Infiltration Basin

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
ac	acres
ac-ft	acre foot/feet
ADT	average daily traffic
ASTM	American Society of Testing and Materials
BEES	Basic Engineering Estimating System
BMP	Best Management Practice
CRZ	Clear Recovery Zone, (AASHTO Clear Zone)
CDA	contributing drainage area
CDPH	California Department of Public Health
CF	cubic foot
cfs	cubic feet per second
CMP	corrugated metal pipe
CY	cubic yard
DPP	Design Pollution Prevention
DPPIA	Design Pollution Prevention Infiltration Area
DWR	Department of Water Resources
FHWA	Federal Highway Administration
ft	foot/feet
ft/s	foot/feet per second
GIS	Geographic Information System
H:V	Horizontal:Vertical
HDM	Highway Design Manual
HEC	Hydraulic Engineering Circular
HQ	Headquarters
hr	hour
HSG	Hydrologic Soils Group
IDF	Intensity-Duration-Frequency
in	inches
LID	Low Impact Development
max	maximum
min	minimum
MSL	Mean Sea Level
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
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 Estimate
PID	Project Initiation Document
PPCE	Project Planning Cost Estimate
PPDG	Project Planning and Design Guide – Storm Water Quality Handbook
PS&E	Plans, Specifications and Estimate
RWQCB	Regional Water Quality Control Board
sec	second
SQFT	square feet
SQYD	square yard
SSPs	Standard Special Provisions
SWDR	Stormwater Data Report
TBMP	Treatment Best Management Practice
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
WQF	Water Quality Flow
WQV	Water Quality Volume

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Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating Infiltration Basin Treatment Best Management Practices (TBMPs) into projects during the planning and design phases of Caltrans highways and facilities. Infiltration Basins are bermed or excavated areas designed to temporarily store runoff for infiltration into underlying soil over a limited period. Infiltration Basins treat water quality volume through infiltration. An Infiltration Basin may also be known as a retention basin, percolation pond, or recharge basin. The primary functions of this document are to:

1. Describe an Infiltration Basin
2. Provide design guidance
3. Review the required elements for implementing the Infiltration Basin 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 Infiltration Basin 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). Coordination with other functional experts is necessary to implement successful and functioning Infiltration Basins.

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 District Landscape Architect for appropriate vegetation 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, when possible or desired, that does not require irrigation and requires the least amount of maintenance.

1.2 Infiltration Basins

Infiltration Basins utilize bermed or excavated areas to store runoff for infiltration. During a storm, runoff enters the Infiltration Basin causing the water level in the basin to rise. During the rainfall, and for some time after it ends, the runoff infiltrates into the soils through the invert area, which is sized based upon the WQV, the permeability of the soil below the invert, and the time period selected for infiltration. It is preferred that events greater than the Water Quality Event be bypassed around the BMP to preserve infiltration capacity, to prevent resuspension of captured pollutants, and to minimize the size of the BMP. Flows can be passed through the BMP, typically over a spillway through the confining berm, or through an overflow riser when necessary.

Infiltration Basins are considered highly effective at removing sediments, nutrients, pesticides, full trash capture, metals, pathogens and bacteria, oil and grease, organics, turbidity, temperature, and mercury as noted in the PPDG and TC-11 of the California Stormwater Quality Association (CASQA) manual (CASQA 2003). Due to the effectiveness of treatment, infiltration is always a first choice to be considered when selecting a TBMP for a Caltrans project.

Infiltration Basins may be configured in different shapes to meet right-of-way restrictions and to conform to the available space and topography. Consider ease of construction and maintenance in the basin design. Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the CRZ.

A schematic of a typical Infiltration Basin is shown in Figure 1-1.

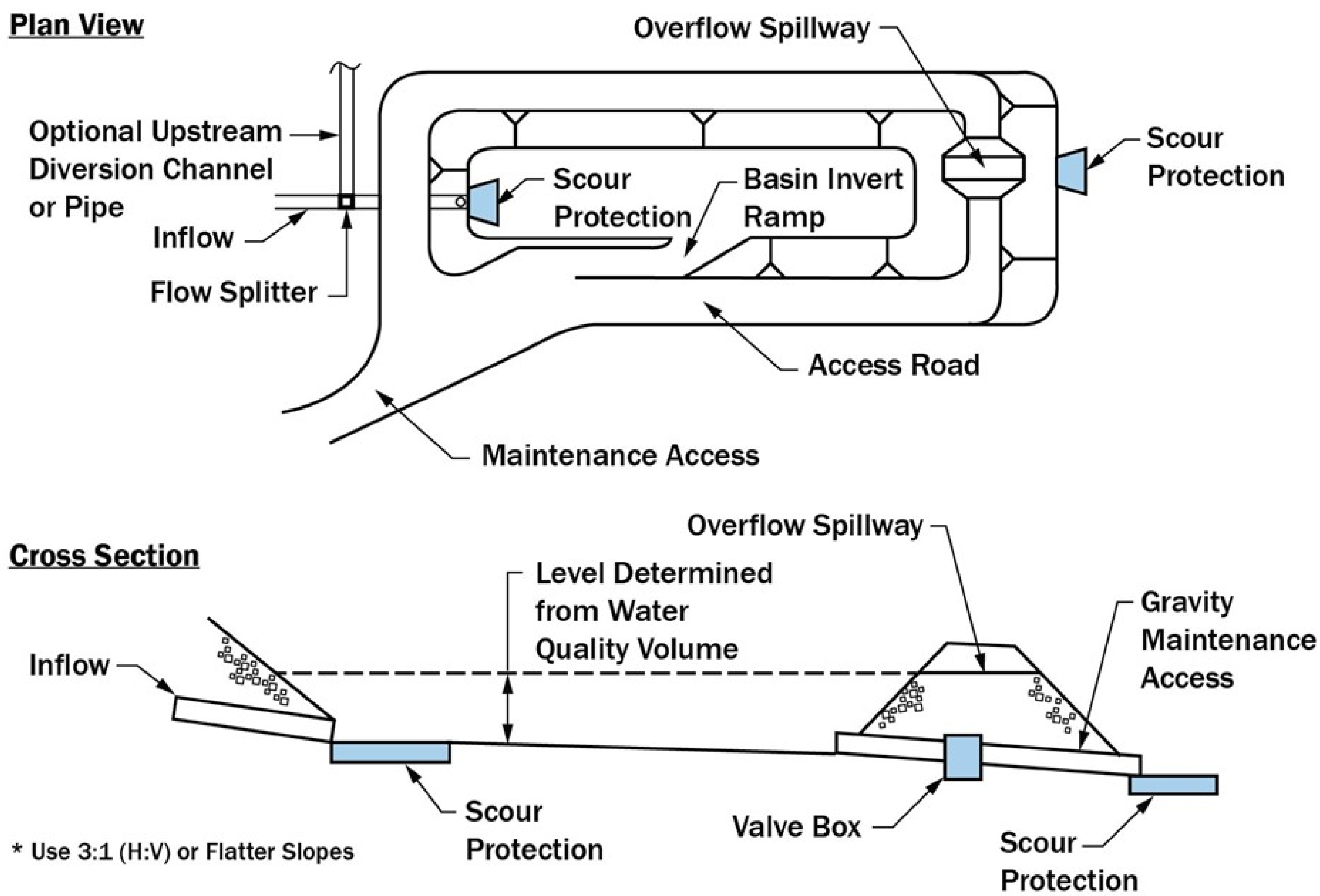

Figure 1-1. Schematic of an Infiltration Basin

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Section 2

Design Considerations

Checklist T-1, Part 2 in the PPDG, assists the PE in evaluating the initial feasibility of Infiltration Basins for a project. The checklist identifies design elements that should be considered during the design of Infiltration Basins. Once the feasibility of the device has been confirmed using Checklist T-1, Part 2 in PPDG, the PE should use the following subsections and Section 3 to further understand the design elements of an Infiltration Basin for a given site.

2.1 Appropriate Applications and Siting

Infiltration Basins may be considered whenever site conditions are favorable for infiltration or can be amended to enhance infiltration, safety criteria are met, and where flow velocities can be mitigated to prevent scour. The site should have sufficient area for pretreatment BMPs (e.g., Biofiltration Strips, Biofiltration Swales, TST) upstream of the basin. The Regional Water Quality Control Board (RWQCB) having jurisdiction may impose additional requirements for water protection purposes.

Consultation with the RWQCB should include an assessment of whether infiltration would exacerbate existing groundwater accretion problems. Groundwater accretion has been implicated in certain areas as a contributing factor to impairment by salt and other salt-associated dissolved constituents, such as boron, selenium, sulfate, and chloride. If stormwater infiltration is determined to increase the risk of groundwater accretion and seepage of high total dissolved solids (TDS) water from down gradient areas, infiltration may not be appropriate.

Additional design criteria applicable to the siting of Infiltration Basin TBMPs are:

1. Runoff quality must meet or exceed standards for infiltration to local groundwater as set by the RWQCB or another local agency; consult with the District/Regional NPDES Coordinator.
2. Should not be located closer than: i) 1,000 ft from any municipal water supply well; ii) 100 ft from any private well, septic tank, or drain field; and iii) 200 ft from a Holocene fault zone.
3. May be considered unsuitable if in close proximity to a Drinking Water Reservoir or a Recharge Facility due to difficulty in cleaning in the event of a spill; consult with the District/Regional NPDES Coordinator and the most recent District Work Plan.

4. Should not be used in fill sites, or on cut slopes steeper than 15 percent (3.7H:1V) unless the location is approved in a geotechnical report.
5. Cannot be used within 10 ft down gradient or 100 ft up gradient of building or other structure foundations when infiltrating to near surface groundwater, geotechnical concurrence should be sought.
6. A proposed site having hazardous soils that would not be completely removed during the excavation, or a site above a contaminated groundwater plume, must receive the concurrence of the District/Regional NPDES Coordinator.
7. Infiltration Basins should be placed offline. Even when placed offline, the basin must be configured with an overflow release device. (See Section 2.8.2) Infiltration Basins may be placed inline when upstream diversion is not feasible in which case, a downstream overflow outlet must be sized to pass the Design Storm.
8. Pretreatment BMPs to capture sediment in the runoff are recommended for Infiltration Basins.
9. Contributing drainage area, conveyance channels, and all inlets to the Infiltration Basin should be stabilized or pretreated to prevent sediment discharge to the Infiltration Basin. Runoff velocities into the Infiltration Basin should be considered for erosion potential; a low flow channel or other energy dissipator can be used to prevent erosion within the Infiltration Basin.
10. An alternative method of draining the Infiltration Basin should be considered (e.g., sump area, drain valve).
11. An access ramp to the basin invert should be provided unless Maintenance concurs with access over the proposed side slopes.
12. Water stored in the Infiltration Basin, when constructed inline, must not cause an objectionable backwater condition upstream in the storm drain system that would adversely impact its ability to convey flows generated by the Design Storms as required in the HDM.
13. Whenever possible provide some type of full trash capture, at the best available location within the basin, to create a multi benefit TBMP that has a full trash capture feature, see Section 2.8.5.

2.2 Site Soils and Infiltration

Infiltration Basins should be located above permeable soils to limit the area of the invert. The soils immediately below the invert should have permeability between 0.5 in/hr and 2.5 in/hr. Infiltration rates over 2.5 in/hr must be justified by adequate groundwater information. If infiltration rates are significantly higher, consider impacts to groundwater quality based on seasonally high groundwater. Coordinate with Geotechnical Design to discuss methods to mitigate high infiltration rates. Contact the District/Regional NPDES Coordinator to determine if consultation with the RWQCB on infiltration rates is needed. Related to permeability, the underlying soils should be classified as NRCS Hydrologic Soils Group (HSG) as A, B, or C and the WQV should infiltrate within a maximum of 96-hours. If an Infiltration Basin is proposed over HSG D soils or if the drawdown time is longer than 96-hours, vector control meeting California Department of Public Health requirements must be implemented. Coordinate with the District/Regional Design Stormwater Coordinator when longer drawdown times are being considered.

Proposed sites for Infiltration Basins should be excluded from consideration if the site is constructed in fill or partially in fill, unless the location is approved in a geotechnical report. The area identified for infiltration should be clearly marked on the plans and delineated in the field. The contractor should only be allowed to access the area during construction of the basin. Use of heavy equipment should be limited or prohibited to prevent compaction of the underlying soils intended for infiltration.

Specific soils testing to be reported in the Geotechnical Design Report must be carefully considered. Soil testing, including determining the infiltration rate of site soils, should be completed as part of the Geotechnical request. The infiltration and soil property tests that may be considered for inclusion in the Geotechnical request are listed in Tables 2-1 and 2-2.

Table 2-1. Infiltration and Soil Properties Testing Table for Input into the Caltrans Infiltration Tool

Parameter	Test Method(s)
Infiltration Rate, in/hr	CTM 750 (modified for shallow depth) ASTM D5126 (Single-Ring/Infiltrometer) ASTM D3385 (Double-Ring/Infiltrometer) ASTM D8152-18 (Modified Philip Dunne/Infiltrometer) CTM 220
Bulk Density Dry Density Water Content	ASTM D7263-09 ASTM D1557 CTM 216 – compaction behavior
Specific Gravity	CTM 209 – specific gravity of the soil ASTM D1557 ASTM D854
Void Ratio	ASTM D1556

Table 2-2. Other Possible Soil Tests	
Parameter	Test Method(s)
Hydraulic Conductivity, Saturated	ASTM D5856
Soil Classification	AASHTO M145 ASTM D2487
Particle Size Distribution	CTM 202 - sieve analysis CTM 203 - hydrometer
Remolded Moisture Curve	ASTM D698 ASTM D1557

In addition to the soil tests listed above there may be additional effort to ensure the effectiveness of the infiltration areas:

- Which project phase the tests are completed in, as some preliminary information may be needed prior to PS&E
- The number of tests needed and spacing of the tests (i.e., if the BMP is 50 ft long vs. 0.25 mile long) to adequately categorize conditions
- Shallow depth of geotechnical tests to estimate infiltration rates

2.3 Invert Separation from Seasonally High Groundwater

Some treatment is provided by the soil below the invert while the runoff is infiltrating, and therefore a separation between seasonally high groundwater and Infiltration Basin inverts is desired; the separation should be 5-ft. Less separation may be considered if justified by adequate groundwater information or by RWQCB concurrence. Infiltration Basins should not be located in areas containing fractured rock within 10 ft of invert. Sites that have subsurface conditions that may be of concern should be discussed with the District/Regional Design Stormwater Coordinator.

2.4 Geometric Shape and Side Slopes for Confining Berm

An Infiltration Basin may assume a plan view configuration consistent with other design requirements such as the surrounding topography, access, and construction issues. Interior side slopes are recommended as 4H:1V or flatter to minimize internal erosion. Side slopes may be steepened up to 3H:1V with the concurrence of District Maintenance.

The width for the flat crest of a confinement berm may be set by requirements for: i) Maintenance access; ii) the breadth of a spillway (discussed in Sections 6.2 and 8.1); iii) or general construction considerations. Minimum width at the top of a bermed confinement should be determined based on design.

Areas immediately adjacent to the Infiltration Basin should be graded to drain such that runoff is not directed into the basin unless the basin is sized to accommodate the increased runoff.

2.5 Safety Considerations

Infiltration Basin TBMPs should be located using the general roadway drainage considerations for safety and CRZ concept in the AASHTO manual (AASHTO 2011). An important part of highway drainage facility design is that of traffic safety. The Infiltration Basin should provide a traversable section for errant traffic leaving the traveled way within the CRZ (HDM Topics 304, 309, and 861.4). It is recommended as a general practice to discuss the proposed location with the Traffic Operations Unit even if outside the CRZ.

Coordinate with other functional experts such as District Traffic Operations, District Maintenance, District Hydraulics, Geotechnical Design, and Traffic Safety, as applicable.

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

2.6 Maintenance

Discuss proposed Infiltration Basin 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 Infiltration Basin. Additionally, a ramp to the basin invert and an alternative method of draining the Infiltration Basin should be considered. Maintenance access ramp design is discussed in detail in the Supplemental Details Design Guidance (Caltrans 2020d).

2.7 Vegetation in Infiltration Basins

Vegetation in Infiltration Basins at the invert and side slopes is encouraged, both for aesthetic reasons and performance. The use of diverse and locally appropriate grass species is recommended. For additional information about plant species suited to the conditions within the Infiltration Basin, on a location-specific basis within the various ecological subregions of California, consult:

- District Landscape Architecture
- The Biofiltration Strip Design Guidance (Caltrans 2020b) and Biofiltration Swale Design Guidance (Caltrans 2020c)
- Ecological Subregions of California Section and Subsection Descriptions, USDA, Forest Service, USDA, Natural Resources Conservation Service,

published May 1998 (online at: http://www.fs.fed.us/r5/projects/ecoregions/) (USDA 1998)

- Calflora Database (online at: http://www.calflora.org)
- Calscape native grass database (online at: https://calscape.org/loc-California/cat-Grasses/ord-popular)

2.8 Other Issues

2.8.1 Upstream Effects

While Infiltration Basins 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.

2.8.2 Inline vs. Offline Placement

An Infiltration Basin can be placed in an inline or offline configuration.

A. Inline Placement

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

Because the volume of the Infiltration Basin is designed for the WQV, alternate means of safely conveying the events larger than the Water Quality Event must be provided. Additionally, the Infiltration Basin must be able to pass the runoff generated during the Design Storm (see Section 2.8.3) 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 2.8.3.

B. Offline Placement

An Infiltration Basin is placed in an offline configuration when an alternate route for the overflow events is provided. The excess runoff is diverted around the Infiltration Basin 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 (see Vault Flow Splitters Design Guidance, Caltrans 2020e). Overflow devices must be considered for offline placement of Infiltration Basins in accordance with Section 2.8.3.

2.8.3 Design Storm and Overflow Release

When placed inline, Infiltration Basins must safely pass events that exceed the WQV. The overflow device is often a weir which can be configured as an open top of a riser pipe or stand pipe, or as a spillway through the confinement berm. The release elevation should be set to the surface of 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 event used in the design of the overflow device is the Design Storm, and it must be consistent with the intensity, duration, and frequency of the rainfall event used in the roadway drainage design for that contributing drainage area (CDA) generating runoff to the TBMP[1] . 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.

2.8.4 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.

2.8.5 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 Infiltration Basin 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

[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.

The Infiltration Basin 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 Infiltration Basin. 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 3

Feasibility Analysis

The following steps are recommended for determining the feasibility of an Infiltration Device:

1. Pre-screening
2. Site Screening
3. Site Investigation
4. Preliminary Design (Section 4)

3.1 Pre-Screening

Pre-screening for the Infiltration Device involves collecting site-specific information necessary to determine whether infiltration is an appropriate stormwater treatment method and to ensure the site meets criteria established by the local RWQCB. Consult with the District/Regional NPDES Coordinator to obtain RWQCB criteria. No field testing is anticipated during this early investigation.

The steps involved in pre-screening include:

- Information Collection
- Preliminary Determination of Infiltration Appropriateness

Pre-screening is usually conducted as early in the project as feasible, often during the Project Initiation Document (PID) phase. Discuss the proposed site with the Geotechnical Design representative to determine if a Preliminary Geotechnical investigation would be beneficial at this stage of the project.

3.1.1 Information Collection

Some of the basic site-specific data required for the determination of the appropriateness of an Infiltration Device are found in the sources listed below. Additional data may be required for local conditions. Data collected by Caltrans project engineering staff and Caltrans District/Regional Stormwater Coordinators include, but may not be limited to:

- Outfall inventory data available through District/Regional Stormwater Coordinators, project alignment, right-of-way, annual average daily traffic (ADT), Caltrans outfall locations, and other basic project maps and data.
- CDAs and surrounding land uses from outfall inventory, as-built drawings, aerial photographs, Geographic Information System (GIS) data from Caltrans and local planning agencies, etc.

- Site surface hydrology data: CDA, runoff coefficients, drainage network, travel times, etc., needed to design facilities to Caltrans hydrologic/hydraulic criteria.
- Basin Plan groundwater beneficial uses and known impairments (RWQCB).
- Caltrans runoff quality data appropriate for the Caltrans land use in the CDA (Caltrans Annual Report or Caltrans Discharge Characterization Study Report [CT SW-RT-03-065.51.42]).
- WQV calculated in accordance with Section 5.1.

Site soil characteristics:

- Indigenous soil types: Natural Resources Conservation Services (NRCS) soil maps and corresponding hydrologic soil classes, USCS classifications, or University of California at Davis's SoilWeb soil web search tool.
- Log of Test Borings for any nearby structures. Existing Geotechnical Reports can be found at GeoDOG
- Soil infiltration rates (estimated and from any existing on-site testing in the vicinity)
- Caltrans project grading plans or as-built plans (if retrofit), if available
- Sample Blow Counts – as part of hollow stem auger drill hole subsurface investigations, 6" and 12" blow counts can provide information on the hardness of the underlying soils and estimated infiltration rates.
- Drill Hole Percolation Tests – 2" polyvinyl-chloride (PVC) perforated casing can be used in the drill hole to get infiltration rates at specific depths.
- Grain Size Curves – Gradation classification will help determine the suitability of an area for infiltration. Locations that contain large fractions of silt and clay where the D_{10} > 0.02mm and D_{20}> 0.06mm may indicate slow infiltration rates.

Existing groundwater and hydrogeology information:

- The Department of Water Resources has an on-line service that provides historic groundwater elevations called California Statewide Groundwater Elevation Monitoring https://www.casgem.water.ca.gov/
- Maps of local aquifers underlying the alignment or location of the proposed Caltrans project
- Aquifer groundwater quality and seasonal groundwater levels
- Monitoring well data, U.S. Geological Survey (USGS), Department of Water Resources (DWR), and local public agency maps and databases (e.g., http://wdl.water.ca.gov/)

Local groundwater quality concerns:

- Consult RWQCB, California Department of Toxic Substances Control (DTSC), local environmental/health department (city/county)

- Site hydrogeology from any existing boring logs: lenses, hardpan, etc.
- Known contaminated groundwater plumes (RWQCB)
- Groundwater rights data: adjudicated groundwater basins, other rights (RWQCB, California Department of Public Health (CDPH))
- State Water Information Management System data for project area (State Water Resources Control Board)

3.1.2 Preliminary Determination of Infiltration Appropriateness

Once the data have been collected and placed in the context of the alignment and/or location of the Caltrans facility being considered for Infiltration Devices, the PE and the District/Regional Design Stormwater Coordinator will use the data and follow the procedure outlined in Figure 3-1.

Applicable steps for determination of infiltration appropriateness include:

1. Estimate the quality of runoff from the Caltrans facility draining into the proposed Infiltration Device using data from the Caltrans stormwater database and annual research summaries.
2. Determine if local Basin Plan or other local ordinances provide limits on quality of water that can be infiltrated. Compare with Caltrans runoff quality and determine if infiltration is permissible. If not, document inapplicability of infiltration in the Stormwater Data Report (SWDR) and continue to step 5 for consideration of other approved TBMPs.
3. Determine if local agencies, public health authorities, legal restrictions, or other concerns preclude consideration of infiltration of stormwater runoff. Consult with District/Regional NPDES Coordinator and representatives of appropriate authorities as needed. If infiltration into the aquifer is not acceptable to local authorities, document inapplicability of infiltration in the project SWDR, and continue to step 5 for consideration of other approved TBMPs.
4. Compare the estimated Caltrans runoff water quality with available groundwater quality data using the receiving water quality objectives from the RWQCB Basin Plan for each groundwater beneficial use. Determine if the separation between the maximum anticipated seasonal high groundwater table and the proposed device invert is at least 5 ft (or less if justified by adequate groundwater information). Tabulate the results and make a preliminary determination of the appropriateness of the Infiltration Device.
5. If the determination is that infiltration is not appropriate, document in the SWDR then consider other approved TBMPs using Checklist T-1, Part 1 in the PPDG. If determination is that infiltration is potentially appropriate, proceed to Site Screening.

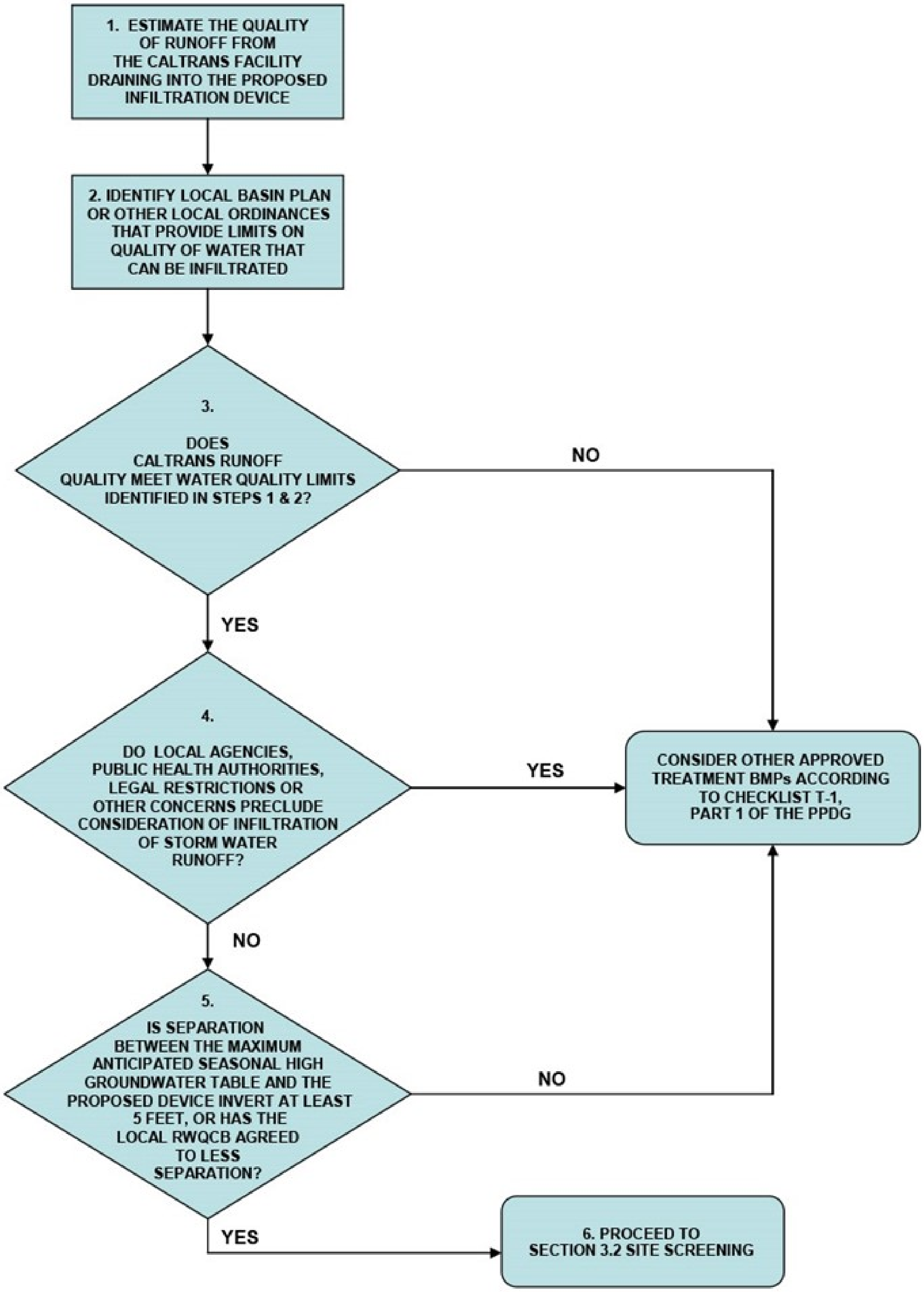

Figure 3-1. Pre-screening for Infiltration Devices

3.2 Site Screening

Using data gathered in the pre-screening process, perform an initial screening of the potential sites, including sites outside of the existing Caltrans right-of-way, to identify the sites to consider for field investigations. Collect additional information as needed then follow the following procedure:

- Identify existing soil type from soil maps and/or U.S. Department of Agriculture (USDA) soil survey tables and/or background information. Consider NRCS HSG A, B, and C. If HSG D is present, vector control may be required. HSG classifications are shown in Table 5-1. In areas where septic systems are in widespread use, the County Environmental Health Department may have information on on-site soil types and infiltration.
- Review other available soils data: percent silt and clay, presence of a restrictive layer, permeable layers interbedded with impermeable layers, and seasonal high-water table. Other geotechnical considerations that may prohibit usage include location in seismic impact zones, unstable areas such as landslides and Karst terrains, and areas with soil liquefaction and differential settlement potential or highly expansive/collapsible soils. Generally, Infiltration Devices should not be constructed in fill or on any slope greater than 15 percent.
- The minimum acceptable spacing between the proposed Infiltration Device invert and the maximum seasonal high groundwater table is 5 ft. If a separation of less than 5 ft is proposed, it must be justified by adequate groundwater information or RWQCB concurrence.

3.3 Site Investigation

This step is usually conducted during the PS&E phase of the project but considered in the Project Approval/Environmental Document (PA/ED) phase. After the desktop screening of sites has been completed, proceed with field investigations of the remaining potential sites. Under this section a two-stage approach to the geotechnical investigation is proposed, 3.3.1 Procedure for Preliminary Infiltration Device Site Investigation and 3.3.2 Detailed Investigation. However, due to potential difficulties in scheduling geotechnical fieldwork, those activities might be conducted jointly.

- Perform site investigation to identify any: (a) regulatory permits that are required, (b) underground utility interference, (c) transportation improvement plan conflicts, or (d) general plan land use data for CDA.
- If considering a parcel outside of the right-of-way, Caltrans must generate greater than 50 percent of the total runoff directed toward that parcel; otherwise investigate opportunities for a cooperative agreement to share stormwater treatment facilities with the other agency, county, or city responsible for the additional flow.

- Assess the feasibility (e.g., degree of plumbing, features or construction practices required, available area) of directing additional runoff to the device; additional Caltrans runoff would have priority. Consider potential downstream impacts from diversions and cost of diverting additional flow. Diversions of runoff from outside the CDA of the Infiltration Device to unimproved conveyances (creeks/streams) are prohibited due to the increased potential for erosion. Diversions to improved conveyances may be permitted if it can be demonstrated that the conveyance has sufficient capacity to accommodate the additional flow, and other environmental considerations are favorable or neutral. If such diversion is being considered, consult with District/Regional Environmental and District Hydraulics units.
- Investigate feasibility of infiltration using criteria and the procedure in Section 3.1.1. Recalculate and verify area requirements using the collected field data. Use Equation 2 (see Section 5.1) and the lowest measured or anticipated infiltration rate, or value considered representative of by the geotechnical professional, to calculate area of the Infiltration Device.
- If an Infiltration Device is feasible, proceed to Section 4.

3.3.1 Procedure for Preliminary Infiltration Device Site Investigation

The following scope of work defines the steps for Infiltration Device studies necessary to determine if an Infiltration Device is feasible. The screening procedure is terminated if the site does not meet the criteria for any step, and assessment of the site would continue for other approved TBMPs.

The depth to groundwater must be known as a first step in determining feasibility because a high groundwater table can lead to infiltration failure and potential contamination of the groundwater table. The in-situ infiltration rate at the device invert must also be known or reasonably estimated to ensure that infiltration of the calculated WQV is possible within 96 hours. Longer drawdown times may be allowable if vector controls have been implemented; coordinate with the District/Regional Design Stormwater Coordinator. Due to the potential variability of site conditions, field investigation is almost always required to determine the depth to groundwater and to provide an evaluation of the in-situ infiltration rate.

3.3.2 Initial Investigation

The initial investigation comprises two parts: A) initial technical field screening and determination of groundwater elevations, and B) geotechnical investigation for soil lithology and select chemical testing. To streamline the initial investigation phase, Part A will be performed first and if the Part A criterion of at least 5 ft clearance for the groundwater elevation below the device invert is satisfied, then the site is deemed appropriate for further consideration. Less separation may be allowable if justified by adequate groundwater information or RWQCB concurrence.

Part A: Initial Technical Field Screening and Determination of Groundwater Elevation

A local or regional groundwater review will be performed based on the available data, including, but not limited to:

- Previously compiled databases on potential BMP sites (such as outfall inventory databases)
- Data and maps available from regional government databases, DWR, USGS, other local agencies and internal Caltrans sources like GeoDOG
- Local soil survey data from the NRCS and other sources
- Soil lithology, infiltration rate and groundwater depth data from the county or other specialists that approve septic system installations in the local area
- Information on local groundwater beneficial uses and groundwater quality issues from the RWQCBs and other water resource agencies
- Information on local groundwater-related drinking water issues from CDPH

An initial indication of the seasonal high groundwater water table elevation will be determined by using a piezometer, previous studies, or other accepted geotechnical means. The piezometer will be installed to a depth of at least 20 ft below the proposed device invert using the direct push or other suitable method. Initial groundwater levels will be recorded at least 24 hours after installation.

The geotechnical professional will make a determination on a site-by-site basis, whether the groundwater elevation determined after 24 hours can be considered to be a reasonable indication of the seasonal high-water table for the purposes of the evaluation of the groundwater depth criterion, described as follows. If such determination cannot be made reasonably based on the available data, the site will be recommended for a longer period of water table elevation monitoring, as necessary.

If the initial seasonal high groundwater elevation indication is within 5 ft of the invert of the proposed Infiltration Device then use of the site must be justified by adequate groundwater information or RWQCB concurrence. If there is not a reliable indication that the seasonal high water table is at least 5 ft below the invert of the proposed Infiltration Device, a more extensive groundwater table elevation investigation will be performed as described in Section 3.3.2 Part C. If the groundwater elevation at the site is clearly deeper than 5 ft from the proposed device invert and all other criteria in the initial investigation are satisfied, a detailed groundwater elevation determination will not be required.

Part B. Geotechnical Investigation for Soil Lithology and Select Chemical Testing

Perform an initial soil investigation to adequately evaluate soil lithology and to determine:

- If there are potential problems in the soil structure that would inhibit the rate or quantity of infiltration desired
- If there are potential adverse impacts to site structures, slopes, or groundwater that could result from the Infiltration Device location

Geotechnical trenches (a boring may be used at the option of the geotechnical professional) will be dug using a backhoe at one or two locations within each site, depending on the site conditions. Clearance of the site for hazardous contaminants through the appropriate District Unit should be done prior to drilling by the geotechnical professional conducting the work. An Underground Service Alert (USA) clearance must also be obtained. The trenches will be at least 6 ft long and 6 ft below the proposed device invert. The soil profiles will be carefully logged to determine variations in the subsurface profile. Of greatest importance is the presence of fine-grained materials such as silts and clays, which should be determined by direct measurement of particle size distribution. Two to four soil samples should be collected for determination of the soil particle size distribution at each site. Samples should be collected from the soil profiles at different horizons and transported to a laboratory for soil indices testing, plasticity, and chemical testing described as follows:

- Soil textures or classifications that are conducive to infiltration include sands, loamy sands, sandy loams, loams, silt loams, and silt in the NRCS classification system, or GW, GM, SP, SW, GC, SC, SM, and ML (in the Unified Soil Classification System [USCS]) as long as the soil does not have more than 30 percent clay or more than 40 percent of clay and silt combined.
- The soil in the first 12 inches below the basin invert will be tested for organic content (OC), pH, and cation exchange capacity (CEC) only if required by the local approving agency. Notify Geotechnical Services prior to site investigation if this testing is required. Values that promote pollutant capture in the soil are: OC > 5 percent, pH in the range of 6-8, and CEC > 5 meq/100 g of soil. Note that soils that have this CEC value are typically fine-grained and would likely be rejected for infiltration based on permeability considerations.

In addition, the trenches or samples from borings should be examined for other characteristics that may adversely affect infiltration. These include evidence of significant mottling (indicative of high groundwater), restrictive layer(s), and significant variation in soil types, either horizontally or vertically. A summary geotechnical report will be prepared addressing the issues noted in this section, with recommendations on the suitability of the site for infiltration and the necessity of carrying out the next phase of the investigation. All the site reports will ultimately be combined in a single report. The geotechnical professional will develop the detailed investigation phase for the sites deemed acceptable from the initial investigation.

3.3.3 Detailed Investigation

If the site conditions appear favorable to infiltration after the geotechnical review and soil investigations, a detailed field investigation will be undertaken, which includes Part A, Detailed Subsurface Soil Investigation, Part B, Permeability Testing, and Part C, Detailed Groundwater Elevation Determination (if required by the geotechnical professional).

Part A. Detailed Subsurface Soil Investigation

For each detailed investigation location, borings will be drilled to a maximum depth of 50 ft, or refusal in rock or rock-like material at a lesser depth, below the invert of the proposed basin, and to a minimum depth of 3 times the WQV depth of water when in the basin.. The boring drilled depth is the depth of interest and may be different at each location. Samples will be obtained at 5-ft intervals for soil characterization and/or laboratory testing. Bulk samples will also be collected at shallow depths (i.e., just below the invert elevation) to verify information collected in Parts A and B of the Initial Investigation.

Part B. Permeability Testing

No single test method is appropriate for the variety of subsurface conditions that might be encountered. For example, a percolation test at the invert elevation might not disclose the existence of layers of either highly permeable or low permeability within the depth of interest. Rather, a permeability evaluation below the invert of the proposed Infiltration Device will be made using infiltration rate tests or other method(s) selected by the geotechnical professional.

Generally, the minimum acceptable infiltration rate for an Infiltration Device will be 0.5 in/hr, however, lower infiltration may be allowable if the drawdown time is within 96-hrs. Coordinate with the District/Regional Design Stormwater Coordinator. If any test hole shows less than the minimum value, the site may be disqualified from further consideration unless strong local geotechnical evidence exists to predict the successful performance of the device. In which case, the infiltration rate provided by the geotechnical professional should be a value considered representative of the Infiltration Device. If the infiltration rate at the site is greater than 2.5 in/hr, the rate must be justified by adequate groundwater information and groundwater quality impacts must be considered based on depth to seasonally high groundwater. Contact the District/Regional NPDES Coordinator to determine if consultation with the RWQCB is needed.

If the site is constructed in fill or partially in fill, it will generally be excluded from consideration unless no silts or clays are present in the soil boring within 13 ft of the device invert or as approved by the Geotechnical Engineer. Fill tends to be compacted with reduced permeability.

The geotechnical investigation will be sufficient to develop an adequate understanding of how the stormwater runoff will move horizontally and vertically through the soil and to determine if there are any geological conditions that could inhibit the movement of water.

Part C. Detailed Groundwater Elevation Determination

If a detailed investigation to determine the groundwater elevation is required per this guidance and in the opinion of the geotechnical professional the seasonal high groundwater elevation may come within 5 ft of proposed device invert, at least one groundwater monitoring well will be installed at a representative location. The well(s) will be observed over a wet and dry season. This observation period will be extended to a second wet season, at the direction of Caltrans, if the first wet season produces regional rainfall less than 80 percent of the historical average. The minimum acceptable spacing between the proposed Infiltration Device invert and the seasonal high-water table is 5 ft unless, in coordination with the RWQCB, it can be demonstrated that the groundwater will not be adversely impacted. A geotechnical professional will oversee the detailed investigation and must also consider other potential factors that may influence the groundwater elevation, such as local or regional groundwater recharge projects, future urbanization, or agricultural practices. The geotechnical professional should also examine the soil borings for indications of previous high water.

A final geotechnical report, overseen by a geotechnical professional, summarizing the findings of the investigation will be prepared. The report will include all results from the initial as well as detailed investigation phases of the feasibility study.

Section 4

Basis of Infiltration Basin Design

After the feasibility of the device has been confirmed using Sections 2 and 3, and Checklist T-1, Part 2 in the PPDG, use the following subsections to further understand the design elements of an Infiltration Basin for a given site.

4.1 Preliminary Design Criteria

Infiltration Basins must meet certain design criteria to perform as an effective TBMP. The primary factors to be incorporated into the design are found below in Table 4-1.

Table 4-1. Infiltration Basin Design Criteria

Parameter	Minimum Value	Maximum Value
Runoff Volume	For water quality treatment: WQV, or portion thereof	None as long as other site conditions and requirements are met[1]
Freeboard[2]	1 ft minimum	1 ft minimum
Design Overflow Event	Use the HDM Design Storm or local regulations; see also discussion under Section 2.8.3	Use the HDM Design Storm or local regulations; see also discussion under Section 2.8.3
Overflow Spillway Length	Minimum 3 ft spillway length; may use 36-inch diameter (min) corrugated metal pipe (CMP) outlet riser	Minimum 3 ft spillway length; may use 36-inch diameter (min) corrugated metal pipe (CMP) outlet riser
Invert Slope	0% (preferred)	3%
Interior Side Slopes	No steeper than and up to 4H:1V	3H:1V (only with approval by District Maintenance)
Drawdown Time[3]	96 hours max	96 hours max
In-situ Infiltration Rate[4]	0.5 in/hr	2.5 in/hr[5]

1. *No theoretical limit on the volume, but if it exceeds 15 ac-ft consult with District Hydraulics to determine if jurisdictional dam limits apply.*
2. *The difference between the surface water elevation during the overflow event and the lowest elevation of the confinement (excluding the overflow spillway if used).*
3. *Longer drawdown times may be allowable if vector controls meeting California Department of Public Health requirements have been implemented; coordinate with District/Regional Design Stormwater Coordinator.*
4. *The soils exhibiting these infiltration rates are typically HSG A, B, and C. Lower infiltration rates may be allowable if drawdown time requirement is still met.*
5. *If the measured infiltration rate is significantly higher, consider the impacts to groundwater quality based on depth to seasonally high groundwater. Coordinate with Geotechnical Design to discuss methods to mitigate high infiltration rates. Contact the District/Regional NPDES Coordinator prior to PS&E submittal to determine if consultation with the RWQCB is needed.*

Preliminary design includes the following:

- Obtain site topography (1 foot contours, 1"=20' scale). Extend topography at least 80 ft beyond the Infiltration Device perimeter to identify how water flows into and out of the basin, including the downstream discharge.
- Develop a conceptual grading plan for improvements showing the device including maintenance access, device outlet, and extent of right-of-way requirements to accommodate the improvements. An Infiltration Basin invert must not have a slope of greater than 3 percent.
- Develop cost estimate to construct the Infiltration Device in accordance with the PPDG. Include allowances for non-standard design features (e.g., traffic management, storm drain system improvements, right-of-way needs, hazardous materials).

Final design efforts involve completing all required activities for which only preliminary assessments had been made and developing the complete PS&E package for the Infiltration Devices.

Figure 4-1 summarizes the BMP siting procedure for Infiltration Devices.

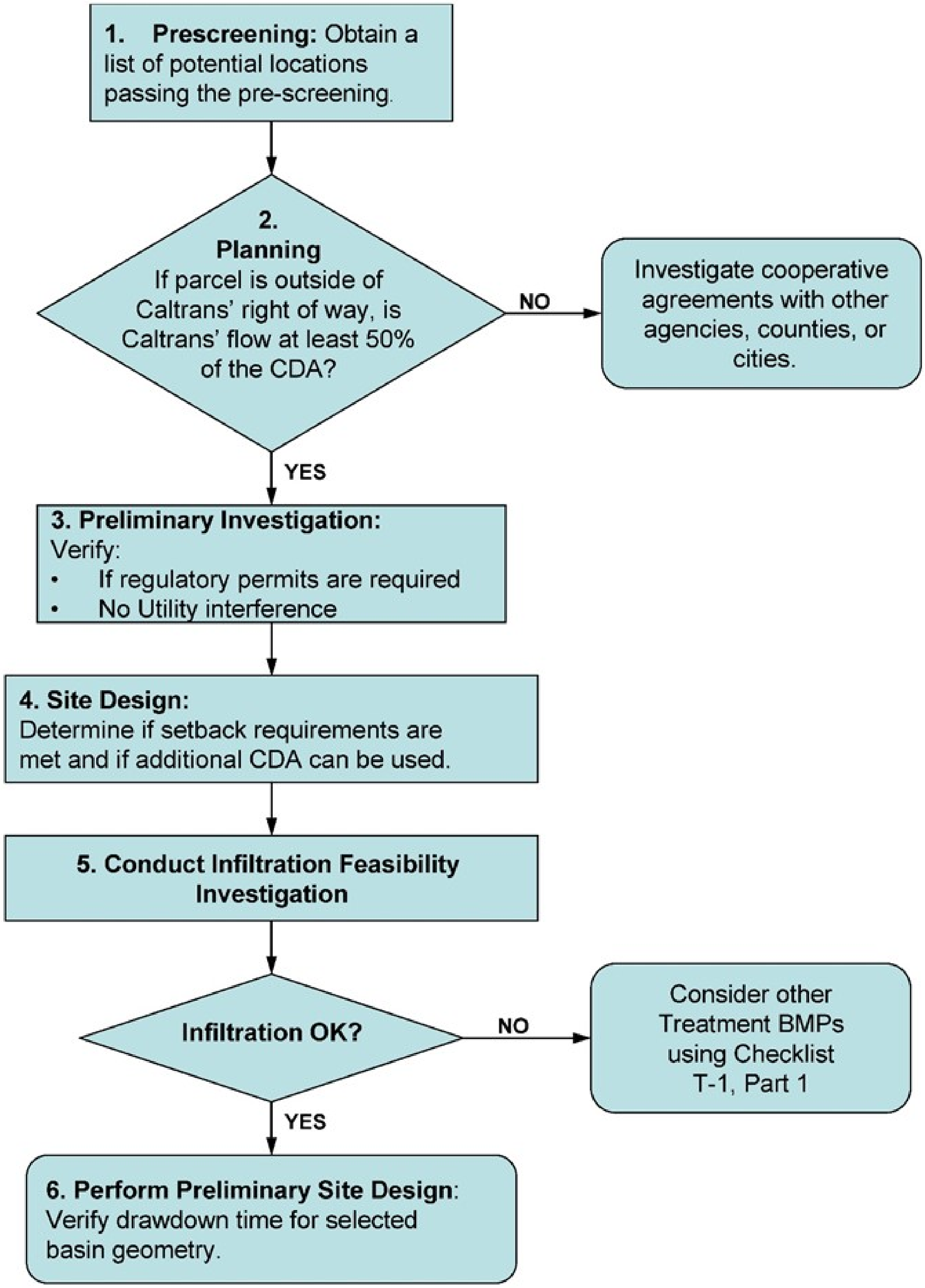

Figure 4-1. BMP Siting Procedure for Infiltration Devices

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Section 5

Preliminary Design

Site conditions are evaluated to obtain and assess the design parameters that will be used to determine if an Infiltration Basin is suitable based on the Feasibility Criteria described in Sections 2 and 3 and in the PPDG. An extensive geotechnical investigation, as outlined in Section 3, is required for Infiltration Basins. This section provides the calculations that are used to verify BMP feasibility. Calculations for CDA length, longitudinal slope, and length of flow path can be obtained from the project design information, and therefore, an example of these calculations is not provided. This section and Section 6 present steps used for the preliminary design of Infiltration Basins.

5.1 Preliminary Design Parameters

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 can be expected. 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.

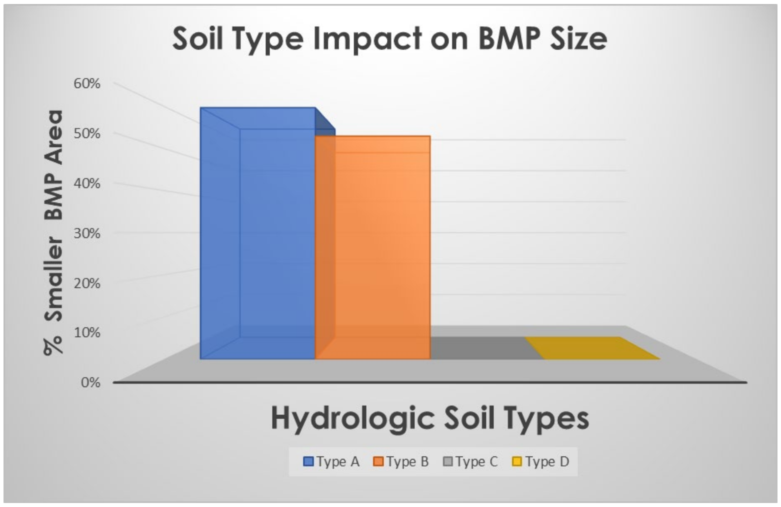

Figure 5-1. BMP Size Reduction Based on Soil Type

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.

5.1.1 Water Quality Volume

Step 1. Calculate the WQV generated by the BMP CDA

The WQV generated by the BMP CDA is calculated using the Small Storm Hydrology Method (PPDG Section 5.3). The Caltrans Infiltration Tool version IT4 can also be used when this BMP is modeled as an infiltration basin. An explanation of CDA delineation and WQV calculation and example can be found in Section 3 of the DPPIA Design Guidance (Caltrans 2019a).

Step 2. Calculate the invert area of the proposed Infiltration Basin, and obtain initial Maintenance clearance for the proposed site

Runoff is assumed to leave Infiltration Basins only through the invert. The invert area is sized using the equation below:

$$A = (12 \times SF \times WQV) / (k \times t) \qquad \text{Eq. 2}$$

Where:

A = area at the invert of the Infiltration Basin (ft^2)

WQV = Water Quality Volume (ft^3)

k = known or estimated infiltration rate, (in/hr)

t = drawdown time of full device (up to 96-hours)

SF = safety factor of 2.0

Note: If the permeability is not known or cannot be reasonably estimated based on available information during the planning phases of a project, use the minimum permeability of 0.5 in/hr to estimate the maximum invert area. Use field tested permeability rates during the design phase. Representative infiltration rates for various soils can be obtained from Table 5-1.

Table 5-1. Typical Infiltration Rates for NRCS Type, HSG, and USCS Classifications[1]

NRCS Soil Type	HSG Classification	USCS Classifications	Typical Infiltration Rates (inches/hour)[2,3]
Sand	A	SP, SW, or SM	8
Loamy Sand	A	SM, ML	2
Sandy Loam	A	SM, SC	1
Loam	B	ML, CL	0.3
Silt Loam and Silt	B	ML, CL	0.25
Sandy Clay Loam	C	CL, CH, ML, MH	0.15
Clay Loam, Silty Clay Loam, Sandy Clay, and Silty Clay	D	CL, CH, ML, MH	< 0.05
Clay	D	CLM CH, MH	< 0.05

1. *USCS classifications are shown as approximation to the NRCS classifications. Note that the NRCS textural classification does not include gravel, while the USCS does. Note also that the gradation criteria (particle diameter) for the three soil types as used in the NRCS and the USCS, while agreeing in large part, are not congruent. Dual classifications in the USCS omitted. Infiltration estimates for USCS found in standard geotechnical references may vary from those shown for NRCS classifications, especially if significant gravel is present.*
2. *Infiltration Basins should be placed at locations with soils classified as HSG A, B, or C soils and the WQV should infiltrate within a maximum of 96-hours. If an Infiltration Basin is proposed over HSG D soils or if the drawdown time is longer than 96-hours, vector control meeting California Department of Public Health requirements must be implemented. Coordinate with the District/Regional Design Stormwater Coordinator when longer drawdown times are being considered. Maximum infiltration rate allowed for any Infiltration Device is 2.5 in/hr unless justified by adequate groundwater information.*
3. *When estimating the invert area for Infiltration Basins placed in HSG Group B and C soils using the equations above, use the minimum infiltration rate of 0.5 in/hr to initially size the Infiltration Device until geotechnical investigation provides a field rate for the proposed location.*

For initial siting, the area of the Infiltration Basin could be estimated as the area calculated above with an additional 25 ft around the entire perimeter if constructed below ground, or 35 feet if constructed in an above-ground confining berm configuration[2, 3]. Once the proposed site has been roughly laid out, it should be discussed with District Maintenance so access issues can be considered.

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[2] 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.

[3] For below ground placement, the 25 ft will account for the height of the WQV, the height of flow released during overflow events, and the freeboard, which must be brought to the surface using the side slope ratio of the interior slopes. For above ground placement, the 35 ft will account for the same items plus the width of the perimeter access (if used).

5.1.2 Existing Soil and Environmental Conditions

Step 3. Assess the groundwater conditions, soil characteristics, and perform environmental studies to clear the site

The seasonally high groundwater elevation should be determined, from nearby borings or estimated from nearby borings or using other available data sources. The elevation differential between the invert of the Infiltration Basin and the seasonally high ground water table will then be compared against the requirements of Section 2.3, and any limitation on the depth of the invert can be established. Also, soil properties will need to be determined from the ground surface elevation to at least 3 times the at the WQV depth and the depth of interest can vary with the site. Contact Geotechnical Services as soon as possible, even in the PID phase, to obtain preliminary geotechnical information (if available), and to begin arrangements for later investigations.

Environmental clearances related to sensitive flora and fauna, archeological, and historical sites should be made, and potential of soil or groundwater contamination determined. Contact the District Environmental Unit for both these studies.

The remaining steps to placing the Infiltration Basin within the project will be presented in Section 6.

Note: When Infiltration Basins are under consideration for a project, the activities under Step 3 should begin during the PID phase of the project due to the potential length of these studies. If the design changed from the initial request, the PE should make other units aware of any changes to the plan dimensions or proposed depth throughout the PS&E phase.

Section 6

BMP Layout

This section provides guidance for incorporating Infiltration Basins into the PS&E packages based on the calculations performed in Section 5, and additional calculations related to overflow release. The Steps continue sequentially from Section 5.

6.1 Layout

Step 4: Calculate the dimensions of the Infiltration Basin, including an estimated height of overflow and the freeboard

The Infiltration Basin may assume any shape but should conform as naturally as possible to the surrounding topography while meeting Maintenance access and constructability requirements. However, the final dimensioning cannot be done until Step 6 is completed, as it involves determining the elevation of the overflow event and providing the freeboard. Pending final completion of Step 6 during the project Design phase, this combined depth can be taken as 1.5 ft for planning purposes.

6.2 Overflow Release

Step 5: Calculate the dimensions of the overflow spillway, the water surface elevation in the Infiltration Basin during the overflow event, and set the various elevations within the Infiltration Basin

An overflow device must be provided, whether the Infiltration Basin is designed for inline or offline placement. Typically, the device will use an overflow spillway through the confinement berm that releases the overflow into a surface conveyance. Some projects might use an overflow outlet riser. For either style, the PE can calculate the hydraulic head needed during the release and provide the required length (or perimeter) of the release device consistent with the overall design.

In addition, to prevent a massive release of the confined runoff, overtopping of the confinement is reduced by providing a freeboard (at a 1-ft minimum) above the elevation of the overflow, thereby establishing the lowest elevation of the confinement. After this step, all the elevations of the Infiltration Basin can be established, as having been previously determined.

When designing an overflow device, refer to Chapter 8 of the Federal Highway Administration (FHWA) Hydraulic Engineering Circular (HEC) No. 22 (FHWA 2009) for equations for broad-crested and sharp-crested weirs, as appropriate. In

Section 8.1 of this document, the calculations used to size a spillway are illustrated using a formula for a broad-crested weir. Consult the Wet Basin Design Guidance (Caltrans 2010) for an example where the overflow device is a CMP riser and the analysis are conducted for flow over a sharp-crested weir.

Consult the Supplemental Details Design Guidance (Caltrans 2020d) for discussion about the selection and calculations of an overflow device (typically as an overflow spillway through the confinement berm and releasing the overflow into a surface conveyance; or as an Overflow Outlet Riser releasing water).

6.3 Final Dimensioning

Step 6: Final dimensioning for the Infiltration Basin and design of ancillary features; obtain final functional unit concurrences for the proposed location.

Consolidate all the dimensions and elevations calculated in the earlier steps to obtain the final dimensions of the Infiltration Basin.

Runoff into the Infiltration Basin should be pretreated to remove trash and sediment in order to prolong the life of the basin. A vegetated swale, sediment forebay, or other device should be placed as pretreatment just upstream of the Infiltration Basin to capture gross sediments, thereby simplifying some of the maintenance effort while increasing the time between major maintenance. A sediment forebay could be formed as a separate cell formed by a wall such as an earthen berm, gabion wall, or loose riprap wall, and would typically be sized at 10 percent to 25 percent of the WQV. A sediment forebay should be accessible for maintenance.

Determine if the Infiltration Basin will be located within the CRZ (as discussed in Section 2.5). If so, consult with Traffic Operations to determine if shielding is required.

Protection of the downstream conveyance (including for overflows), maintenance access, and all other physical features should be finalized at this stage. Vegetation should be selected by the District Landscape Architect.

Section 7

PS&E Preparation

This section provides guidance for incorporating Infiltration Basins 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 Infiltration Basins 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

Infiltration Basin TBMPs do not have standard drawings for the device as a complete feature. The PE is responsible for incorporating all design aspects of the Infiltration Basin into the PS&E drawings in accordance with the procedures typically followed when developing a PS&E package.

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

- Layout(s): Show location(s) of the Infiltration Basins. This will aid in recognizing, both within and outside Caltrans, that Infiltration Basins were placed within the project limits.
- Grading or Contour Grading(s): As Infiltration Basins are primarily earthwork features they should be shown on Contour Grading sheets or grading plans. Any other associated grading surrounding the Infiltration Basin should be shown on these sheet(s).
- Drainage Plan(s), Profiles, Details, and Quantities:
    - Drainage Plan sheets should show each Infiltration Basin in plan view, along with other existing (or proposed) drainage conveyance devices that direct the runoff into the device and overflow from the device.
    - Drainage Profile sheets should show the Infiltration Basin in profile within the drainage conveyance system. These sheets should also call out the specific Infiltration Basin inlet and outlet flow line (surface) elevations and invert elevation.
    - Drainage Detail sheets should show any detailing needed for the construction of the Infiltration Basin. Inflow and outflow detailing should be shown including the overflow release device (e.g., spillway through the confining berm or through a CMP riser).

  - Drainage Quantity sheets should include all pay and non-pay items associated with the construction of the Infiltration Basins, 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 Infiltration Basin should be provided.
- Temporary Water Pollution Control Plans: These sheets are used to show the temporary BMPs used to establish the Infiltration Basin BMPs and compliance with the Construction General Permit.

7.2 Specifications

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

The special provisions for the various items of work directly needed to construct the Infiltration Basin could be organized under an umbrella 'Infiltration Basin' nSSP with the required items listed as subheadings. Payment would be made for by 'each' Infiltration Basin. 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 Infiltration Basin TBMP. Consider the construction of the Infiltration Basin 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

17 General (Earthwork and Landscape)

19 Earthwork

20 Landscape

21 Erosion Control

64 Plastic Pipe

68 Subsurface Drains

70 Miscellaneous Drainage Facility

71 Existing Drainage Facilities

72 Slope Protection

96 Geosynthetics

7.2.2 Standard Special Provisions

SSPs are not typically used for a project that constructs an Infiltration Basin TBMP; the PE should consider the construction of Infiltration Basins 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 Infiltration Basin 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 Infiltration Basin 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 has developed the following website to assist in the development of cost estimates:

http://www.dot.ca.gov/hq/oppd/costest/costest.htm

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.

At the PID phase of the project, the construction cost for Infiltration Basins could be estimated based on the findings of the BMP Retrofit Pilot Program Final

Report (Caltrans 2004), as $16/CF of WQV treated[4]. To determine an initial cost estimate using this value simply use the following equation:

Initial construction cost = ($16/CF x run-up factor) x WQV

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 stormwater BMPs and are input into 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 Infiltration Basin location and determine limits of excavation and backfill.

7.4 Developing Infiltration Basin 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 Infiltration Basin. 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.

Additionally, 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 SQFT) estimate if they are required for the Infiltration Basin. Table 7-1 is not a complete list and must be modified on a project-specific basis to accommodate all aspects of design.

[4] In 2021 dollars inflated from 1999; contact District Office Engineer for appropriate run-up factors based on local experience.

Contract Item	Type	Unit	Quantity	Price	Amount
Clearing and Grubbing		LS			
Excavation		CY			
Embankment		CY			
Alternative Pipe Culvert		LF			
Rock Blanket		SQFT			
Permeable Material		CY			
Class D Filter Fabric		SQYD			
Lean Concrete Backfill		CY			
Erosion Control (e.g., Dry Seed)		SQFT			
Slope Protection		CY			

Table 7-1. Example Infiltration Basin Estimate

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.

Watch for the costs associated with earthwork and landscaping for each specific Infiltration Basin location, as that item of work will have the most variable costs for this TBMP. For earthwork exclusive to Infiltration Basins earthwork, use Section 19-2 Roadway Excavation of the Standard Specifications.

Estimate the total cost of each Infiltration Basin used on the project for tracking TBMP costs at PS&E. Document all BMP costs in the project SWDR at PS&E. Some Infiltration Basin features may be required for drainage or other project features and should not be double counted. Cost items will vary by project.

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Section 8

Design Example

8.1 Problem Statement

Givens and Desired Design Parameters

5.0-acre CDA (217,800 ft^2)

Drawdown Time = 40 hrs

Precipitation depth (WQV): 0.75 inches (from Basin Sizer (CSUS 2013); linearly interpolated between 24 and 48 hrs)

Volumetric runoff coefficient: 0.89 (100 percent impervious CDA)

Soil permeability (Infiltration Rate): 0.8 in/hr

No depth to groundwater or environmental restrictions restrict placement at the site

Assume a circular shape for the Infiltration Basin, with the confinement elevation set at elevation 100 ft mean sea level (MSL), and an interior side slope ratio of 4H:1V

Overflow Design Storm: the rainfall event for the design of drainage for the upstream CDA has a 2 inch/hour intensity, giving an approximate Q_{25} = 9.0 cfs using the Rational Formula

Overflow release: use an overflow spillway through the confinement berm having a breadth of 6 ft; use minimum freeboard of 1.0 ft, so top of water surface elevation during overflow event must be set at 99.0 ft

Step 1: Calculate WQV using the volumetric runoff coefficient, precipitation depth, and CDA.

WQV = R_v (P/12) A

Where:

WQV = Runoff volume generated by the 85th percentile 24-hr storm event (CF)

R_v = Volumetric Runoff Coefficient, 0.89

P = Precipitation Depth, 0.75 in

A = Contributing Drainage Area, 5.0 ac = 217,800 SQFT

WQV = 0.89 x 0.75 in (1 in /12 ft) x 217,800 SQFT = 12,115 CF

Step 2: Calculate the invert area of the proposed Infiltration Basin and obtain initial Maintenance clearance for the proposed site.

A = (12 x SF x WQV) / (k x t)

Where:

A	=	area at the invert of the Infiltration Basin (ft^2)
WQV	=	Water Quality Volume, 12,115 CF
k	=	known or estimated infiltration rate, 0.80 in/hr
t	=	drawdown time of full device, 40 hrs

Inserting the known values from the problem statement:

A = (12 in/ft x 2 x 12,115 ft^3) / (0.8 in/hr x 40 hrs) = 9,086 SQFT

Since a circular shape will be used, the invert radius is the unknown, but it can be solved for by re-arranging the equation for area of a circle:

Radius = $(\text{Area} / \text{pi})^{0.5}$ = $(9{,}086 \text{ SQFT} / 3.141592)^{0.5}$ = 53.8 ft

After adding the estimated 25 ft to the radius (see Section 5.1.2), begin discussions about the proposed location with District Maintenance.

Step 3: Assess the groundwater conditions, soil characteristics, and perform environmental studies to clear the site.

Assume this work is on-going, beginning from the PID phase of the project. As information becomes available, review the proposed design and make needed changes or revise the selected TBMP using the process of Checklist T-1, Part 1 in the PPDG if Infiltration Basins become infeasible.

Step 4: Calculate the dimensions of the Infiltration Basin, including an estimated height of overflow and the freeboard

The circular shape when placed with interior slopes (4H:1V ratio) becomes a truncated cone, whose volume is calculated using the following equation:

Volume $V = 1/3 \text{ pi} \times (R_1^2 + R_2^2 + [R_1 \times R_2]) \times H$

Where:

V	=	volume of the truncated cone, set as the WQV (CF)
pi	=	3.141592
R_1	=	radius at the Infiltration Basin invert (ft)
R_2	=	radius at the top of the WQV water surface (ft)
H	=	distance from invert to top of WQV water surface (ft)

Recognizing that R_2 is a function of R_1, H, and the side slope ratio, a spreadsheet solution was developed with height intervals selected at 0.25 ft, and the equation solved for V provides the following values:

V = 12,523 CF, slightly larger than 12,115 CF OK

R_1 = 53.8 ft, from Step 2

R_2 = 59.1 ft

H = 1.25 ft

Adding the estimated height of overflow and the freeboard, at 1.5 ft, at the same interior side slope ratio, the surface radius at the top of the confining berm would be about 78 ft.

Step 5: Calculate the dimensions of the overflow spillway, the water surface elevation in the Infiltration Basin during the overflow event and set the various elevations within the Infiltration Basin.

Release of events larger than the water quality event will be provided through the confining berm using a spillway set below the berm crest elevation. The height of the runoff during the overflow event added to the freeboard distance as the combined height will determine the minimum confinement berm elevation within the Infiltration Basin (illustrated in Step 6).

The equation related to flow through a spillway is analyzed as a flow over a broad crested weir, whose formula is presented below.

$$Q_{Overflow} = C_{BCW} \times L \times H^{1.5}$$

Where

$Q_{Overflow}$ = overflow event, consistent with the IDF of the upstream CDA

C_{BCW} = weir coefficient, from Table 8-1, appropriate for the breadth of weir and overflow height

L = length of weir (perpendicular to flow) Note: minimum 'L' is 3.0 ft.

H = difference in elevations between the water at overflow event and the weir elevation

Rearranged based upon the unknown to be solved:

$$L = [Q_{Overflow} / (C_{BCW} \times H^{1.5})] \text{ or } H = [Q_{Overflow} / (C_{BCW} \times L)]^{2/3}$$

Table 8-1. Broad Crested Weir Coefficients, C_{BCW}							
Height Above Spillway During Overflow (Head)	Breadth of Weir Having Vertical Sides (ft) [C_{BCW} units of $ft^{0.5}$/sec]						
(ft)	2.00	2.50	3.00	4.00	5.00	10.00	15.00
0.20	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.40	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.60	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.80	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.00	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.20	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.40	2.77	2.68	2.64	2.65	2.65	2.67	2.64

1. *From: HEC No. 22. Page 8-26.*
2. *Breadth of weir is measured parallel to the flow; length of weir is measured perpendicular to flow.*
3. *Refinements on the C_{BCW} coefficient can be made, based on the cross section of the spillway being trapezoidal; the C_{BCW} coefficient would be increased from those shown above. Also, the length of a broad-crested weir, as defined above, will increase if constructed with tapered sides, with some references suggesting it is acceptable to use a length equal to the average of the top and base of the weir's length, as defined above. Both of these effects are ignored in the document, with the practical effect being the overflow height calculated will be somewhat overestimated, and the freeboard will be increased by the same amount.*
4. *For conversion into metric units: at the converted Head and Breadth, divide C_{BCW} by 1.81*

Calculate the water surface elevation in the Infiltration Basin during the overflow event: If the height of the overflow is the unknown, an assumed value for the C_{BCW} must be made; at the end of the calculations verify that the assumed value was reasonable for the design inputs. If the length of the weir is assumed but the height of flow is known, no revision is required on the C_{BCW} from the table.

Since the minimum length (shown as breadth of Table 4-1) of the spillway is set on Table 4-1 as 3.0 ft, as a trial solve for H using that dimension and compare the results to the assumed value. Assume a C_{BCW} value estimating the overflow height as 0.20 ft, and interpolate for a breadth of 6 ft. However, note that the C_{BCW} values are fairly insensitive to changes in overflow height or breadth at the values of interest. Then:

$$H = [Q_{Overflow} / (C_{BCW} \times L)]^{2/3}$$

Where:

$Q_{Overflow}$ = 9.0 cfs

C_{BCW} = weir coefficient; interpolate for Breadth as 6 ft, from table for H = 0.2 ft; use 2.37

L = Length of weir (perpendicular to flow): 3.0 ft

H = difference in elevations between the water at overflow event and the weir elevation

$$H = [9.0 / (2.37 \times 3.0)]^{2/3} = 1.17 \text{ ft}$$

The C_{BCW} was selected assuming that the height of overflow was 0.2 ft, but the estimated height with the length of spillway provided greatly exceeds that, so a value of C_{BCW} consistent height with the calculated L equal to 3 must be obtained by iteration; this value is approximately 2.97 for height of 1.10. Since at that overflow height the assumptions made for the project (of a combined height of overflow and freeboard at 1.5 ft) were exceeded, the length of the weir will be used as the unknown, with the 0.5 ft as the overflow height used as a known[5]. Re-arranging the formula to let L be the unknown, with H as 0.5 ft, gives:

$$L = [Q_{Overflow} / (C_{BCW} \times H^{1.5})]$$

Where

$Q_{Overflow}$ = 9.0 cfs

C_{BCW} = weir coefficient; use 2.62 by double interpolation of table on Head and Breadth

L = Length of weir (perpendicular to flow): to be determined.

H = difference in elevations between the water at overflow event and the weir elevation.

$$L = [9.0 / (2.62 \times 0.5^{1.5})] = 9.7 \text{ ft}$$

Call 10.0 ft okay and ignore the slight reduction in height of the overflow afforded by the longer weir. Since the C_{BCW} value was selected based on Height, it does not change with the length of the weir perpendicular to flow; therefore, no further check must be made on the C_{BCW} value.

Calculate various elevations within the Infiltration Basin as shown in Table 8-2.

Table 8-2. Infiltration Basin Design Elevations

Description	Height, ft	Elevation, ft MSL
Top of the confinement	--	100.00
Bottom of Freeboard Note: bottom of freeboard coincides with top of overflow water surface	1.00	99.00
Height of runoff during overflow Note: bottom of overflow coincides with top of WQV and the elevation of the spillway	0.50	98.50
WQV (bottom) Note: bottom of WQV defines Infiltration Basin invert	4.25	94.25

[5] Note that the combined height of the freeboard and overflow were rejected due to the assumptions made, but the 3 ft weir could be used if space were available.

The relative positions of these features are shown on the schematic below.

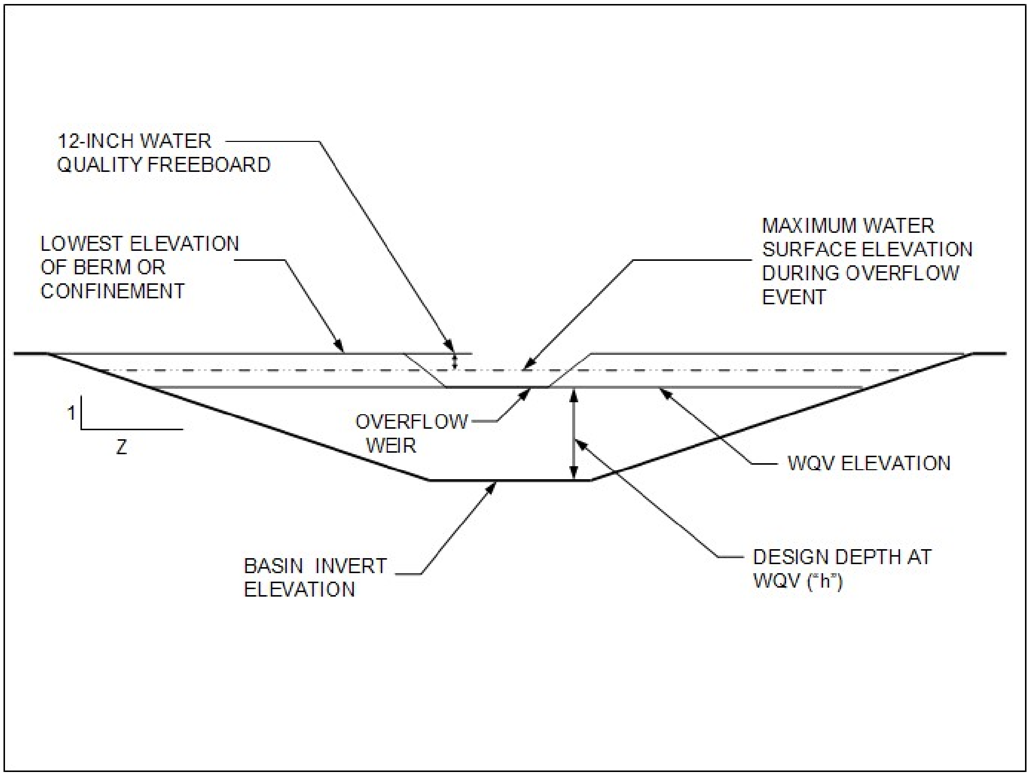

Figure 8-1. Schematic Illustrating Elevations within an Infiltration Basin

Step 6: Final dimensioning for the Infiltration Basin and design of ancillary features; obtain final functional unit concurrences and clearances for the proposed location.

Revise plan view of the Infiltration Basin based on requirements for maintenance access, etc., once final dimensions and elevations have been obtained. Verify that the WQV is closely approximated if revisions to the layout are made.

Review the completed report describing the geotechnical investigation and verify that all siting requirements for separation from groundwater and soil permeability have been met.

Verify that the proposed site meets the remaining requirements in PPDG Checklists T-1, Parts 1 and 2, for the Infiltration Basins.

Other checks: i) Review for potential effects on drainage from the roadway in the CDA. ii) Review for potential downstream effects due to overflow release. iii) Consult with Traffic Operations to determine if shielding is required.

Lay out the inflow conveyance, the overflow spillway, the maintenance release valve (if placed), and any other drainage details for the Infiltration Basin. Obtain requirements from District Landscape Architect for planting plan.

If an Infiltration Basin becomes infeasible at any stage of the project, based on additional or revised information, use the process of PPDG Checklist T-1, Part 1, to select the new TBMP for the site, and document in the SWDR the issues that prevented placement of the Infiltration Basin.

8.2 Additional Notes

If the permeability is not known or cannot be reasonably estimated based on available information, the PE should use the minimum permeability of 0.5 in/hr to estimate the maximum invert area. Representative infiltration rates for various soils can be obtained from Table 5-1.

Due to limited right of way or other siting restrictions, a retaining wall around a portion of the perimeter of an Infiltration Basin in lieu of an earthen slope could be considered with no loss in water quality effectiveness. Discuss with the District/Regional Design Stormwater Coordinator and Geotechnical Services if under consideration.

When designing an overflow device, refer to Chapter 8 of HEC No. 22 for equations for broad-crested and sharp-crested weirs, as appropriate. See the Wet Basins Design Guidance for an example calculation of overflow release using an overflow outlet riser, analyzed for sharp-crested flow.

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Section 9

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