

3.2 Preliminary Calculations

3.2.1 AVSF Dimensions

After calculating the WQV, Table 3-1 can be used to select a pre-determined AVSF type. Layout No. 1 of the AVSF Detail Drawings graphically depicts the parameters that are listed in Table 3-1.

Table 3-1. Design WQV vs. AVSF Interior Dimensions

Designation	WQV Range (CF)	W (ft)	L_S (ft)	L_F (ft)	H_W (ft)
S-3500-3	3,500	21	14	38	3
L-3500-3	3,500	15	18	53	3
S-3500-4.5	3,501 - 4,380	21	14	38	4.5
L-3500-4.5	3,501 - 4,380	15	18	53	4.5
S-3500-6	4,381 – 5,260	21	14	38	6
L-3500-6	4,381 – 5,260	15	18	53	6
S-5000-3	4,356 - 5,000	27	15	42	3
L-5000-3	4,356 - 5,000	18	21	63	3
S-5000-4.5	5,001 - 6,250	27	15	42	4.5
L-5000-4.5	5,001 - 6,250	18	21	63	4.5
S-5000-6	6,251 - 7,500	27	15	42	6
L-5000-6	6,251 - 7,500	18	21	63	6
S-10000-3	7,501 - 10,000	36	21	63	3
L-10000-3	7,501 - 10,000	24	30	94	3
S-10000-4.5	10,001 - 12,500	36	21	63	4.5
L-10000-4.5	10,001 - 12,500	24	30	94	4.5
S-10000-6	12,501 - 15,000	36	21	63	6
L-10000-6	12,501 - 15,000	24	30	94	6
S-15000-3	12,501 - 15,000	45	25	76	3
L-15000-3	12,501 - 15,000	30	37	115	3
S-15000-4.5	15,001 - 18,750	45	25	76	4.5
L-15000-4.5	15,001 - 18,750	30	37	115	4.5
S-15000-6	18,751 - 22,500	45	25	76	6
L-15000-6	18,751 - 22,500	30	37	115	6

Each AVSF type "Designation" consists of three components:

- Length Configuration (S or L): Either a short (S) or a long (L) configuration can be selected, depending on the footprint of the available land. The length-to-width ratios of the short and long configurations are approximately 2:1 and 5:1, respectively;
- WQV: As calculated in Section 3.1.1. For most projects, an upper limit of 22,500 CF will meet most siting conditions, and a Special Design would be required for a WQV higher than the upper limit. For the AVSF type designations, "S-XXXX-H_W", listed in Table 3-1 above, the "XXXX" refers to the minimum WQV that would be provided at the lowest H_W using plan dimensions shown. However, the WQV should be taken directly from the "WQV Range" column in Table 3-1.
- Design Water Depth (H_W): For calculations, the maximum water surface elevations in the filtration chamber have been given values of 3, 4.5, and 6 ft, as these are the standard heights of gabion walls that Caltrans uses. H_W should match the height of the gabion wall as close as possible but should not exceed the height of the tallest gabion wall (6 ft).

The following methodology outlines the steps used in obtaining the values in Table 3-1. It should be noted that the dimensions given in Table 3-1 are interior dimensions of the vault structure. Once the interior dimensions are determined, refer to Layout No. 2 of the AVSF Detail Drawings in order to determine the total exterior dimensions and compare them to the available footprint of the site:

1. The required filtration chamber areas for a range of Design Water Depths and WQVs were calculated using following equations:

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

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 = WQV; CF

d = depth of sand layer in the Austin-style filter bed, typically 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

$$A_{fp} = 1.8A_{fc} \quad \text{(Eq. 2)}$$

Where:

A_{fp} = area of 2nd chamber filter bed for a partial sedimentation device, and Afc is calculated as above.

2. The storage volumes in the filtration chamber were calculated using equation 3 below. The storage volume consists of two parts: (a) the volume in the pore spaces of the sand layer, and (b) the volume in the Design Water Depth (i.e., to the H_W elevation) above the sand layer. A void ratio of 0.35 for the sand layer was assumed.

$$V_V = 0.35A_{fc} \times (d + d_g) \quad \text{(Eq. 3)}$$

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)

3. The next step was to determine the storage volume required in the sediment chamber. Two values were initially calculated: (a) a minimum sediment chamber volume of 20 percent of the WQV, and (b) a volume calculated by subtracting the filtration chamber volume from the WQV. The maximum of these two values was then used to calculate the storage area required in the sediment chamber by dividing the sediment chamber volume by the Design Water Depth.
4. The total area of the AVSF was calculated by adding the areas of the filtration and sediment chambers, and the gabion wall.
5. The width (W) was determined from the total areas of the filtration and sediment chambers and the aspect ratio (L=2W or L=5W), and then adjusted to the nearest standard gabion width (3 ft).
6. The lengths of the filtration and sediment chambers (L_F and L_S, respectively) were obtained by dividing their areas by the width (W). The lengths of the sediment chambers were adjusted for the width of the gabion wall (3 ft) by

adding 2 ft (assuming a void ratio of 33 percent for the gabion rocks, the "effective" width of the gabion wall is 2 ft).

3.2.2 AVSF Wall Heights

After the footprint dimensions of the AVSF have been determined, calculate the wall heights. The ranges of allowable design wall heights are shown in Table 3-2.

The actual wall heights are used to determine the quantities of concrete, steel rebar, and excavation required for the walls and footing. The Design H values range from 6 ft to 16 ft, in increments of 2 ft. One Design H should be calculated for each of the sediment and filtration basins. The maximum wall height for each of the basins should be used for each basin's Design H.

Layout No. 1 of the AVSF Detail Drawings shows the dimension of Design H, which is from the top of footing to top of wall.

Table 3-2. AVSF Allowable Design Wall Height Table

Designation[1]	Sediment Chamber (ft)	Filtration Chamber (ft)
S-xxxx-3	6-12	10-16
L-xxxx-3	6-12	10-16
S-xxxx-4.5	8-12	12-16
L-xxxx-4.5	8-12	12-16
S-xxxx-6	10-12	14-16
L-xxxx-6	10-12	14-16

1. this column, "xxxx" can represent 3,500, 5,000, 10,000, or 15,000 CF of WQV.

This page intentionally left blank.

Section 4

BMP Selection

The method for selecting the most appropriate AVSF size and configuration for a site will often be an iterative process where the design factors presented in Section 3 are evaluated together. Figure 4-1 presents the typical process flowchart for selecting the most appropriate AVSF size and configuration for a project. Selecting which AVSF to use for a project is a four-step process with each step being discussed in detail below.

This guidance and the AVSF Detail Drawings assume that the AVSF 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.

4.1 Review Site Conditions

Review the site conditions to ensure that none of the site restrictions discussed in Section 2 are present, and to confirm that there is available, unobstructed area for placement of the AVSF.

4.2 Select AVSF Size and Configuration

After calculating the WQV, determine the proper AVSF size by using Table 3-1. The table includes two different AVSF configurations for each WQV range. One configuration is a shorter but wider vault, while the other is a longer but narrower structure. The dimensions for the "3500", handle minimum WQVs to 5,260 CF. For the "5000", the dimensions handle 4,356 – 7,500 CF. For the "10000", the dimensions handle 7,501 – 15,000 CF, and for the "15000", they handle 15,001 – 22,500 CF.

Select the proper row in the table by finding the WQV range that the calculated WQV falls within. For example, if the calculated WQV was 5,921 CF, select a unit corresponding to the WQV range of 5,001 – 6,250 CF. Finally, select either the short (S) or long (L) configuration to determine the following dimensions:

- W: The width of the sediment and filtration chambers
- L_S: The length of the sediment chamber
- L_F: The length of the filtration chamber
- H_W: The Design Water Depth

If both the short and long configuration would fit inside the available footprint, the short configuration should be used, as it always requires less concrete and steel. If the WQV is outside the range of the values in Table 3-1, consider a Special Design for the site (see Section 8) or splitting the drainage area into sections, and using additional devices in series or parallel arrangements.

Note that the lengths and width calculated above are only for the interior of the AVSF, and do not take into account the dimensions of the concrete walls or the footings. Thus, when siting the AVSF, carefully consider construction access, final outside dimensions, and formwork around the dimensions calculated above.

4.3 Determine Wall Heights

Layout No. 1 graphically depicts the wall heights that are determined using the procedure described below.

1. Obtain the finished grade (FG) elevations that correspond to the top of wall elevations (WE) 1 and WE6 (AVSF inlet), WE2 and WE5 (beginning of the filtration chamber), WE3 and WE4 (AVSF outlet), as shown on Layout No. 1 of the AVSF Detail Drawings.
2. Establish the four, corner top of wall elevations (WE)s (WE1, WE6, WE3, and WE4) at 6 inches above their corresponding FG elevations.
3. Linearly interpolate between WE1 and WE3 to obtain top of WE2. Similarly, interpolate between WE4 and WE6 to obtain top of WE5. There should be a smooth linear slope from WE1 to WE3 and from WE4 to WE6. However, if using an interpolated top of wall elevation causes the difference between the wall elevation and finished grade to be less than 0.5 ft, the wall elevation must be corrected accordingly or the site grading must be changed.
4. After the top of wall elevations are determined, the footing elevations (FE) must be calculated. First, calculate FE4 located at the inside of the outlet wall of the filtration basin by selecting a point that is 2 inches below the outlet flow line elevation. Calculate FE5 located at the outside edge of the filtration footing using FE4 elevation and multiplying the filtration basin slope of minus 1 percent by the sum of the wall thickness and one ft, which is the distance between the outside wall edge of the filtration basin and the outside edge of the footing.
5. Multiply the applicable interior length of the filtration chamber by its slope (1 percent) and add to FE4 to obtain FE3. This corresponds to the footing elevation at the upstream end of the filtration chamber.
6. Add the combined depths of the sand and gravel layer (2.5 ft) to the footing elevation obtained in Step 5 to determine FE2. This corresponds to the footing elevation at the downstream end of the sediment chamber.
7. Multiply the applicable interior length of the sediment chamber by its slope (2 percent) to calculate FE1. This corresponds to the footing elevation at the upstream end of the sediment chamber. Calculate FE0 using the sum of the wall thickness plus one ft (one ft is the distance between the outside wall edge of the sedimentation basin and the outside edge of the footing) multiplied by the filtration slope of 1 percent.

8. A minimum 6 inches of separation must be provided from the outer diameter of the inlet pipe to the invert of the sediment chamber (FE1), as shown in Section A-A on Details No. 1 of the AVSF Detail Drawings. Provide minimum ground cover above the crown of the inlet pipe, as applicable. Refer to HDM, Table 856.5.
9. After obtaining the wall and footing elevations, calculate a Design H value for the sedimentation basin and the filtration basin. Use the largest wall height for each basin to obtain the Design H.

If the calculated wall design heights do not fall within the values listed in Table 3-2, a Special Design will be required for the site, or the flow line elevation of the pipe leading to or from the AVSF must be changed (flattened). Consider the upstream and/or downstream hydraulic effects if the pipe slope is changed. To prevent destabilizing earth pressure moments from being generated on the AVSF walls, the height difference between the two side walls or the inlet and outlet walls may not exceed 8 ft.

4.4 Check AVSF Footprint

Next, calculate the “out-to-out” concrete dimensions of the selected AVSF type to the available footprint of the site.

Use the Reinforcing Steel Table on Layout No. 1 of the AVSF Detail Drawings to determine a “T” dimension (thickness of wall) for all four walls.

Find the “T” dimensions in the table and add them to the overall length of the AVSF plus two feet (one foot footing on each side of AVSF). Check this updated length against the available footprint at the site.

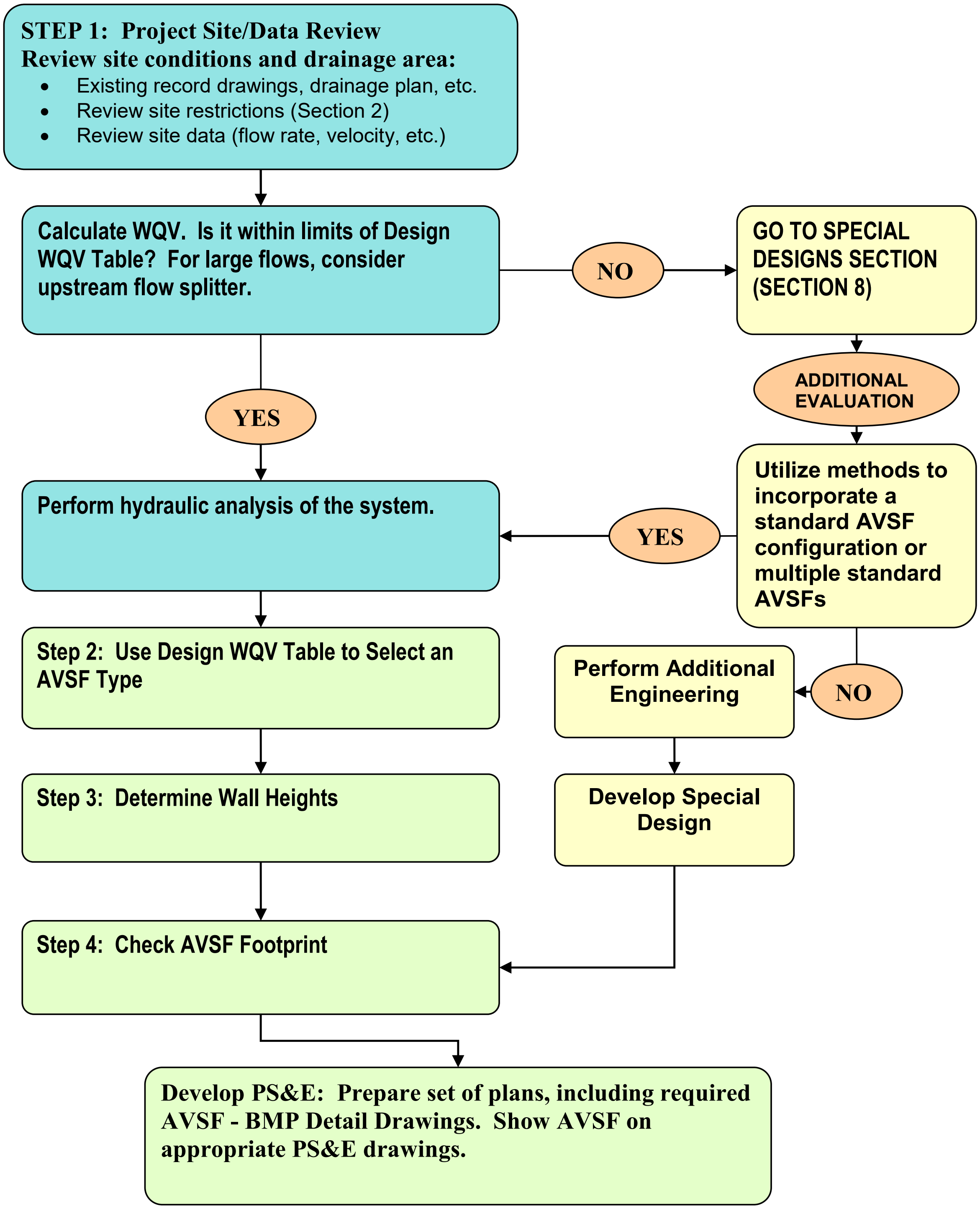


Figure 4-1. Typical AVSF Selection Flowchart

Section 5

BMP Layout

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

5.1 AVSF Layout

The layout of the AVSF is set by positioning the device inline with the direction of the incoming flow, and by adhering to the limitations of the AVSF design. The AVSF can have a maximum divergence angle of 45 degrees with the incoming flow. For any divergence greater than 45 degrees, it is recommended that the device be rotated 90 degrees, which would be considered a Special Design as described in Section 8.3 or add a manhole upstream. The layout of the AVSF must consider the structure's footprint "out-to-out" concrete dimensions compared to the available site footprint, as well as the existing inlet and outlet drain pipe layout compared to the AVSF requirements.

5.2 Space Considerations

AVSFs 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 AVSF structure and should be verified by checking the structure dimensions using the "out-to-out" concrete dimensions as shown in the AVSF Detail Drawings. Verify the proposed AVSF locations with District Maintenance to confirm the space and access availability for maintenance and inspection of the structure.

5.3 Site Requirements

Successful implementation and utilization of the AVSF Detail Drawings 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 AVSF, particularly for retrofit applications. The AVSF Detail Drawings should not be used or modified for any conditions outside the range of values presented in Table 2-1 (for exceptions, see Section 8).

AVSFs should generally be sited in an unobstructed location that can be easily accessed by maintenance vehicles. The entire AVSF structure must be above seasonally high groundwater. In cold regions, the bottom of the AVSF structure must be below the frost line to prevent damage from frost heave.

5.4 Construction Requirements and Restrictions

All construction requirements for AVSFs should be specified in the project drawings and accompanying Special Provisions (see Section 7).

In addition, a minimum 4-ft separation between the gabion wall and the AVSF wall parallel to (in front of) the gabion wall is recommended to allow for energy/velocity dissipation before the flow hits the gabions.

5.5 Inlet and Outlet Pipe Diameter Restrictions

In general, the inlet and outlet diameters of the AVSF 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, consider reducing the velocity at the inlet by enlarging the pipe diameter or by installing energy dissipating baffles in the sediment chamber. If the pipe diameter is increased beyond the maximum allowable diameter shown on Details No. 1 of the AVSF Detail Drawings, or if energy dissipating baffles are installed, a Special Design would be required.

Section 6

Design Elements

Certain supplemental structures and devices may be required in the construction of AVSFs. These supplemental design elements are discussed in detail in the Supplemental Details Design Guidance (Caltrans 2020d). It is the PE's responsibility to determine which of the AVSF supplemental design elements are required for a specific site.

6.1 Maintenance Access

Discuss proposed AVSF location and access with the District Maintenance Stormwater Coordinator, as maintenance is critical to these devices. Provide vehicle access around the AVSF to adequately and safely allow access to all structures and devices located within the vault area. Maintenance access roads, if required, must be located within Caltrans right-of-way or within a maintenance easement and must be able to accommodate all sizes of vehicles to cover routine visits; they must allow for trash and debris removal, possibly using a vacuum truck. Coordinate with District Maintenance Stormwater Coordinator on maintenance access to the device.

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 direction on determining the proper return frequency). 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[1].

6.3 Overflow Events

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

[1] 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.

flows are designed to travel through the AVSF with release through an overflow device.

6.4 Overflow Devices

When placed inline, the AVSF must safely pass events that exceed the WQV. Overflow devices must also be considered for offline placement if clogging of the upstream flow splitter or other unusual conditions occur. The overflow device for an AVSF is often an overflow chamber. The release elevation should be set to the surface of the WQV.

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.

6.5 Flow Splitters

Flow splitters are upstream drainage bifurcation structures designed to direct inflows corresponding to the treatment volume to TBMPs and to divert peak flows. Possible conditions requiring the implementation of a flow splitter in conjunction with an TBMP are listed below:

- Backwater effect in the TBMP
- Large peak storm effects
- Inlet/Outlet pipe elevation constraints
- Available capacity of overflow device discharge connection
- Downstream effects of an overflow device

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

6.6 Excessive Flows

In addition to implementing flow splitters as described above, in cases where the WQV of a drainage area would require an AVSF footprint larger than what is available, or for AVSFs with aspect ratios other than 2:1 or 5:1, 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 AVSFs in parallel arrangements. However, parallel arrangements may result in operational issues, and the preferred method would be the placement of a single AVSF to serve an entire CDA.

6.7 Upstream Effects

While AVSFs 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.

When placed inline, 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 and should be coordinated with District Hydraulics.

6.8 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.

6.9 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.

6.10 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.

Section 7

PS&E Preparation

This section provides guidance for incorporating AVSFs into the PS&E package, discusses the 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 AVSFs into the PS&E in accordance with the requirements of Section 2 of the Construction Contract Development Guide (Caltrans 2019d).

7.1 Plans

This section provides guidance for incorporating the AVSF Detail Drawings into a PS&E package. The PE is responsible for incorporating the AVSF 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 AVSF with the appropriate references to incorporate the AVSF Detail Drawings into the PS&E package.

PS&E drawings for most projects having AVSFs may include:

- Layout(s): Show the location(s) of the AVSF and call out standard AVSF configuration types. This will aid in recognizing, both within and outside Caltrans, that AVSFs were placed within the project limits.
- Grading Plan(s): Show the AVSF on this sheet for clarity and associated grading surrounding the AVSF should be shown on these sheet(s).
- Drainage Plan(s), Profiles, Details, and Quantities:
  - Drainage Plan sheets should show each AVSF 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 AVSF in profile within the drainage conveyance system. These sheets should also call out the specific AVSF inlet and outlet flow line (surface) elevations and invert elevation.
  - Drainage Detail sheets should show the details as needed to construct or clarify AVSF interface points. Most of the required information is included on the AVSF Detail Drawings. These drawings should be included with the Drainage Details section of the PS&E. Other details may be necessary to adequately reflect the required improvements.

  - Drainage Quantity sheets should include a summary of quantities table with station, offset, and dimensions of the AVSFs and should include all pay and non-pay items associated with the construction of the AVSF, except for those items that will be placed on the Summary of Quantities sheets.
- Temporary Water Pollution Control Plans: These sheets are used to show the temporary BMPs used to establish the AVSF BMPs and compliance with the Construction General Permit.

7.2 Specifications

Contract specifications for AVSF projects 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 AVSF could be organized under an umbrella 'AVSF' nSSP with the required items listed as subheadings. Payment would be made for by 'each' AVSF. 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

Listed below are Standard Specifications that would typically be used for a project that constructs an AVSF. Consider the construction of the AVSF in the context of the entire project to determine if other Standard Specifications may be required.

13 Water Pollution Control

15 Existing Facilities

19 Earthwork

26 Aggregate Bases

51 Concrete Structures

52 Reinforcement

54 Waterproofing

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

80 Fences

96 Geosynthetics

7.2.2 Standard Special Provisions

SSPs may be included for a project that constructs an AVSF. Additional SSPs may be required depending on the types of appurtenant facilities and materials proposed for the project. Consult the current index of SSPs available on the Office of Construction Contract Standards section of the Caltrans website. Each SSP topic should be examined in the context of the entire project to determine if other SSPs may be required.

7.2.3 Non-Standard Special Provisions

A project that constructs an AVSF may require an nSSP to provide details to assure that the design assumptions are constructed properly. The PE and PDT should decide the most appropriate specifications for the site-specific site conditions to meet design requirements and other goals in the HDM (e.g., safety, slope stability). If the PE and PDT deem nSSPs necessary, coordinate with OHSD. OHSD can provide nSSPs to support the design.

OHSD has developed an nSSP to cover the many variables that an AVSF may contain and is available upon request.

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 Section 6.4.9 and Appendix F of the PPDG. 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 AVSF location. Limits of excavation and backfill are determined by the PE and should be in accordance with the Legend, "General Notes", of the AVSF Detail Drawings.

7.4 Developing AVSF Cost Estimates

Develop a quantity-based cost estimate. As the design process proceeds, the project cost estimate should be updated as new data becomes available.

AVSF costs are to be reported as EACH in the SWDR. It may not be necessary to include costs for items that support the Treatment BMP in the unit cost. For example, utility relocation, traffic safety items, drainage systems, or site design elements that are required for the project regardless of TBMP construction could be excluded. However, the items that are required due solely to the TBMP construction should be included in TBMP unit cost.

The AVSF Calculation Spreadsheet (Caltrans 2016) can be obtained from OHSD to assist in the preparation of quantities and costs. The Estimated Quantities tab of the spreadsheet provides a table of quantities calculated based on design inputs as shown in Figure 7-1.

Note that due to the variability of perforated plastic pipe underdrain and plastic pipe underdrain systems, they are not included in the Estimated Quantities tab. It is the PE's responsibility to obtain and include underdrain quantities and costs.

STATE OF CALIFORNIA-DEPARTMENT OF TRANSPORTATION **ESTIMATED QUANTITIES**													Date:	11/3/2016
STRUCTURE Austin Vault Sand Filter Type: S-10000-6				EA	DISTRICT						COUNTY	ROUTE	CALCULATED BY	CHECKED BY
Description Estimated Quantities		Unit (CY)	Unit (LB)	Unit (CY)	Unit (CY)	Unit (CY)	Unit (LF)	Unit (CY)	Unit (CY)	Unit (SQYD)	Unit (LB)			
Structural Concrete		✓												
Bar Reinforcing Steel			✓											
Structure Excavation				✓										
Structure Backfill					✓									
Gabion						✓								
Cable Railing							✓							
Class 4 Permeable Material								✓						
Class 5 Permeable Material									✓					
Class D Filter Fabric										✓				
Miscellaneous Metal											✓			

Figure 7-1. AVSF Estimated Quantities

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/

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

If the AVSF is a Special Design as defined elsewhere in this document, then quantities for cost estimating and construction pay items will need to be calculated and incorporated into the modified drawings and estimates.

7.5 Plan Sheet Approval

The AVSF Detail Drawings may be used when standard sized vaults are incorporated. A set of pdf drawings can be requested from OHSD. At the PS&E phase, the PE must request an electronic copy of drawings that will be incorporated into the PS&E package to be submitted to the District Office Engineer. Prior to submitting the plans to DES Office Engineer, the PE is responsible to request the latest plans available to see if revisions have been made. If so, the new set of plans must be incorporated into the project.

This page intentionally left blank.

Section 8

Special Design

The AVSF Detail Drawings account for specific design load cases. A Special Design will be required where the design parameter values are beyond the ranges given in Sections 2 and 3. Conditions that do not meet the standard design criteria may include:

- High ground water table (above the bottom of the concrete footing of the AVSF)
- Surcharge loads that exceed the DES Underground Structures design criteria (LRFD)
- Inadequate bearing capacity
- Inlet velocities which exceed 8.0 fps at the gabion wall
- Excessive or uneven settlement due to seismic or other causes

This section provides guidance for situations where the specific project requirements do not meet the design parameters specified in the AVSF Detail Drawings. The following recommendations are provided as alternatives to expand the applicability of the AVSFs beyond the design elements and constraints shown in the AVSF Detail Drawings.

Note that any of the following design approaches may require additional engineering, such as a structural and hydraulic analysis, or ground modification. Consult with OHSD when considering special designs.

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 AVSF sizing calculations in this guidance are intended for standard inline designs under normal conditions with typical external loading requirements and have prescriptive 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 of up to 51 percent can be expected.

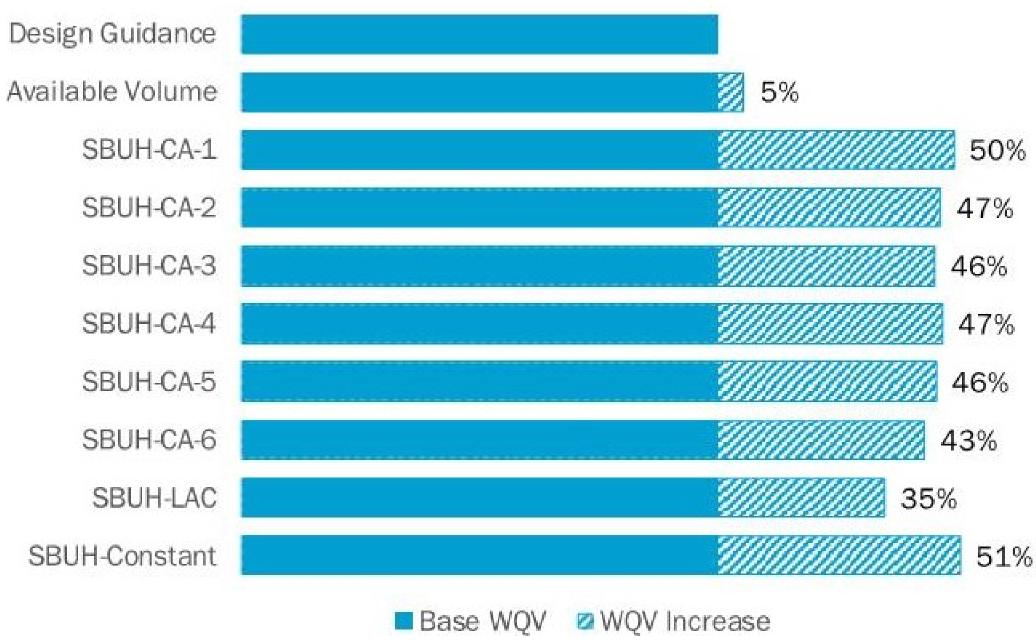


Figure 8-1. Maximum WQV Treated

The base WQV shown in Figure 8-1 is the WQV treated as calculated using the slug-flow method. The WQV increase is the additional WQV treated by the same size BMP using an unsteady-flow routing method and select rainfall distributions. Details of this methodology and findings are discussed in the Review of Design Guidance for Sizing Media Filters for Stormwater Quality Treatment (Caltrans 2019e).

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 AVSF Orientation

The orientation of the AVSF may be rotated up to 90 degrees from what is shown on the AVSF Detail Drawings. The flow may enter the AVSF through any of the three walls of either the forebay or sediment chamber, above the gabion wall. Additionally, the flow exiting the AVSF must be tied into the existing stormwater conveyance system.

If flow enters the AVSF through either of the side walls (flow direction parallel to gabion wall), it is recommended that the inlet pipe be placed as close to the wall opposite the gabion wall as possible. A minimum 2-ft separation between the inlet and gabion wall is recommended.

8.4 Customizing the BMP Detail Drawings

When using a Special Design, the AVSF Detail Drawings must be modified as required to show any changes relative to the following:

- Design WQV Tables: If different WQVs or AVSF dimensions are used, these new values are to be reflected in the Design WQV Table on the Legend of the AVSF Detail Drawings. This is to be noted as Non-Standard data under the "Design Notes" section on the Legend of the AVSF Detail Drawings.
- Legend – "General Notes" Section: Any notes should be changed as required to fit the Special Design
- Reinforcing Steel Tables: The Reinforcing Steel Tables on Layout No. 1 of the AVSF Detail Drawings should be updated for new dimensions as appropriate.
- Quantity Summary Tables: AVSF quantity tables should be updated for new values as appropriate.
- Dimensions: In general, changing the design of the AVSF structures may result in changes to various dimensions. These should be updated on all sheets, views, sections, and details.

Additional changes may be required to facilitate use of the AVSF Detail Drawings. A structural review will be required whenever there are changes in geometry not covered on the drawings. The changed drawings must go through the standard PS&E review process and then be signed and sealed by the PE that completed the approved structural calculations.

This page intentionally left blank.

Section 9

Design Example

9.1 AVSF Design Example

This section presents an example on how to implement the procedure presented in Section 4 for a site. The location for this example is in the City of Murrieta at the Rte-215 and Clinton Keith Road interchange in District 8. The layout of the proposed AVSF structure is shown on Figure 9-1.

Step 1: Review Site Conditions

There is ample room to site an AVSF unit in the northwest quadrant of the interchange.

Step 2: Select AVSF Size and Configuration

The AVSF will be located between southbound Rte-215, the Clinton Keith Road overcrossing, and the southbound Rte-215 exit ramp. The WQV can be found in the project SWDR:

WQV = 14,319 CF ≈ 14,320 CF

Using the WQV above and Table 3-1, and then choosing a short configuration, the S-15000-3 type is selected for this site.

Step 3: Determine Wall Heights

Following the step-by-step instructions in Section 4:

1. Top of wall elevations (WE) and Design H values are shown in Table 9-1. The WEs at the four corners (WE1, WE3, WE4, and WE6) were obtained by adding 6 inches to the finished grade elevations at those locations. The wall elevations at WE2 and WE5 were then obtained via linear interpolation.
2. Using Figures 9-2 and 9-3, the footing elevations were calculated, starting with the AVSF outlet. Subtracting 2 inches from the outlet flow line elevation of 1495.90 ft results in a footing elevation of 1495.73 ft at FE4.
3. Using linear interpolation based on the slopes in the filtration and sediment chambers (1 and 2 percent, respectively), the footing elevations at FE3, FE2, and FE1 were calculated. Footing elevation values are shown in Column 6 of Table 9-1.
4. Interpolating between footing elevations FE3 and FE4, and using the slope of the filtration chamber, the footing elevation at FE5 was then calculated. Likewise, interpolating between footing elevations FE2 and FE1, and using the slope of the sedimentation chamber, the footing elevation at FE0 was calculated.

5. The actual wall height (Column 7) elevations were used for each chamber to determine the maximum Design H for each chamber shown at the bottom of Column 8. The Wall Height (Column 7) was calculated by taking the difference between Column 3 (top of wall elevation) and Column 6 (wall height elevation). Design H (Column 8) was determined by rounding Column 7 upward to the nearest two-ft increment.
6. The design wall heights all fall within the prescribed ranges for the filtration and sediment chambers as shown in Table 3-2. In addition, the wall height values in Column 7 can be used to verify that the difference between the inlet and outlet walls, and the left and right sidewalls is less than 8 ft.

Table 9-1. Wall Height and Design H Calculations

1 Wall Location	2 Finished Grade (FG) (ft)	3 Top of Wall (WE) (ft)	4 Diff top wall and FG (ft)	5 Footing Location	6 Footing Elevation (FE) (ft)	7 Wall Height (ft)	8 Design H Value (ft)
WE1	1,510.00	1,510.50	0.50	FE1	1499.49	11.01	12
WE2	1,510.00	1510.50	0.50	FE2	1498.99	11.51	12
WE2	1,510.00	1510.50	0.50	FE3	1496.49	14.01	16
WE3	1,510.00	1,510.50	0.50	FE4	1495.73	14.77	16
WE4	1,511.00	1,511.50	0.50	FE4	1495.73	15.77	16
WE5	1,511.19	1511.69	0.50	FE3	1496.49	15.20	16
WE5	1,511.19	1511.69	0.50	FE2	1498.99	12.70	14
WE6	1,511.25	1,511.75	0.50	FE1	1499.49	12.26	14

Design "H" Value to use for Sedimentation Chamber = 14 ft

Design "H" Value to use for Filtration Chamber = 16 ft

Step 4: Check AVSF Footprint

An additional 2.17 ft is required on all four sides of the AVSF to accommodate the width of the walls and footings. The wall thickness is determined using the Reinforcing Steel Table on Layout No. 1 of the AVSF Detail Drawings. For a Design H of 14 and 15 ft, the wall thickness is 14 inches for each. The added footing length is also shown on Layout No. 1 of the AVSF Detail Drawings. The stem footing extends one ft beyond the wall for all types of AVSFs. Therefore, an extra 4.33 ft is required along both the width and length of the AVSF. Checking the AVSF layout in Figure 9-1 confirms that this extra space is available.

9.2 PS&E Preparation

Incorporate the AVSF design into the PS&E package, including revising the required drawings and adding the necessary AVSF Detail Drawings. For the example above, the following drawings are to be revised as shown:

- Layout: Show location of the selected AVSF configuration S-15000-3
- Drainage Plan: Show the selected AVSF plan with the existing and proposed drainage conveyance system, including pipes and inlets
- Drainage Profile: Show the selected AVSF profile with the existing and proposed drainage conveyance system, including pipes and inlets

This page intentionally left blank.

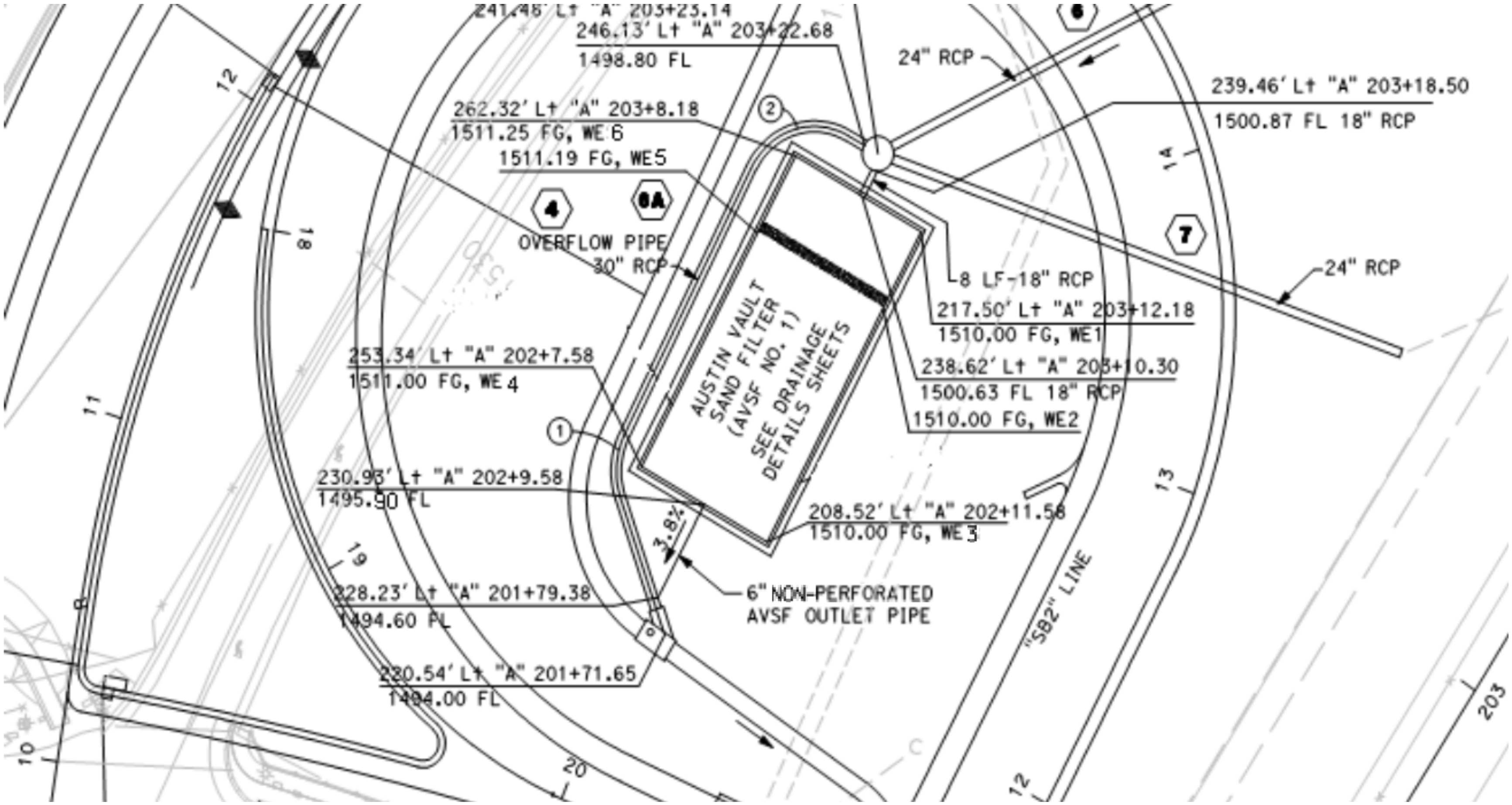
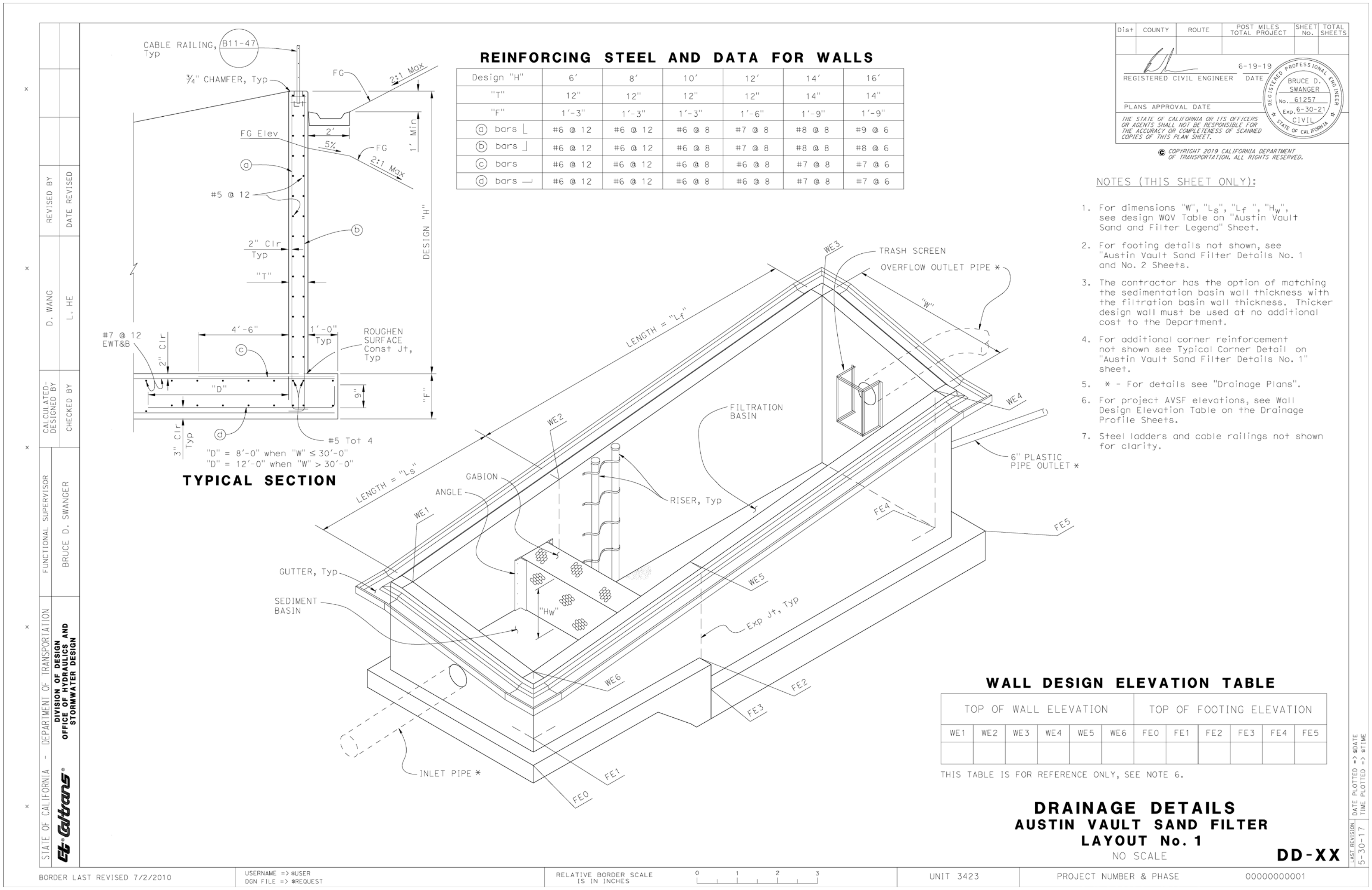


Figure 9-1. AVSF Location

This page intentionally left blank.



REINFORCING STEEL AND DATA FOR WALLS

Design "H"	6'	8'	10'	12'	14'	16'
"T"	12"	12"	12"	12"	14"	14"
"F"	1'-3"	1'-3"	1'-3"	1'-6"	1'-9"	1'-9"
(a) bars	#6 @ 12	#6 @ 12	#6 @ 8	#7 @ 8	#8 @ 8	#9 @ 6
(b) bars	#6 @ 12	#6 @ 12	#6 @ 8	#7 @ 8	#8 @ 8	#8 @ 6
(c) bars	#6 @ 12	#6 @ 12	#6 @ 8	#6 @ 8	#7 @ 8	#7 @ 6
(d) bars	#6 @ 12	#6 @ 12	#6 @ 8	#6 @ 8	#7 @ 8	#7 @ 6

WALL DESIGN ELEVATION TABLE

TOP OF WALL ELEVATION						TOP OF FOOTING ELEVATION					
WE1	WE2	WE3	WE4	WE5	WE6	FE0	FE1	FE2	FE3	FE4	FE5

Figure 9-2. AVSF Layout

This page intentionally left blank.

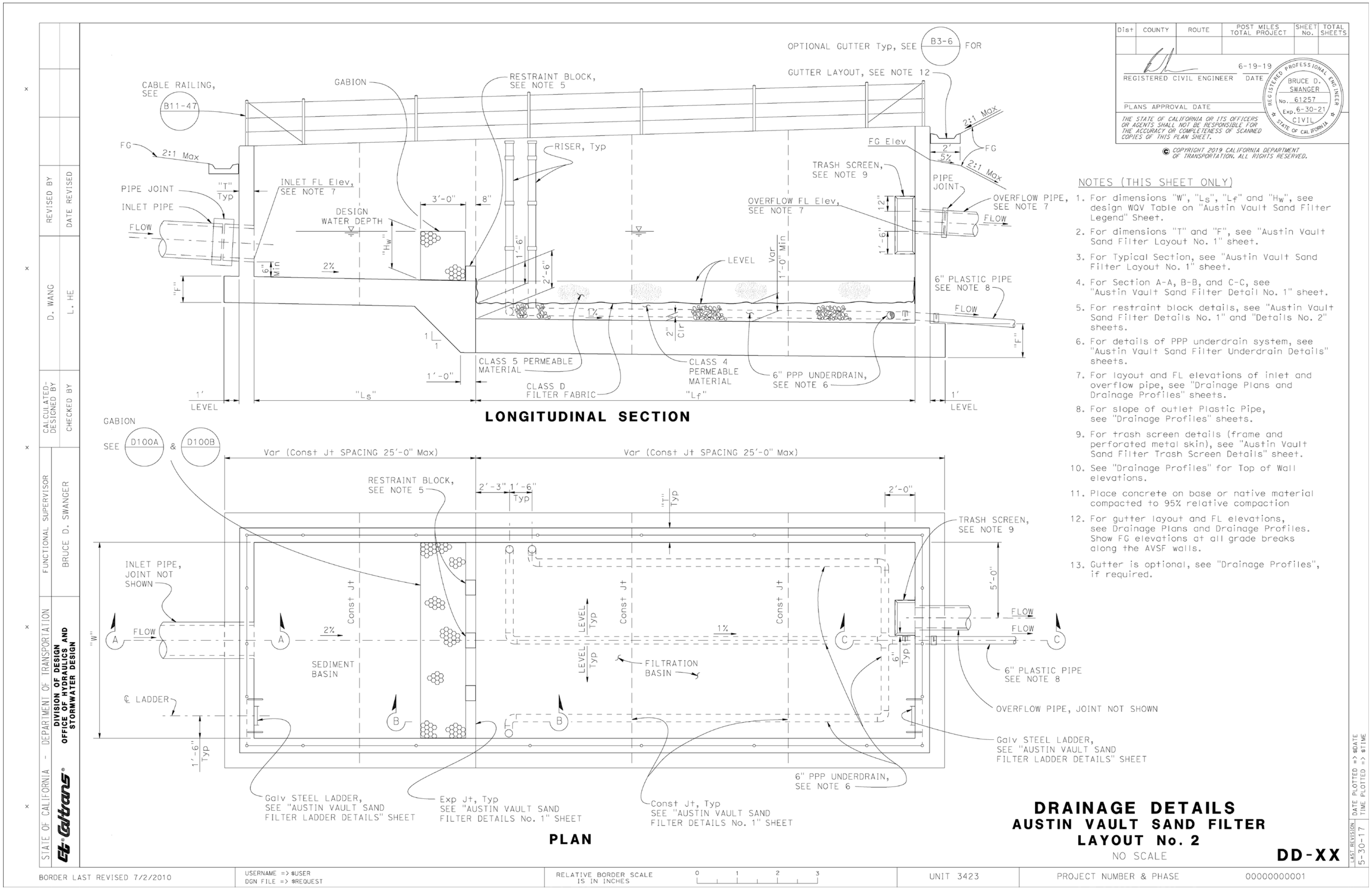


Figure 9-3. AVSF Wall Elevations

This page intentionally left blank.

Section 10

References

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

California Department of Transportation (Caltrans), 2016. Caltrans AVSF Calculation Spreadsheet, AVSF_quantities_modified_djd_rev7.xls, available upon request from OHSD, Accessed 2016.

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

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

California Department of Transportation (Caltrans), 2020b. Caltrans AVSF Detail Drawings, 132ASFVltParSedPlans.zip, available upon request from OHSD, Accessed June 2020.

California Department of Transportation (Caltrans), 2020c. Stormwater Quality Handbooks: Austin Sand Filter – Earthen Type Design Guidance, December 2020

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

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

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"

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

This page intentionally left blank.