Infiltration Gallery

Design Guidance

June 2021

California Department of Transportation
HQ Division of Design

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List of Abbreviations

AASHTO American Association of State Highway and Transportation Officials

ACI American Concrete Institute

ASTM American Society for Testing and Materials

BEES Basic Engineering Estimating System

BMP Best Management Practice

CRZ Clear Recovery Zone, (AASHTO Clear Zone)

CDA contributing drainage area

CF cubic foot

CY cubic yard

DPPIA Design Pollution Prevention Infiltration Area

FHWA Federal Highway Administration

ft foot/feet

H:V Horizontal:Vertical

HDM Highway Design Manual

HQ Headquarters

HSG Hydrologic Soil Group

LID Low Impact Development

LRFD Load and Resistance Factor Design

MSL Mean Sea Level

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

nSSPs non-Standard Special Provisions

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

PS&E Plans, Specifications and Estimate

RCB Reinforced Concrete Box

RWQCB Regional Water Quality Control Board

SQFT square foot

SQYD square yard

SSP Standard Special Provision

SWDR Stormwater Data Report

SWRCB State Water Resources Control Board

TBMP Treatment Best Management Practice

USCS Unified Soil Classification System

WQF Water Quality Flow

WQV Water Quality Volume

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Section 1

Introduction

This document provides information for Caltrans Designers for evaluating and incorporating Infiltration Galleries as Treatment Best Management Practices (TBMPs) into projects during the planning and design of Caltrans highways and facilities. Use of this TBMP must be approved by the District/Regional Design Stormwater Coordinator. Infiltration Gallery TBMPs are underground structures designed to temporarily store runoff for infiltration. An Infiltration Gallery is an infiltration device, functionally equivalent to an Infiltration Basin or Infiltration Trench, except that the Infiltration Gallery is an underground structure that requires structural analysis as maintenance vehicles may drive across or park on them occasionally. The primary functions of this document are to:

1. Describe an Infiltration Gallery
2. Provide design considerations
3. Review the required design elements for implementing Infiltration Gallery TBMPs 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 2019a).

The following guidance is based on a review of several types of Infiltration Gallery TBMPs. Designers may utilize alternatives to the calculation methodologies presented in this guidance provided the alternative calculations and design decisions are documented in the project Stormwater Data Report (SWDR) and the Project File. The SWDR template can be found in the PPDG.

Depending on the size and type of infiltration system designers can use either approved perforated pipe sizes or special structures. A structural design analysis using the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 8th Edition, with California Amendments (AASHTO 2019) criteria and construction shop drawings may be required for Infiltration Gallery TBMPs. Geotechnical reports of the underlying soil and adjacent slopes may also be necessary to provide appropriate siting and design criteria.

1.1 Design Responsibility

The Project Engineer (PE) is responsible for the design of Infiltration Gallery hydrology, hydraulics, and grading because they are part of the highway drainage system. The PE is expected to apply their own engineering knowledge and judgement when evaluating and designing Infiltration Gallery TBMPs. The PE must also work with geotechnical, materials, and structural engineers or professionals to determine: the ability of the soils to infiltrate the WQV, the soils ability to support the structural components of the Infiltration Gallery, and to identify necessary structural design and reinforcement of the TBMP. The designer must consider highway grading and structures plans, and the impact that stormwater infiltration may have on the roadway or slopes above the Infiltration Gallery. Coordinate with other functional experts to implement successful and functioning Infiltration Galleries. An Advanced Planning Study (APS) should be requested from Design and Engineering Services (DES) Bridge Design for applicable region of State.

The aspects of hydraulic engineering that are presented in this guide will focus on the site-specific design of the Infiltration Gallery TBMP, and not on all aspects of hydraulic or hydrologic engineering. 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 designs that require the least amount of maintenance. The District/Regional Design Stormwater Coordinator must approve the design and use of all TBMPs used to meet the requirements of the Caltrans Permit.

1.2 Infiltration Gallery

An Infiltration Gallery utilizes underground facilities to store runoff for infiltration. During a storm, runoff enters the Infiltration Gallery causing the water level in the underground facilities to rise. During rainfall, and for some time after it ends, runoff infiltrates into the soils through the invert area of underground facilities. When designing enclosed infiltration TBMPs, consider including an air vent to allow air to move freely out of and into the TBMP during filling and draining. Also consider installing a monitoring pipe to allow observation of the bottom of the TBMP from the surface. Pretreatment for sediment and debris is required and must be sufficiently sized for the expected loading. Refer to the D11 Chollas Creek BMP Retrofit Evaluation TM for air vent and pretreatment design lessons learned (Caltrans 2020d).

Each Infiltration Gallery can vary in size; it may be small, for example a 12-inch perforated pipe backfilled with aggregate base, large like the configuration shown in Figure 1-1, or any size in between. The size of these facilities is based on the design WQV, the permeability of the soil below the invert, and the period selected for infiltration. Events that are greater than the Water Quality Event (WQ Event) must be bypassed around the TBMP via an upstream diversion or flow splitter. Coordinate with the District Design Stormwater Coordinator to determine the appropriate size configuration for each TBMP location.

Infiltration devices are highly effective at removing sediments, nutrients, pesticides, trash, 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 should be considered first when selecting a TBMP for a Caltrans project.

Infiltration Gallery TBMPs are configured to meet right-of-way restrictions. The design should conform to the available space and topography, consider ease of maintenance and construction, and account for structural and geotechnical limitations. For ease of design, construction, and maintenance when possible the Infiltration Gallery should use Standard Plans such as a 24" alternative perforated pipe, referring to Section 68 of the Standard Specifications under Subsurface Drains. For large galleries Caltrans Structures Bridge Standard Details (XS Sheets), Section 17 - Underground Structures, Cast-In-Place (CIP) Bottomless Culvert could be used. See Section 4.1.1 for information on use of proprietary devices within the right-of-way. Special designs for the larger galleries will be provided by DES Office of Bridge Design as reinforced concrete structures. Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the clear recovery zone (CRZ).

A example of a large type Infiltration Gallery is shown in Figure 1-1.

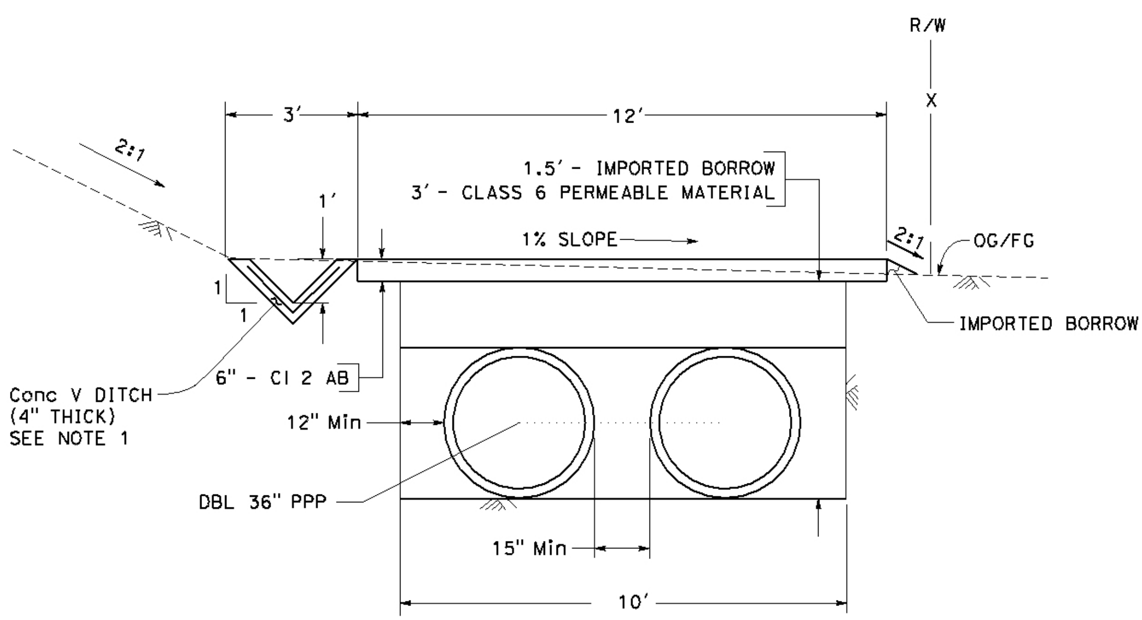

Figure 1-1. Schematic of a Medium Type Infiltration Gallery installed on 07-LA-210 (EA 323104)

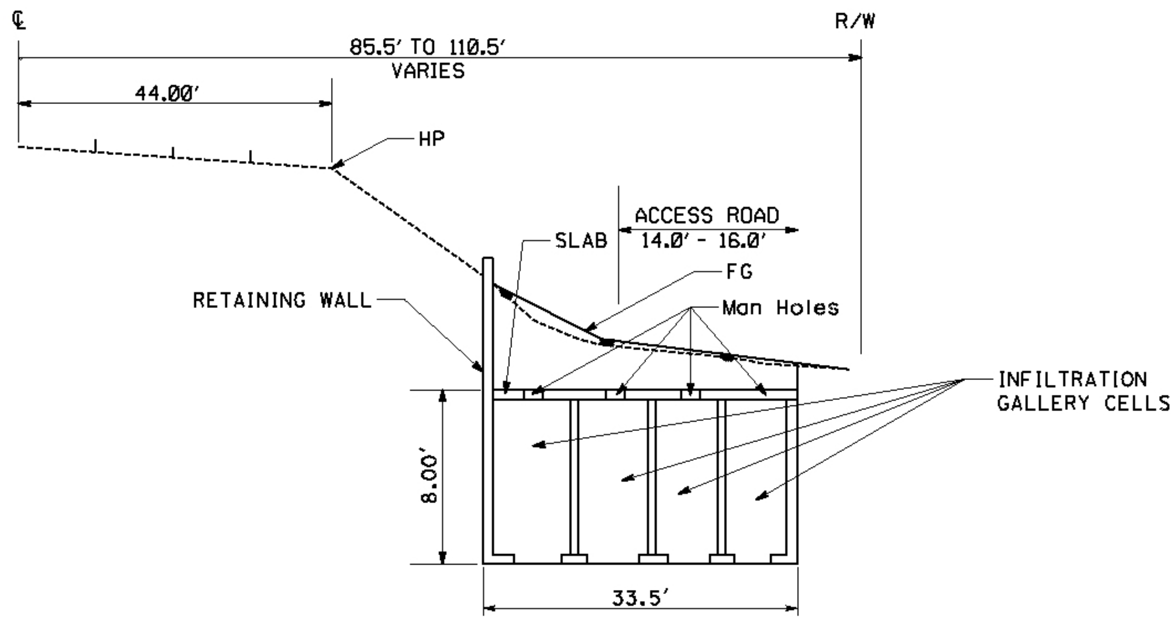

Figure 1-2. Schematic of a Large Type Infiltration Gallery installed on 07-Ven-118 (EA 336004)

Section 2

Infiltration Gallery Design

This section describes design considerations of Infiltration Gallery TBMPs. For additional considerations when siting an infiltration TBMP, refer to Infiltration Basins Design Guidance (Caltrans 2020b).

The Infiltration Gallery design must meet Caltrans requirements and design standards and must be approved for use by the District/Regional Design Stormwater Coordinator.

To be suitable for Infiltration Gallery TBMPs, the site must have soils that meet infiltration requirements, conform to structural stability criteria, meet safety criteria, allow safe access to maintenance staff and vehicles, and where flow velocities can be mitigated to prevent scour. Design elements and feasibility of implementing an Infiltration Gallery TBMP on a project may include consideration of:

- Infiltration Gallery TBMPs are load bearing and must be designed by a licensed, professional civil engineer to ensure structural integrity.
- Typically used on sites where there are space constraints or a very high percent of impervious surface.
- Placement perpendicular to or along freeway or roadway structural sections must be carefully analyzed. The concern being saturation of subgrade and adverse effects on either the structural section of the roadway, fill embankments, bridge abutements, or retaining walls foundation.
- Should be placed under flatter sloped areas, and in interchange loops in an off-line flow connection when possible. Could be used under other Caltrans facilities such as Park-and-Rides and Maintenace Yards.
- Infiltration Gallery TBMPs will require approval/coordination with the District/Regional Design Stormwater Coordinator, District Hydraulics, District Traffic Operations, District Maintenance, Geotechnical Design, District Maintenance Stormwater Coordinator, Traffic Safety, and OHSD.
- Widely applicable for storage of runoff from roof tops, sidewalks, parking areas, and places with light traffic loads.
- Site on relatively flat terrain, preferably with slopes less than 15 percent.
- Areas contributing runoff directly into the Infiltration Gallery should be stabilized and not be a source of sediments.
- Pretreatment of the runoff must be provided before runoff enters the Infiltration Gallery to increase longevity of the system and to maximize time between

periodic cleaning. Pretreatment may include incorporation of a sediment forebay or basin and full trash capture system.

2.1 Preliminary Design Criteria

Infiltration Gallery TBMPs must meet certain preliminary design parameters to perform as an effective TBMP. The primary parameters to be incorporated into the design are found in Table 2-1.

Table 2-1. Infiltration Gallery Design Criteria

Parameter	Minimum Value	Maximum Value
Runoff Volume	WQV, or portion thereof	WQV
Freeboard[1]	Not required	Not required
Monitoring Well	May be required	May be required
Air Vent	May be required	May be required
Design Bypass Event[2]	Use the HDM Design Storm or local regulations; see also discussion under Section 3.1.3	Use the HDM Design Storm or local regulations; see also discussion under Section 3.1.3
Invert Slope	0% (preferred); provided no objectionable backwater condition is created	0% (preferred); provided no objectionable backwater condition is created
Drawdown Time[3]	12 hours	96 hours
Seasonally High Groundwater	5-feet	Not applicable
In-Situ Infiltration Rate[4]	0.5 inches per hour	2.5 inches per hour

1. *If freeboard is not provided, the design should consider pressurized conditions. The need for bolt-down manhole covers and inlet grates should be evaluated. For online and offline systems, backwater conditions should be analyzed.*
2. *When BMP is placed inline.*
3. *The drawdown time may be as high as 96 hours. The recommended design drainage time is between 40 and 48 hours. Drawdown times longer than 96 hours may be allowable if vector controls meeting California Department of Public Health requirements are implemented. Coordinate with District/Regional Design Stormwater Coordinator.*
4. *The soils exhibiting these infiltration rates are typically Hydrologic Soil Group (HSG) A, B, and C. Lower infiltration rates may be allowable if drawdown time requirement is still met.*

2.2 Site Soils and Infiltration

Soil testing to determine the infiltration rate of site soils should be completed as part of the Geotechnical request. The tests that should be considered are included in Tables 2-2 and 2-3 below.

In addition to the soil tests listed below, reviewing any existing soil data will help in estimating the in-situ infiltrations rate. Other possible sources and criteria that will aid in determining estimated infiltration rates include the following:

- Some preliminary information may be available from County or private groundwater managers.
- 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/
- The number of tests needed and spacing of the tests (i.e., if the TBMP is 50 ft long vs. 0.25-mile-long) to adequately categorize conditions
- 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 D10 > 0.02mm and D20> 0.06mm may indicate slow infiltration rates.

Infiltration Gallery TBMPs 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. All infiltration inverts will become less permeable with time because of silts and fines so even 2.5 in/hr may be possible by adjustments to tested rates. 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 or B and the WQV should infiltrate within a maximum of 96-hours. If an Infiltration Gallery is proposed over HSG C or 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 Gallery TBMPs 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 TBMP. Use of heavy equipment should be limited or prohibited to prevent compaction of the underlying soils intended for infiltration.

For soils where there is a potential for the gallery bottom to freeze, discuss with the Geotechnical Engineer options to line the bottom of the Infiltration Gallery with 6 inches to 1 foot (ft) of clean sand or gravel. This technique provides a layer of soil that will infiltrate better than native soils and provide a thermal barrier to reduce freezing potential.

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 2-2. Posssible Infiltration and Soil Properties Tests

Parameter	Test method(s)
Infiltration Rate, in/hr	CTM 750 (modified for shallow depth) ASTM D5126 (Single-Ring/Infiltrometer) ASTM D3385 (Dbl-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 2-3. 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

Determine soil properties from the ground surface elevation to a maximum of 50 ft (or refusal in rock or rock-like material at a lesser depth) below the invert of the proposed Infiltration Gallery, and to a minimum depth of 3 times the depth of water in the Infiltration Gallery (at the WQV depth). Contact Geotechnical Services early in the project, even in the Project Initiation Document (PID) phase, to obtain preliminary geotechnical information and to begin arrangements for later investigations.

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 Geotechnical Considerations

The Geotechnical Report, or a separate geotechnical technical memorandum, should evaluate soil characteristics and surrounding slopes to determine the feasibility of using an Infiltration Gallery. The geotechnical investigation should identify the infiltration rates of native soil and slope stability, and review other available key soils data, including: percent silt and clay, presence of a restrictive layer, permeable layers interbedded with impermeable layers, minimum and maximum groundwater elevations, and the seasonal high-water table.

Other geotechnical considerations that may prohibit the use of an Infiltration Gallery include: location in seismic impact zones, unstable areas such as landslides and Karst terrains, 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. Any other possible roadway structural section degrading effects should be considered and evaluated in the Geotechnical Report by infiltrating water near it.

2.4 Structural Considerations

The proposed structure location should be reviewed to establish structural feasibility based on potential loading, surrounding slopes, and construction access. Static and dynamic soil pressures on the structure shall be applied based on site-specific parameters obtained from Geotechnical investigations (i.e. active/at-rest, dynamic lateral earth pressures and groundwater elevation). Live load (including impact if applicable) shall be applied in accordance with Section 3 of the AASHTO LRFD Bridge Design Specifications, 8th Edition, with California Amendments. Load combinations shall follow Table 3.4.1-1. Design of reinforced concrete sections shall be in accordance with the American Concrete Institute (ACI) 318-14: Building Code Requirements for Structural Concrete and Commentary (ACI 2014). Structural considerations that may render use of an Infiltration Gallery TBMP impractical include but are not limited to, proximity to roadway and placement in uncontrolled parking areas.

Refer to the Geotechnical Report to develop foundation requirements to minimize static and dynamic settlement and scour. Use minimum and maximum groundwater levels established in the Geotechnical Report to determine buoyancy design requirements. Infiltration devices should not be constructed in areas that would require pile foundations or other means of tie down.

2.5 Safety Considerations

Infiltration Gallery TBMPs 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 Infiltration Gallery 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, Structure Design, and Traffic Safety, as applicable.

2.6 Restrictions/Coordination

Successful implementation and utilization of the Infiltration Gallery will require proper siting by the PDT with coordination of the District/Regional Design Stormwater Coordinator, District Hydraulics, District Maintenance, District Traffic Operations, District Landscape Architecture, Geotechnical Design, Structure

Design, and Traffic Safety, as applicable. Infiltration Gallery design decisions and coordination must be documented in the SWDR and the project file.

Design criteria applicable to the use of Infiltration Gallery TBMPs are:

- Runoff quality must meet or exceed standards for infiltration to local groundwater. Consider consultation with RWQCB or other local agency if there is less than five feet separation from invert. Consult with the District/Regional NPDES Coordinator.
- 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.
- May be considered unsuitable if near 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.
- Should not be used in fill sites or on cut slopes steeper than 15 percent (3.7 Horizontal:Vertical [H:1V]). If galleries are proposed in steeper locations, a project Geotechnical Design Report and approval are required.
- 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. In this instance, a subsurface drain may be recommended to convey runoff to a more appropriate location for infiltration. A project Geotechnical Design Report and approval are required if outside these criteria.
- Infiltration Galleries should not cause scour or undermine adjacent structures or the supporting soils of adjacent structures. Infiltration Galleries should neither adversely impact the settlement of adjacent structures nor surcharge adjacent structures.
- A proposed site having hazardous soils that would not be completely removed during the excavation, or a site above or near a contaminated groundwater plume, must receive the concurrence of the District/Regional NPDES Coordinator.
- Infiltration Galleries should be placed offline and configured with an overflow release device (See Section 4.4). Infiltration Galleries may be placed inline when upstream diversion is not feasible.
- If placed inline, the upstream and downstream conveyance on either side of the Infiltration Gallery must be able to convey peak design flows from the contributing drainage area (CDA) that were used in the drainage system design for that roadway section[1].

[1] For convenience in this document, this design storm flow will be referred to as Q25, although other recurrence intervals might have been used, as described in HDM Chapter 830, Transportation Facility Drainage. Confer with District Hydraulics.

- When constructed inline, water stored in the Infiltration Galleries must not cause backwater conditions upstream in the storm drain system that would adversely impact its ability to convey flows generated by peak drainage design storms as required in the HDM.
- The geometric configuration must be sized to allow the Infiltration Gallery to drain within 96 hours. Required drain time may be more stringent based on District specific or local vector requirements.
- Not appropriate for areas with inadequate soil infiltration rate (less than 0.5 inches per hour and/or HSG Type C soils). Note that constructed embankments used to support highways are highly disturbed areas, and it is likely that the infiltration rate will be degraded compared to that of the native soils. These sites should not be considered without consultation with Geotechnical Services and other Data Sources.
- Not appropriate for areas with seasonally high groundwater (minimum 5-ft separation required), where groundwater has known contamination, in seismic impact zones, or in areas with soil liquefaction and differential settlement potential is possible.

The RWQCB having jurisdiction may impose additional requirements for water protection purposes. Consultations 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 water from down gradient areas, infiltration may not be appropriate.

Section 3

Getting Started

Evaluate site conditions to obtain and assess the design parameters that will be used to determine if an Infiltration Gallery is suitable based on the Feasibility Criteria described in Section 2. Infiltration Gallery TBMPs require an extensive geotechnical investigation, see the Infiltration Basins Design Guidance for more information. This section provides the calculations that are used to verify TBMP feasibility and to determine the portion of WQV infiltrated by the TBMP. If the Infiltration Gallery is configured inline, also verify that the TBMP can convey the Design Storm flows.

Because the Infiltration Gallery is a newly approved TBMP, the TBMP design must be approved for use by the District/Regional Design Stormwater Coordinator.

3.1 Preliminary Design Parameters

The calculations in this guidance assume instantaneous runoff to the TBMP (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 TBMP. 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 TBMP 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 2019c).

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.

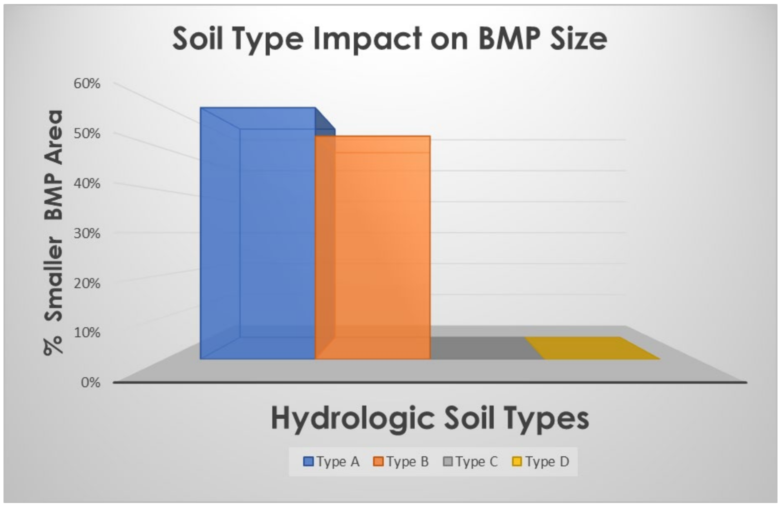

Figure 3-1. BMP Size Reduction Based on Soil Type

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 required.

3.1.1 Contributing Drainage Area and WQV

The WQV generated by the TBMP 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 TBMP site has infiltration capacity. An explanation of CDA delineation and WQV calculation and example can be found in Section 3 of the DPPIA Design Guidance (Caltrans 2021).

3.1.2 Invert Area

The geometric requirements of the Infiltration Gallery are based on the WQV, the in-situ infiltration rate, and the desired drawdown time. Runoff is assumed to leave Infiltration Galleries only through the invert. The invert area is sized using the equation below:

$$A_{inv} = \frac{12 \times SF \times WQV}{k_{est} \times t} \qquad \text{Eq. 2}$$

Where:

A_{inv} = area at the invert of the Infiltration Gallery (SQFT)
WQV = WQV (CF)
k_{est} = known or estimated soil infiltration rate (in/hr)
t = drawdown time of full device (recommended as 40 to 48 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 3-1.

Table 3-1. 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. *Unified soil classification system (USCS) classifications are shown as approximation to the Natural Resources Conservation Service (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 are 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 Gallery should typically be placed at locations with soils classified as HSG A, or B soils and the WQV should infiltrate within a maximum of 96 hours. If an Infiltration Gallery can't drawdown in 96 hours, vector control meeting California Department of Public Health requirements must also be implemented. Coordinate with the District/Regional Design Stormwater Coordinator when longer drawdown times are being considered. A maximum allowable infiltration rate is not specified unless justified by adequate groundwater information.*
3. *When estimating the invert area for Infiltration Gallery placed in HSG Group B soils using the equations above, use the minimum infiltration rate of 0.5 inches per hour to initially size the TBMP until geotechnical investigation provides a field rate for the proposed location.*

3.1.3 Design Storm Event

WQV-based TBMPs that are designed for both inline placement (see Section 4.2) and offline placement must safely bypass flows that are larger than the WQV Event, typically through an overflow/bypass device. The TBMP bypass must be designed to convey peak drainage from the roadway and CDA in accordance with HDM Topic 831. This event is called the Design Storm[2]. Continue to use the runoff coefficients in HDM Topic 819.2 and the total TBMP CDA for drainage design and flood flows. The permissible velocity and permissible shear stress of upstream and/or downstream channels during the Design Storm must be evaluated, see HDM Chapter 860 and Table 865.2. The upstream and downstream conveyance design is beyond the scope of this document.

[2] For convenience in this document, this flow will be referred to as Q25, although other recurrence intervals might have been used as described in HDM Chapter 830, Transportation Facility Drainage. Confer with District Hydraulics.

Section 4

BMP Layout

This section discusses various detailing needed to place an Infiltration Gallery within a project, including: inline versus offline placement, pretreatment of runoff, geotechnical investigation considerations, and structural design requirements.

4.1 Layout

The Infiltration Gallery may assume any shape and may be configured using proprietary devices. Caltrans has not studied proprietary devices; therefore, these devices may not comply with current maintenance practices. The Infiltration Gallery may be designed using modified standard drainage facilities, such as perforated drainage pipe (used for underdrains), open bottom RCBs, or arch culverts with open bottoms, when feasible. The design must consider maintenance access, constructability, and pretreatment to reduce sediment loading on the system. When possible the Standard Plans for items such as excavation and backfill or structural features should be used.

Safety of the traveling public is paramount and, therefore, the placement of this or any other TBMP must not cause objectionable backwater or violate requirements of Chapter 800 of the HDM. Specific consideration of the overall placement within the existing drainage system is beyond the scope of this document, and should be coordinated with District Hydraulics, as needed.

Example configurations of Infiltration Galleries are shown in Figure 4-1 and Figure 4-2.

4.1.1 Proprietary Devices

The use of proprietary devices within the right-of-way requires approval from the District/Regional Design Stormwater Coordinator, District Office Engineer, OHSD, District Maintenance Stormwater Coordinator and potentially other functional units, as appropriate. Infiltration Gallery TBMPs that utilize a prefabricated product (proprietary device) shall follow the manufacturer's specifications for design, installation, and maintenance. Public interest findings may be required to be submitted to the Office of Federal Resources for review and approval. See the Construction Contract Development Guide (Caltrans 2019b) and the Public Interest Finding Guidelines for a complete list of requirements.

Figure 4-1. Example of Perforated HDPE Pipe installation, Photo from Plastic Pipe Institute website.

Figure 4-2. Example of Perforated Metal Pipe installation, Photo from Storm Water Solutions Magazine website.

4.2 Inline vs. Offline Placement

An Infiltration Gallery can be placed in an inline or offline configuration. An Infiltration Gallery is placed in an inline configuration when an alternate route for the overflow event (or Design Storm) is not provided. Designing an Infiltration Gallery in an inline configuration is not the preferred method but may be acceptable due to space restrictions.

Because the volume of the Infiltration Gallery is designed for the WQV, alternate means of safely conveying the events larger than the Water Quality Event must be provided. Additionally, the Infiltration Gallery must be able to pass the runoff generated during the Design Storm (see Section 3.1.3) through the TBMP to downstream conveyance without objectionable backwater effects to upstream facilities. An overflow device shall be designed to convey the runoff from an overflow event in accordance with Section 4.4.

An Infiltration Gallery is placed in an offline configuration when an alternative route for runoff in excess of the WQV is provided. The excess volume is diverted around the Infiltration Gallery to avoid exposing the treatment facility to events larger than the WQ Event. Offline placement also provides better treatment by collecting first-flush runoff and does not flush out collected pollutants during high-flow storm events. A flow diversion structure typically consists of a flow splitter, weir, orifice, or pipe to bypass excess runoff (Caltrans 2020c). Whatever bypass design is chosen is should be a passive system that does not require anyone for it to function. The bypass device should meet the design criteria and be accompanied with downstream conveyance engineered to handle the Design Storm flow (see Section 3.1.3).

4.3 Pretreatment of Runoff

Runoff entering an Infiltration Gallery must be pretreated to minimize the build-up of sediments and trash in the device, which will impair performance (Caltrans 2020d). Pretreatment is used to extend the maintenance interval on the system and reduce the life cycle cost.

Stormwater runoff that is directed to an Infiltration Gallery would usually be in a concentrated flow regime. Place a sufficiently sized sediment basin or sump and full trash capture BMP immediately upstream of the Infiltration Gallery inlet and provide safe access for maintenance staff and vehicles.

Pretreatment of runoff for oil and grease is recommended for large parking lots, commercial sites, and industrial sites when a significant potential exists for discharge of contaminants to groundwater or surface water (e.g., spills, high concentrations of oil/grease). Consideration of trash capture in these areas is also advisable due to the increased potential for generation of litter.

4.3.1 Maintenance

Infiltation Gallery TBMP can easily be overwhelmed by sediment, trash, or aggregate and some can be very hard or nearly impossible to clean if loaded with material. Maintainable, sufficiently sized pretreatment devices must be implemented to reduce the risk of clogging or failure of this TBMP (Caltrans 2020d). At a minimum, the inline system should include the following:

1. Sumps at forebay and afterbay, along with cleanouts placed at a maximum of 150’ apart.
2. Screened inlet to prevent sediment and trash from entering void space area.
3. Weirs at grates preceding forebay and cleanout inlets to divert water into system.
4. Trash screening upstream of system if warranted for heavy trash loading areas.

When installed correctly only clean water free from trash and sediment will enter the Infliltration Gallery. This is the goal for pretreatment. Pretreatment is critical since these galleries can range in size from small 12" perforated plastic pipe to large reinforced concrete structures so access will range from small cleanout to manholes, inlets, and steel hinged access covers. Access could be problematic for small systems but if the water going into these is clean, then this should not be a problem.

For large galleries manholes and/or inlet structures should be placed at necessary intervals to allow for ease of maintenance access, ingress, and egress. These access facilities must have appropriate steps, ladders, or rigid rail fall protection to ensure safe access into the Infiltration Gallery. The large Infiltration Gallery configuration would be classified as a confined space.

The devices should be inspected prior to the start of the wet season and periodically during the wet season; the NPDES permit requires annual inspections. The TBMP requires sufficient space adjacent to the TBMP to allow Maintenance staff and vehicles safe access. Discuss all proposed Infiltration Gallery locations with the District Maintenance Stormwater Coordinator, because maintenance is critical to the performance of these devices. Locate the TBMP where adequate access is available for maintenance activities without requiring lane or shoulder closures. When possible, maintain a minimum space of twelve feet (one lane width) between moving traffic and the work area. Include a minimum 9-ft parking width for maintenance vehicles.

4.4 Detailing of the Infiltration Gallery Inlet

Properly size and maintain the upstream drainage system discharging to the Infiltration Gallery to allow stormwater runoff from the intended CDA to enter the facility. Calculate the velocity of flow entering the Infiltration Gallery, particularly during the overflow event, to determine if scour protection is required. Depending on the velocity entering the proposed Infiltration Gallery, an energy dissipator may be required (HDM, Table 865.2). Coordinate the design of an energy dissipator with District Hydraulics.

4.5 Geotechnical Investigations

A Geotechnical Investigation must be performed by a qualified, licensed geotechnical engineer registered in the state of California. The geotechnical engineer must issue a report summarizing findings. The report should comment on the following items: potential site hazards (e.g., slope stability, landslides, liquefaction, lateral spreading); appropriate setbacks from sloped terrain, adjacent foundations, and utilities; seismic load parameters, including seismic increments for soil loading; permanent ground deformation and fault rupture; differential settlement (due to static and seismic considerations); and identification of hazards or conditions that may prohibit the installation of the gallery infiltration system (e.g., location in seismic impact zones, unstable areas such as landslides and Karst terrains, areas with high potential for soil liquefaction and differential settlement, highly expansive/collapsible soils).

The geotechnical investigation provides information for both the structural foundation load bearing calculations and estimating the expected infiltration rates of the underlying soil. The subsurface investigation should generally follow the Infiltration Basins Design Guidance with respect to the number and depth of the borings. The borings should identify the site soils and any impermeable layers and shallow groundwater that may affect the infiltration capability of the site soils. Perform soil laboratory testing to help develop engineering soil parameters for use in determining the bearing capacity, settlement, and overall stability of the proposed Infiltration Gallery foundation systems.

Perform either site-specific infiltration testing or hydraulic conductivity testing at the site in the borings or on recovered samples to determine the design infiltration rates. Testing should consist of gradation, plasticity, strength, and time-dependent settlement soil testing.

4.6 Structural Design

The Infiltration Galleries design should be evaluated for structural feasibility based on potential loading, surrounding slopes, and construction and maintenance access locations. Calculations should state all relevant codes considered, the design criteria and loading used, and clearly describe any loads imposed on existing or adjacent structures. Structural designs are to be coordinated with other discipline documents and the structural elements shall explicitly account for effects of miscellaneous openings, manholes and access openings, and pipe penetrations. Refer to the Geotechnical Report for foundation and other design requirements not noted below.

Infiltration structures should be designed based on the California Building Code (CBC), 2016 Edition with local amendments, ASCE 7-10: Minimum Design Loads and Associated Criteria for Buildings and Other Structures, and ACI 318-14: Building Code Requirements for Structural Concrete and Commentary (ACI 2014). Additionally, liquid containing structures should be designed in accordance with ACI 350-06: Code Requirements for Environmental Engineering Structures, and ACI 350.3-06: Seismic Design of Liquid-Containing Structures.

The design of all structural members should follow Load Resistance and Factored Design (LRFD) methods. Soil and geotechnical designs and considerations may follow LRFD methods or Allowable Stress Design (ASD) methods. Load combinations should follow Table 3.4.1-1 of the AASHTO LRFD Bridge Design Specifications, 8th Edition, with California Amendments. Live loads (including increases for impact, if applicable) should be applied in accordance with Section 3.

Infiltration structures that act as retaining structures should be designed for both the static and dynamic soil loads provided in the Geotechnical Report. Static soil loads should be based on active pressures or at-rest pressures as applicable. Retaining structures that are restrained at the top in the final condition but are subject to cantilever behavior during construction, should be designed for the worst effect between the active and at-rest soil load cases. Infiltration structures that act as retaining structures should have a minimum factor of safety against sliding and overturning of 1.5. Where earthquake loads are included, the minimum safety factor for sliding and overturning may be reduced to 1.1.

Infiltration structures that are located underground or are partially underground should be designed assuming that counteracting soil effects (i.e., passive pressures at concrete walls above the foundation) against active soil loads, at-rest soil loads, and seismic loads are non-existent unless explicit guidance is otherwise provided by the Geotechnical Engineer.

Infiltration structures should be designed for the following surcharge loads: surcharge effects of HL93 trucks and surcharge effects of adjacent structures and foundations. In lieu of designing for surcharge effects of adjacent structures, infiltration structures may be located beyond the adjacent structure's realm of influence assuming a 1.5 H:1 V sloping line emanating from the bottom of the nearest adjacent footing, mat slab or pile cap.

Use minimum and maximum groundwater levels established in the Geotechnical Report to determine buoyancy design requirements, if applicable. The design for Infiltration Galleries must account for depth to seasonal high groundwater which must be at least 5 feet below the bottom of the gallery. Infiltration devices should not be constructed in areas that would require pile foundations or other means of tie down.

Foundations for infiltration structures should be designed and configured to minimize static and dynamic differential settlements. Total differential foundation settlements (inclusive of seismic considerations) should conform to the following limits: 0.005*L for structures less than 10 feet tall, and 0.003*L for structures greater than 10 feet tall.

Where Caltrans permits the installations of Infiltration Galleries near roadways or vehicular traffic, the structure should be designed to support HL93 truck loading. The HL93 truck loading should be increased per the AASHTO LRFD Bridge Design Specifications, 8th Edition, with California Amendments to account for impact forces of moving wheels.

4.7 Site Specific Design Elements

4.7.1 Soil Compaction

A Geotechnical Design Report should be completed for siting Infiltration Gallery TBMPs. The area identified for infiltration should be clearly marked on the plans and delineated in the field. During construction, use of heavy equipment over the invert of the gallery should be limited or prohibited to prevent compaction of the underlying soils intended for infiltration.

4.7.2 Invert Separation from Seasonally High Groundwater

Treatment is provided by the soil below the invert while the runoff is infiltrating. A 5-ft separation between seasonally high groundwater and Infiltration Gallery inverts is desired. Less separation may be considered if justified by adequate groundwater information or contact the District/Regional NPDES Coordinator to determine if consultation with the RWQCB is needed. The Infiltration Gallery should not be located in areas that contain fractured rock within 10 ft of the invert. Sites that have subsurface conditions that may be of concern, should be discussed with the District/Regional NPDES Coordinator.

4.7.3 Environmental Conditions

Obtain environmental clearances related to sensitive flora and fauna, archeological and historical sites, and determine the potential for soil or groundwater contamination. Contact the District Environmental Unit for these studies.

4.7.4 Upstream Effects

Infiltration Gallery is placed for water quality purposes and must operate safely and effectively as part of the overall highway drainage system. Hydraulic design issues must be carefully evaluated during the design process, keeping the safety of the traveling public paramount. TBMP placement and design must consider 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.

4.7.5 Potential Downstream Impacts

Potential downstream erosion must be considered during overflow events if the overflow release is proposed for surface conveyance. Refer to the PPDG Appendix A, for means to prevent erosion, and Chapter 800 of the HDM, to design and protect downstream conveyance.

Section 5

PS&E Preparation

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

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

5.1 PS&E Drawings

This section provides guidance for incorporating the Infiltration Gallery TBMP into the contract plans. Infiltration Gallery TBMPs do not have standard drawings but there are several sheets that should be placed in the PS&E package. The PS&E drawings for most projects having an Infiltration Gallery may include the following:

- Layout(s): Show location(s) of the Infiltration Gallery. This will aid in recognizing, both within and outside Caltrans, that the Infiltration Gallery was placed within the project limits.
- Drainage Plan(s), Profiles, Details, and Quantities:
  - Drainage Plan sheets should show each Infiltration Gallery in plan view, along with other existing (or proposed) drainage conveyance devices that direct the runoff into or around the device (i.e., inline versus offline) and overflow from the device.
  - Drainage Profile sheets should show the Infiltration Gallery in profile within the drainage conveyance system. These sheets should also call out the specific Infiltration Gallery inlet and outlet flow line (surface) elevations, as applicable, and invert elevations.
  - Drainage Detail sheets should show detailing needed for the construction of the Infiltration Gallery. Inflow and outflow detailing should be shown, including the overflow release device (e.g., outlet pipe or riser). If an RCB configuration is used, the dimensions, structural elements, reinforcement types, and spacing should be shown. Structure Plans may need to be developed to show additional details (e.g., general plan, footing details, log of test borings).
  - Drainage Quantity sheets should include all pay and non-pay items associated with the construction of the Infiltration Gallery, except for those items that will be placed on the Summary of Quantities sheets.

- Temporary Water Pollution Control Plans: These sheets show the temporary TBMPs used to establish the Infiltration Gallery TBMPs and compliance with the Construction General Permit.

5.2 Specifications

Contract specifications for projects that include Infiltration Gallery TBMPs will include Standard Specifications and may include Standard Special Provisions (SSPs) and non-Standard Special Provisions (nSSPs). [3]

If special provisions are needed for the various items of work to construct the Infiltration Gallery TBMP, they could be organized under the blanket heading of 'Infiltration Gallery' with some or all of these items listed as subheadings. Payment would be made for 'each' Infiltration Gallery. 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.

5.2.1 Standard Specifications

Standard Specifications are to be used for a project that constructs an Infiltration Gallery TBMP. Consider the construction of the Infiltration Gallery 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

21 Erosion Control

51 Concrete Structures

52 Reinforcement

62 Class D Filter Fabric

64 Plastic Pipe

68 Subsurface Drains

70 Miscellaneous Drainage Facility

71 Existing Drainage Facilities

72 Slope Protection

73 Concrete Curbs

96 Geosynthetics

[3] Standard Specifications will not be included but merely referenced in the contract's special provisions.

5.2.2 Standard Special Provisions

SSPs are not typically used for a project that constructs an Infiltration Gallery TBMP. Consider the construction of the Infiltration Gallery in the context of the entire project to determine if SSPs are required or if they can enhance the overall design.

5.2.3 Non-Standard Special Provisions

A project that constructs an Infiltration Gallery 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 Gallery may contain and is available by request.

5.3 Project Cost Estimates

Project Cost Estimates are required at every phase of the project: 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.

5.3.1 PID and PA/ED Phases

Project planning cost estimates typically proceed as: project feasibility, project initiation, draft project report, and project report. A refined version of the cost estimate is the project report cost estimate and is developed in the PA/ED phase. For details on what needs to be included in the TBMP cost estimate refer to Appendix F of the PPDG. This estimate must be modified as the project progresses.

5.3.2 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 Gallery location and determine limits of excavation and backfill.

5.4 Developing Infiltration Gallery 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 contract items required to construct the Infiltration Gallery. Table 5-1 includes typical contract items that may be included in the unit cost (CY and SQFT) estimate if they are required for Infiltration Galleries. Table 5-1 is not a complete list and must be modified on a project-specific basis to accommodate all aspects of design.

Table 5-1. Example Infiltration Gallery Estimate

Contract Item	Type	Unit	Quantity	Price	Amount
Structural Concrete		CY			
Bar Reinforcing Steel		LB			
Structure Excavation		CY			
Structure Backfill		CY			

When developing costs based on unit quantities, the cost estimates should be based upon the most recent Caltrans Contract Cost Data Book and District 8 Cost Data Base for current similar projects in the District: http://sv08web/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 for each specific Infiltration Gallery location, including the need for shoring to protect an existing highway feature. Calculate quantities for cost estimating and construction pay items and incorporate into the modified drawings and estimates.

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

Section 6

Design Example

The site chosen for this example is a proposed bridge expansion at Sea World Drive, District 11, located at Route 5. An aerial photograph of the site is provided in Figure 6-1.

Figure 6-1. Proposed Infiltration Gallery Project, Sea World Drive, Route 5

Givens:

- Invert elevation at proposed Infiltration Gallery: 15 ft Mean Sea Level (MSL)
- Geotechnical Properties:
  - Permeability (K_{est}) as 1.50 inches per hour
  - Groundwater elevation below proposed Infiltration Gallery: 5 ft MSL
  - Geotechnical Report concludes the site is suitable for placement of Infiltration Galleries
- Assume instantaneous runoff to the TBMP (i.e., slug-flow)
- CDA (A) as 1.54 acres (80% impervious):
  - 1.23 acres impervious roadway
  - 0.31 acre unpaved
    - Available length (parallel to roadway) for Infiltration Gallery is 50 ft
- Drawdown time (t) as 48 hours
- Precipitation depth (P) as 0.49 inch
- No Water Quality siting restrictions apply
- Offline system
- Pretreatment system sized separately

Step 1: Determine the WQV:

WQV = R_v (P/12) A

Where:

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

R_v = Volumetric Runoff Coefficient, 0.60 – from PPDG Section 5.3 for 80 percent impervious drainage area

P = Precipitation Depth, 0.49 inch (given)

A = CDA, 1.54 ac (given)

WQV = 0.60 x 0.49 inch (1 inch /12 ft) x (1.54 acres x 43,560 SQFT/acre) = **1,644 CF**

Step 2: Calculate minimum required floor area using Darcy's Law for one-dimensional flow.

A_{inv} = (12 inches per foot x WQV) / (k_{est} x t)

WQV = 1,644 CF

k_{est} = 1.50 inches per hour (given)

t = 48 hours (given)

A_{inv} = (12 inches per ft x 1,644 CF)/(1.50 inches per hour x 48 hour) = 274 SQFT

Step 3: Size the TBMP storage based on the selected configuration:

Example calculations for an RCB and an open bottom arch culvert (Figure 6-2) are shown below. Additional calculations may be required to design this TBMP. All calculations must be prepared by a Structural Engineer for the modified RCB. Coordination with OHSD or other appropriate office is required.

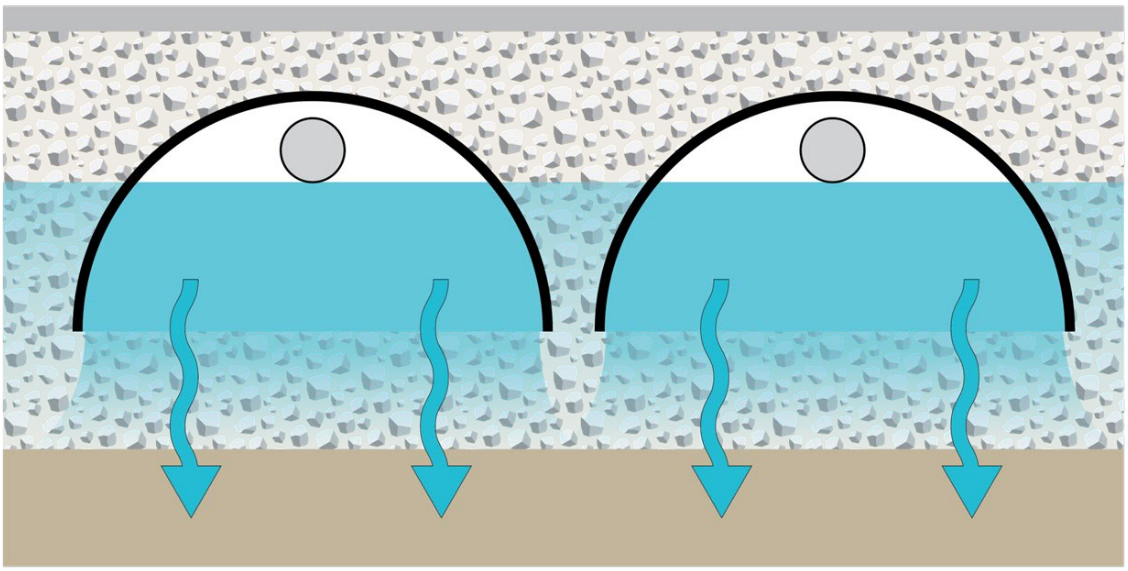

Figure 6-2. Illustration of One-Dimensional Flow Out of an Infiltration Gallery

Taken from Minnesota Stormwater Manual

Configuration A: RCB

Standard RCB Dimensions:

Step A-1: Width of RCB:

274 SQFT/50 ft = 5.5 ft → Caltrans Standard Plan D80, use 6 ft span

Step A-2: Height of RCB to contain WQV:

1,644 CF/(50 ft x 6 ft) = 5.48 ft → Standard Plan D80, use 6 ft height

- Verify: 50 ft x 6 ft x 6 ft = 1,800 CF > 1,644 CF

Configuration B: Arch Culvert

Step B-1: In this step the minimum circular pipe diameter is calculated assuming the pipe is limited to 50 ft (given), and assuming this is a circular or half-circle pipe. This tells us minimum pipe diameter size given the required bottom area of 274 SQFT.

274 SQFT/50 ft = 5.5 ft or 66 inches

Step B-2: This step determines the cross-sectional area of the half-circle pipe that is assumed to be filled completely with water. This tells us along with minimum pipe diameter size in Step A-1 how many SQFT of water per FT of pipe it can hold.

$0.5 \times (\pi \times (5.5 \text{ ft})^2) = 11.9$ SQFT

Step B-3: We complete the calculations by using the results of Step A-2 to determine how many 50ft rows of 66 in pipe will be required to hold the whole WQV of 1,644 CF.

1,644 CF/(11.9 SQFT x 50 ft) = 2.8 rows → 3 rows

Detailed example structural calculations are not provided here because culvert material and type can vary by project. Detailed calculations must be prepared by a licensed professional and submitted for approval and design concurrence from the appropriate Caltrans functional units.

Alternative Configuration: Modified RCB

The site is suitable for infiltration, so a potential configuration is to modify the RCB to be open bottom. A licensed professional must submit project-specific calculations for approval or design concurrence from the appropriate Caltrans functional units.

As this configuration is similar to a bridge, when used, the TBMP must be designed by an engineer experienced in structural design. The California Amendments to AASHTO LRFD Bridge Design Specifications must be considered during design. Calculations include and are not limited to wall design, top slab design, and footing design.

Section 7

References

American Association of State Highway and Transportation Officials (AASHTO), 2011. Roadside Design Guide, 4th Edition; with errata published in July 2015

Bay Area Stormwater Management Agencies Association (BASMAA), 2016a. Biotreatment Soil Media and Specification: Current Research on Trees and Water Quality Treatment, Literature Review, September 14, 2016.

Bay Area Stormwater Management Agencies Association (BASMAA), 2016b. Bioretention Design for Tree Health: Literature Review. September 15, 2016.

California Stormwater Quality Associations (CASQA), May 2017, Removing Barriers to Low Impact Development (LID), Bioretention Details and Standards Review.

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

California Department of Transportation (Caltrans), 2021. Stormwater Quality Handbooks: Design Pollution Prevention Infiltration Area (DPPIA) Design Guidance

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

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

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

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

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

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

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

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

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

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

California Department of Transportation (Caltrans), 2019e. Caltrans Infiltration Tool v4.0, available on the California State University Sacramento, Office of Water Programs website https://www.owp.csus.edu/research/caltrans-infiltration-tool.php

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

California Department of Transportation (Caltrans), 2016. Caltrans, District 4, San Francisco-Oakland Bay Bridge (SFOBB) Bioretention Pilot Project – Media Analysis, CTSW-TM-16-325.05.01.