

Port of San Diego's BMP Design Manual



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Summary

In May 2013, the California Regional Water Quality Control Board for the San Diego Region reissued a municipal storm water, National Pollutant Discharge Elimination System permit (Municipal Separate Storm Sewer Systems [MS4] Permit) to San Diego area municipal Copermittees (Order No. R9-2013-0001). The reissued MS4 Permit updates and expands storm water requirements for new developments and redevelopments. The MS4 Permit was amended by Order No. R9-2015-001 in February 2015 and again in November 2015 by Order No. R9-2015-0100

As required by the reissued MS4 Permit, the Copermittees prepared a Model Best Management Practices (BMP) Design Manual to replace the current Countywide Model Standard Urban Stormwater Mitigation Plan (SUSMP), dated March 25, 2011, which was based on the requirements of the 2007 MS4 Permit. The Model BMP Design Manual (Model Manual) is available at www.projectcleanwater.org. The Model Manual content was made available for public review and comment from January 20, 2015 to February 20, 2015. Comments from the public review of the Model Manual have been incorporated into the final version submitted for regulatory approval in June 2015.

The Port of San Diego (Port) is required to adopt a jurisdiction specific local BMP Design Manual. This BMP Design Manual is applicable to projects carried out on Port managed tidelands. The manual closely follows the outline and requirements of the Model Manual with modifications to fit Port-specific project processing requirements. The Port also held a public review and comment period for the Port BMP Design Manual from May 5 through May 27, 2015. Although no comments were received, comments received on the Model Manual have also been incorporated into the Port's manual.

The BMP Design Manual has since been revised to incorporate changes based on the recent guidance and anticipated letter from the Water Board on the use of proprietary biofiltration BMPs, and due to unique constraints impacting certain Port projects (green streets exemption and routine maintenance language).

This BMP Design Manual is designed to comply with the Port's Stormwater Management and Discharge Control Ordinance (Article 10) and the enforcement and development and review process described in the Port's Jurisdictional Runoff Management Plan (JRMP). The effective date of this manual

What this manual is intended to address:

This manual addresses updated onsite post-construction storm water requirements for Standard Projects and Priority Development Projects (PDPs), and provides updated procedures for planning, preliminary design, selection, and design of permanent storm water BMPs based on the performance standards presented in the MS4 Permit.

The intended users of the BMP Design Manual include project applicants, for both tenant and capital developments, their representatives responsible for preparation of Storm Water Quality Management Plans (SWQMPs) and Port personnel responsible for review of these plans.

The following are significant updates to storm water requirements of the MS4 Permit compared to the 2007 MS4 Permit and 2011 Countywide Model SUSMP:

- PDP categories have been updated, and the minimum threshold of impervious area to qualify as a PDP has been reduced.
- Many of the low impact development (LID) requirements for site design that were applicable only to PDPs under the 2007 MS4 Permit are applicable to all projects (Standard Projects and PDPs) under the MS4 Permit.
- The standard for storm water pollutant control (formerly treatment control) is retention of the 24-hour 85th percentile storm volume, defined as the event that has a precipitation total greater than or equal to 85 percent of all daily storm events larger than 0.01 inches over a given period of record in a specific area or location.
- For situations where onsite retention of the 85th percentile storm volume is technically not feasible, biofiltration must be provided to satisfy specific “biofiltration standards”. These standards consist of a set of siting, selection, sizing, design and operation and maintenance (O&M) criteria that must be met for a BMP to be considered a “biofiltration BMP” – see Section 2.2.1 and Appendix F.
- Exemptions from hydromodification management are reduced, and certain categories of exemptions that are not identified in the MS4 Permit must be identified in a Watershed Management Area Analysis (WMAA).
- The flow control performance standard for hydromodification management is based on controlling flow to pre-development condition (natural) rather than pre-project condition.
- The flow control performance standard is updated. Requirement to compare flow frequency curves is removed. Performance standard for comparing pre-development and post-project flow duration curves is revised.
- Hydromodification management requirements are expanded to include requirements to protect critical coarse sediment yield areas.
- Alternative compliance approaches are provided as an option to satisfy pollutant control or hydromodification management performance standards if a Copermittee implements an alternative compliance program. Copermittees are given discretion by the MS4 Permit to allow the project applicants to participate in an alternative compliance program without demonstrating technical infeasibility of retention and/or biofiltration BMPs onsite.

What this manual does not address:

This manual provides guidelines for compliance with onsite post-construction storm water requirements in the MS4 Permit, which apply to both tenant and capital projects. The MS4 Permit includes provisions for discretionary participation in an alternative compliance program. As this element is jurisdiction-specific and in different stages of development across the San Diego region, this manual **does not provide guidance for participation in an alternative compliance program**. This manual only indicates the conditions under which project applicants, capital or tenant, can seek to participate in alternative compliance at the discretion of the Port. Additionally, This manual addresses only post-construction storm water requirements and is not intended to serve as a guidance or criteria document for construction-phase storm water controls.

Disclaimer

Currently, some of the Copermittees are pursuing a subvention of funds from the State to pay for certain activities required by the 2007 Municipal Permit, including activities that require Copermittees to perform activities outside their jurisdictional boundaries and on a regional or watershed basis. Nothing in this manual should be viewed as a waiver of those claims or as a waiver of the rights of

Copermittees to pursue a subvention of funds from the State to pay for certain activities required by the MS4 Permit, including the preparation and implementation of the BMP Design Manual. In addition, several Copermittees have filed petitions with the State Board challenging some of the requirements of Provision E of the MS4 Permit. Nothing in this manual should be viewed as a waiver of those claims. Because the State Board has not issued a stay of the 2013 Municipal Permit, Copermittees must comply with the MS4 Permit's requirements while the State Board process is pending.

This manual is organized in the following manner:

An introductory section titled **“How to Use this Manual”** provides a practical orientation to intended uses and provides examples of recommended workflows for using the manual.

Chapter 1 provides information to help the manual user determine which of the storm water management requirements are applicable to the project; source controls/site design, pollutant controls, and hydromodification management. This chapter also introduces the procedural requirements for preparation, review, and approval of project submittals. Port requirements for processing project submittals are provided in this chapter.

Chapter 2 defines the performance standards for source control and site design BMPs, storm water pollutant control BMPs, and hydromodification management BMPs based on the MS4 Permit. These are the underlying criteria that must be met by projects, as applicable. This chapter also presents information on the underlying concepts associated with these performance standards to provide the project applicant with technical background; explains why the performance standards are important; and gives a general description of how the performance standards can be met.

Chapter 3 describes the essential steps in preparing a comprehensive storm water management design and explains the importance of starting the process early during the preliminary design phase. By following the recommended procedures in Chapter 3, project applicants can develop a design that complies with the complex and overlapping storm water requirements. This chapter is intended to be used by both Standard Projects and PDPs; however, certain steps will not apply to Standard Projects (as identified in the chapter).

Chapter 4 presents the source control and site design requirements to be met by all development projects and is therefore intended to be used by Standard Projects and PDPs.

Chapter 5 applies to PDPs. It presents the specific process for determining which category of onsite pollutant control BMP, or combination of BMPs, is most appropriate for the PDP site and how to design the BMP to meet the storm water pollutant control performance standard. The prioritization order of onsite pollutant control BMPs begins with retention, then biofiltration, and finally flow-thru treatment control (in combination with offsite alternative compliance). Chapter 5 does not apply to Standard Projects.

Chapter 6 applies to PDPs that are subject to hydromodification management requirements. This chapter provides guidance for meeting the performance standards for the two components of hydromodification management: protection of critical coarse sediment yield areas and flow control for post-project runoff from the project site. Chapter 6 incorporates applicable requirements of the "Final Hydromodification Management Plan (HMP) Prepared for County of San Diego, California," dated March 2011, with modifications based on updated requirements in the MS4 Permit. Chapter 6 does not apply to Standard Projects or to PDPs with only pollutant control requirements.

Chapter 7 addresses the long term O&M requirements of structural BMPs presented in this manual,

and mechanisms to ensure O&M in perpetuity. Chapter 7 applies to PDPs only and is not required for Standard Projects; however Standard Projects may use this chapter as a reference.

Chapter 8 describes the specific requirements for the content of project submittals to facilitate Port review of project plans for compliance with applicable requirements of the manual and the MS4 Permit. This chapter is applicable to Standard Projects and PDPs. This chapter pertains specifically to the content of project submittals, and not to specific details of Port requirements for processing of submittals; it is intended to complement the requirements for processing of project submittals that are included in Chapter 1.

Appendices to this manual provide detailed guidance for BMP design, calculation procedures, worksheets, maps and other figures to be referenced for BMP design. These Appendices are not intended to be used independently from the overall manual – rather they are intended to be used only as referenced in the main body of the manual.

This manual is organized based on project category. Requirements that are applicable to both Standard Projects and PDPs are presented in Chapter 4. Additional requirements applicable only to PDPs are presented in Chapters 5 through 7. While source control and site design BMPs are required for all projects inclusive of Standard Projects and PDPs, structural BMPs are only required for PDPs. Throughout this manual, the term "structural BMP" is a general term that encompasses the pollutant control BMPs and hydromodification management BMPs required for PDPs under the MS4 Permit. A structural BMP may be a pollutant control BMP, a hydromodification management BMP, or an integrated pollutant control and hydromodification management BMP. Hydromodification management BMPs are also referred to as flow control BMPs in this manual.

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List of Acronyms

303(d)	Refers to Clean Water Act Section 303(d) list of impaired and threatened waters
ASTM	American Society for Testing and Materials
BF	Biofiltration (BMP Category)
BMPs	Best Management Practices
CEQA	California Environmental Quality Act
CWA	Clean Water Act
DCV	Design Capture Volume
DMA	Drainage Management Area
ESA	Environmentally Sensitive Area
FT	Flow-thru Treatment Control BMP (BMP Category)
GLUs	Geomorphic Landscape Units
GR	General Requirements
HMP	Hydromodification Management Plan
HSG	Hydrologic Soils Group
HSPF	Hydrologic Simulation Program-FORTRAN
HU	Harvest and Use
INF	Infiltration (BMP Category)
LID	Low Impact Development
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
NRCS	Natural Resource Conservation Service
O&M	Operation and Maintenance
PDPs	Priority Development Projects
POC	Point of Compliance
PR	Partial Retention (BMP Category)
R9	Region 9 (of the California Regional Water Quality Control Board)
SC	Source Control
SCCWRP	Southern California Coastal Water Research Project
SD	Site Design
SDHM	San Diego Hydrology Model
SIC	Standard Industrial Classification
SUSMP	Standard Urban Stormwater Mitigation Plan
SWMM	Storm Water Management Model
SWQMP	Storm Water Quality Management Plan
TN	Total Nitrogen
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WMAA	Watershed Management Area Analysis
WQIP	Water Quality Improvement Plan

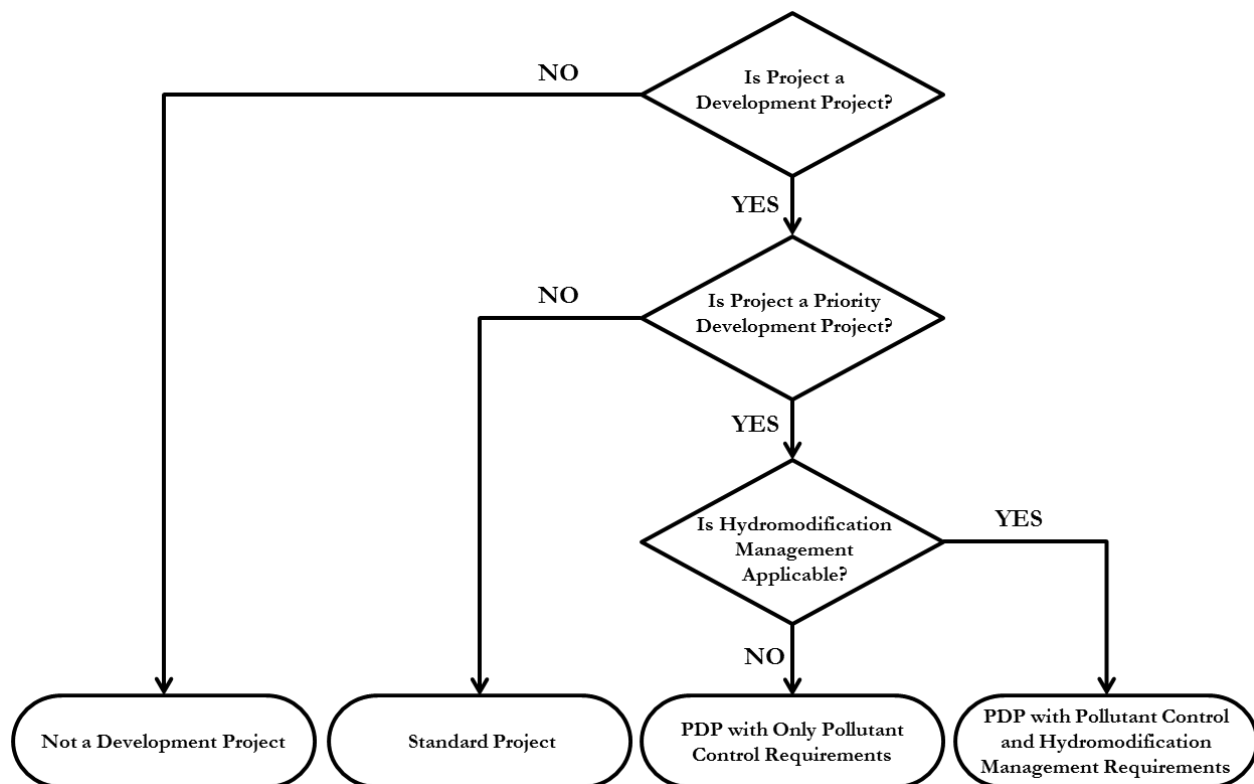
How to Use this Manual

This manual is intended to help a project applicant, in coordination with Port staff, develop a SWQMP for a development project (capital or tenant) that complies with local and MS4 Permit requirements. Most applicants will require the assistance of a qualified civil engineer, architect, and/or landscape architect to prepare a SWQMP. As every project is different, the applicant should begin by checking specific requirements with the Port.

Beginning Steps for All Projects: What requirements apply?

To use this manual, start by reviewing **Chapter 1** to determine whether your project is a “Standard Project” or a “PDP” and which storm water quality requirements apply to your project.

Not all of the requirements and processes described in this manual apply to all projects. Therefore, it is important to begin with a careful analysis of which requirements apply. Chapter 1 also provides an overview of the process of planning, design, construction, operation, and maintenance, with associated Port review and approval steps, leading to compliance. A flow chart that shows how to categorize a project in terms of applicable post-construction storm water requirements is included below. The flow chart is followed by a table that lists the applicable section of this manual for each project type.



Project Type	Applicable Requirements		
	Source Control and Site Design (Chapter 4)	Storm Water Pollutant Control BMPs (Chapter 5)	Hydromodification Management BMPs (Chapter 6)
Not a Development Project (without impact to storm water quality or quantity – e.g. interior remodels, routine maintenance; Refer to Section 1.3)	Requirements in this manual do not apply		
Standard Projects	X		
PDPs with only Pollutant Control Requirements	X	X	
PDPs with Pollutant Control and Hydromodification Management Requirements	X	X	X

Once an applicant has determined which requirements apply, **Chapter 2** describes the specific performance standards associated with each requirement. For example, an applicant may learn from Chapter 1 that the project must meet storm water pollutant control requirements. Chapter 2 describes what these requirements entail. This chapter also provides background on key storm water concepts to help understand why these requirements are in place and how they can be met. Refer to the list of acronyms and glossary as guidance to understanding the meaning of key terms within the context of this manual.

Next Steps for All Projects: How should an applicant approach a project storm water management design?

Most projects will then proceed to **Chapter 3** to follow the step-by-step guidance to prepare a storm water project submittal for the site. This chapter does not specify any regulatory criteria beyond those already specified in Chapter 1 and 2 – rather it is intended to serve as a resource for project applicants to help navigate the task of developing a compliant storm water project submittal. Note that the first steps in Chapter 3 apply to both Standard Projects and PDPs; while other steps in Chapter 3 only apply to PDPs.

The use of a step-by-step approach is highly recommended because it helps ensure that the right information is collected, analyzed, and incorporated in to project plans and submittal at the appropriate time in the Port review process. It also helps facilitate a common framework for discussion between the applicant and the reviewer. However, each project is different and it may be appropriate to use a different approach as long as the applicant demonstrates compliance with the MS4 Permit requirements that apply to the project.

Final Steps in Using This Manual: How should an applicant design BMPs and prepare documents for compliance?

Standard Projects	PDPs
<p>Standard Projects will proceed to Chapter 4 for guidance on implementing source control and site design requirements.</p> <p>After Chapter 4, Standard Projects will proceed to Chapter 8 for project submittal requirements.</p>	<p>PDPs will also proceed to Chapter 4 for guidance on implementing source control and site design requirements.</p> <p>PDPs will use Chapters 5 through 7 and associated Appendices to implement pollutant control requirements, and hydromodification management requirements for the project site, as applicable. These projects will proceed to Chapter 8 for project submittal requirements.</p>

Plan Ahead to Avoid Common Mistakes

The following list identifies some common errors made by applicants that delay or compromise development approvals with respect to storm water compliance.

- Not planning for compliance early enough. The strategy for storm water quality compliance should be considered before completing a conceptual site design or sketching a layout of project site or subdivision lots (see Chapter 3). Planning early is crucial under current requirements compared to previous requirements; for example, LID/Site Design is required for all development projects and onsite retention of storm water runoff is required for PDPs. Additionally, collection of necessary information early in the planning process (e.g. geotechnical conditions, groundwater conditions) can help avoid delays resulting from redesign.
- Assuming proprietary storm water treatment facilities will be adequate for compliance and/or relying on strategies acceptable under previous MS4 Permits may not be sufficient to meet compliance. Under the MS4 Permit, the standard for pollutant control for PDPs is **retention of the 85th percentile storm volume** (see Chapter 5). Flow-thru treatment cannot be used to satisfy permit requirements unless the project also participates in an alternative compliance program. Under some conditions, certain proprietary BMPs may be equivalent to “biofiltration” according to Appendix F of this manual and can be used for primary compliance with storm water pollutant treatment requirements (i.e. without alternative compliance); see description and further references in Chapter 2.2 for additional guidance.
- Not planning for on-going inspections and maintenance of PDP structural BMPs in perpetuity. It is essential to secure a mechanism for funding of long term O&M of structural BMPs, select structural BMPs that can be effectively operated and maintained by the tenant/Port, and include design measures to ensure access for maintenance and to control maintenance costs (see Chapter 7).

Policies and Procedural Requirements

This chapter introduces storm water management policies and is intended to help categorize a project and determine the applicable storm water management requirements as well as options for compliance. This chapter also introduces the procedural requirements for preparation, review, and approval of project submittals.

1.1 Introduction to Storm Water Management Policies

MS4 Permit Provision E.3.a-c; E.3.d.(1)

Storm water management requirements for development projects are derived from the MS4 Permit and implemented by the Port.

On May 8, 2013, the California Regional Water Quality Control Board San Diego Region (referred to as “San Diego Water Board”) reissued a municipal storm water permit titled “National Pollutant Discharge Elimination System Permit and Waste Discharge Requirements for Discharges from the MS4s draining the watersheds within the San Diego Region” (Order No. R9-2013-0001; referred to as MS4 Permit) to the municipal Copermittees. The MS4 Permit was amended in February 2015 by Order R9-2015-0001, and again in November 2015 by Order R9-2015-0100. The MS4 Permit was issued by the San Diego Water Board pursuant to section 402 of the federal Clean Water Act and implementing regulations (Code of Federal Regulations Title 40, Part 122) adopted by the United States Environmental Protection Agency, and Chapter 5.5, Division 7 of the California Water Code. The MS4 Permit, in part, requires each Copermittee to use its land use and planning authority to implement a development planning program to control and reduce the discharge of pollutants in storm water from new development and significant redevelopment to the maximum extent practicable (MEP). MEP is defined in the MS4 Permit.

Different requirements apply to different project types.

The MS4 Permit requires all development projects to implement source control and site design practices that will minimize the generation of pollutants. While all development projects are required to implement source control and site design/LID practices, the MS4 Permit has additional requirements for development projects that exceed size thresholds and/or fit under specific use

categories. These projects, referred to as PDPs, are required to incorporate structural BMPs into the project plan to reduce the discharge of pollutants, and address potential hydromodification impacts from changes in flow and sediment supply.

1.2 Purpose and Use of the Manual

This manual presents a “unified BMP design approach.”

To assist the land development community, streamline project reviews, and maximize cost-effective environmental benefits, the regional Copermittees have developed a unified BMP design approach¹ that meets the performance standards specified in the MS4 Permit. By following the process outlined in this manual, project applicants (for both tenant and capital developments) can develop a single integrated design that complies with the complex and overlapping MS4 Permit source control and site design requirements, storm water pollutant control requirements (i.e. water quality), and hydromodification management (flow-control and sediment supply) requirements.

1.2.1 Determining Applicability of Permanent BMP Requirements

Figure 1-1 below presents a flow chart of the decision process that the manual user should use to:

1. Categorize a project;
2. Determine storm water requirements; and
3. Understand how to submit projects for review and verification.

This figure also indicates where specific procedural steps associated with this process are addressed in Chapter 1. An applicability checklist for project applicants to determine which project category and requirements apply to their projects is available on the Port’s website at <https://www.portofsandiego.org/stormwater-management>.

Alternative BMP design approaches that meet applicable performance standards may also be acceptable.

Applicants may choose not to use the unified BMP design approach present in this manual, in which case they will need to demonstrate to the satisfaction of the Port, in their submittal, compliance with applicable performance standards. These performance standards are described in **Chapter 2** and in Section E.3.c of the MS4 Permit.

¹ The term “unified BMP design approach” refers to the standardized process for site and watershed investigation, BMP selection, BMP sizing, and BMP design that is outlined and described in this manual with associated appendices and templates. This approach is considered to be “unified” because it represents a pathway for compliance with the MS4 Permit requirements that is anticipated to be reasonably consistent across the local jurisdictions in San Diego County. In contrast, applicants may choose to take an alternative approach where they demonstrate to the satisfaction of the Port, in their submittal, compliance with applicable performance standards without necessarily following the process identified in this manual.

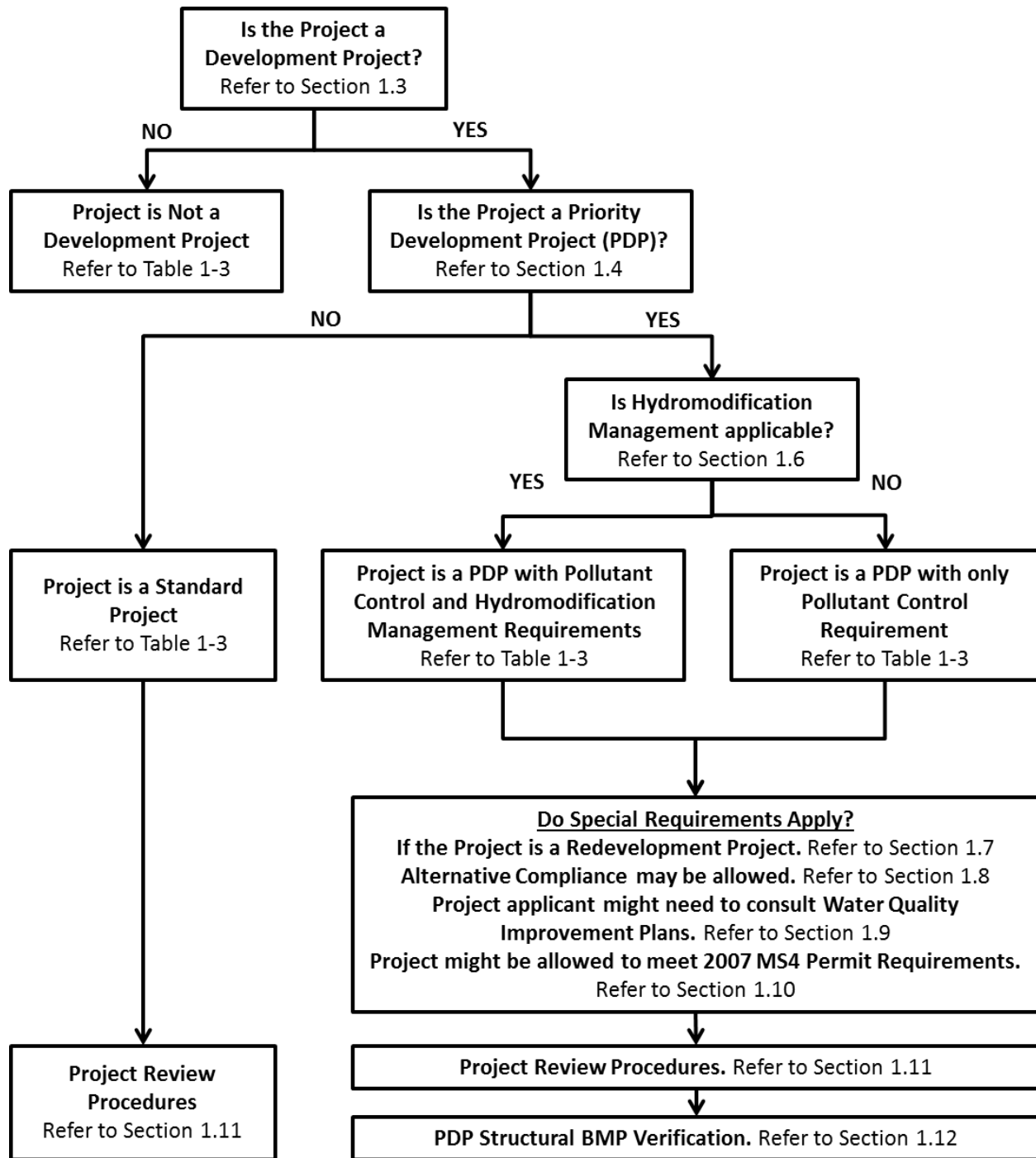


FIGURE 1-1. Procedural Requirements for a Project to Identify Storm Water Requirements

1.2.2 Determine Applicability of Construction BMP Requirements

All projects, or phases of projects, even if exempted from meeting some or all of the Permanent BMP Requirements, are required to implement temporary erosion, sediment, good housekeeping and pollution prevention BMPs to mitigate storm water pollutants during the construction phase. See the Port's Storm Water Requirements Applicability Checklist for information on and project applicability

of these requirements.

1.3 Defining a Project

Not all site improvements are considered “development projects” under the MS4 Permit.

Development projects are defined by the MS4 Permit as "construction, rehabilitation, redevelopment, or reconstruction of any capital or tenant projects". Development projects are issued local permits to allow construction activities. This manual applies only to development or redevelopment activities that have the potential to contact storm water and contribute an anthropogenic source of pollutants, or reduce the natural absorption and infiltration abilities of the land.

A project must be defined consistent with the California Environmental Quality Act (CEQA) definitions of "project."

CEQA defines a project as: a discretionary action being undertaken by a public agency that would have a direct or reasonably foreseeable indirect impact on the physical environment. This includes actions by the agency, financing and grants, and permits, licenses, plans, regulations or other entitlements granted by the agency. CEQA requires that the project include “the whole of the action” before the agency. This requirement precludes "piecemealing," which is the improper (and often artificial) separation of a project into smaller parts in order to avoid preparing EIR-level documentation.

In the context of this manual, the "project" is the "whole of the action" which has the potential for adding or replacing or resulting in the addition or replacement of, roofs, pavement, or other impervious surfaces and thereby resulting in increased flows and storm water pollutants. "Whole of the action" means the project may not be segmented or phased into small parts either onsite or offsite if the effect is to reduce the quantity of impervious area and fall below thresholds for applicability of storm water requirements.

When defining the project, the following questions are considered:

- What are the project activities?
- Do they occur onsite or offsite?
- What are the limits of the project (project boundary)?
- What is the whole of the action associated with the project (i.e., what is the total amount of new or replaced impervious area considering all of the collective project components through all phases of the project)?
- Are any facilities or agreements to build facilities offsite in conjunction with providing service to the project (street widening, utilities)?

Table 1-1 is used to determine whether storm water management requirements defined in the MS4 Permit and presented in this manual apply to the project.

If a project meets one of the exemptions in Table 1-1 then the project is exempt. If permanent BMP requirements apply to a project, Sections 1.4 to 1.7 will define the extent of the applicable requirements based on the MS4 Permit. The MS4 Permit contains standard requirements that are applicable to all projects (Standard Projects and PDPs), and specific requirements for projects that are classified as

PDPs.

TABLE 1-1. Applicability of Permanent, Post-Construction Storm Water Requirements

Do permanent storm water requirements apply to your project?
<i>Requirements DO NOT apply to:</i>
<p>1. Routine Maintenance</p> <p>Replacement of impervious surfaces that are part of a routine maintenance activity, such as:</p> <ul style="list-style-type: none"> • Replacing roof material on an existing building • Resurfacing existing roadways, parking lots, sidewalks, pedestrian ramps, and bike lanes, including slurry, overlay and restriping • Restoring a historic building to its original historic design • Installation of ground mounted solar arrays over existing impermeable surfaces <p>Note: Work in any of the above categories that creates impervious surface outside the existing impervious footprint is not considered routine maintenance.</p> <p>2. Work Over Water</p> <p>Work that occurs over water and does not disturb or expose uncompacted or compacted placed fill placed as part of a structural cross section or native soil. This includes, for example, work on pile supported piers or marinas, such as replacing the pier pavement or surface, adding or replacing buildings, and berth repair.</p> <p>Work on mole piers that disturbs or exposes the fill portion of the mole pier is not considered work over water, but certain work on mole piers may be considered routine maintenance. See the “Conditional Routine Maintenance” category below; Section 1.3.1 provides additional details.</p> <p>3. Conditional Routine Maintenance</p> <p>Several other types of work are also considered routine maintenance when completed in accordance with the conditions described in Section 1.3.1. These include the following; see Section 1.3.1 for additional details:</p> <ul style="list-style-type: none"> • Full depth replacement of damaged pavement, including pavement on mole piers and boat ramps, that does not disturb native soil • Replacement of pavement or other surface materials affected by trenching for underground utility work (e.g., pipe replacement) • Replacement or addition of curb ramps for ADA purposes • Replacement of driveway aprons for ADA purposes • Repair or replacement of shoreline protection structures <p>Note that some additional types of pavement work that does not qualify as routine maintenance per Section 1.3.1 may qualify to use the Green Street Exemption; see Section 1.3.1 for additional details.</p> <p>4. Interior or Exterior Repair or Improvements to Existing Buildings</p> <p>Repair or improvements to an existing building or structure that do not alter the size:</p> <ul style="list-style-type: none"> • Plumbing, electrical and HVAC work • Interior alterations including major interior remodels and tenant build-out within an existing commercial building • Exterior alterations that do not change the general dimensions and structural framing of the

Do permanent storm water requirements apply to your project?
<i>Requirements DO NOT apply to:</i>
building (does not include building additions or projects where the existing building is demolished)

1.3.1 Conditional Routine Maintenance Determination for Pavement and Shoreline Projects

Table 1-2 provides additional detail about whether several types of projects that typically occur in or along streets, alleys, shorelines, and similar areas can be considered routine maintenance. This table reflects guidance provided by the San Diego Water Board to the Port District in August 2023, and builds off similar guidance previous provided by the Board to the Cities of Lemon Grove (March 2022), Poway (September 2021), and San Diego (October 2020). Based on this guidance, both Port and tenant implemented projects may be considered routine maintenance as described in this section, provided all conditions enumerated below Table 1-2 are met.

TABLE 1-2. Applicability of Conditional Routine Maintenance Exemptions

Project Scenarios	Routine Maintenance
<p>1. Full depth replacement of damaged impervious pavement, including work that disturbs the subgrade or other parts of the structural pavement section, but not including work that disturbs the underlying uncompacted native soil outside the structural pavement section. This category applies to replacement of damaged pavement locations such as roads, parking lots, sidewalks, walkways, boat ramps, and over mole piers. The following are common examples of when this scenario applies:</p> <ul style="list-style-type: none"> a. A single contiguous area of pavement replacement that exceeds the applicable PDP threshold size (2,500 or 5,000 sf, depending on whether the project directly discharges to an ESA). b. Several non-contiguous pavement patches, with each patch being below the applicable PDP threshold size, but cumulatively the sum of the area of the patches is over the applicable PDP threshold size c. Pavement replacement that takes place on a mole pier or marina, including pavement replacement that disturbs fill placed under the mole pier surface for structural support. 	Yes^{1, 3}
<p>2. Pavement replacement when the pavement is disturbed as a result of trenching for utility work. Utility work includes access subsurface</p>	Yes^{1, 3}

Project Scenarios	Routine Maintenance
<p>assets, such as pipes or curtain walls, for maintenance purposes. The following are common examples of when this scenario applies:</p> <ul style="list-style-type: none"> a. Replacing an entire concrete panel when a portion of the panel is disturbed by trenching b. Replacing asphalt, other types of impervious pavement, or other surface materials disturbed by trenching, provided that the limits of the trench are no larger than what is needed to complete maintenance on the applicable subsurface asset(s) 	
<p>3. Routine replacement or repair of shoreline protection structures, including disturbance of native soil and excavation behind sea wall to access/repair tieback structures as needed.</p>	<p>Yes¹</p>
<p>4. Creating and/or replacing curb ramps in any of the following situations, with the disturbed area being the minimum footprint needed to meet ADA requirements:</p> <ul style="list-style-type: none"> a. Curb ramp replacement completely within existing curb ramp footprint b. Curb ramp replacement encroaches into the street without creating new impervious area c. Curb ramp replacement encroaches into the pervious parkway and creates new impervious area d. New curb ramp that encroaches into street without creating new impervious area e. New curb ramp encroaches into pervious parkway and creates new impervious area 	<p>Yes¹</p>
<p>5. Replacing driveway aprons, with the disturbed area being the minimum footprint needed to meet ADA requirements that includes one or more of the following:</p> <ul style="list-style-type: none"> a. Driveway apron replacement completely within existing driveway apron footprint b. Driveway apron replacement encroaches into the street as needed without creating new impervious area c. Driveway apron replacement encroaches into the pervious parkway as needed and creates new impervious area 	<p>Yes¹</p>
<p>6. Creating driveway aprons, with the disturbed area being the minimum footprint needed to meet ADA requirements that include one or more of the following:</p>	<p>No²</p>

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Project Scenarios	Routine Maintenance
<ul style="list-style-type: none"> a. New driveway apron encroaches into the street as needed without creating new impervious area b. New driveway apron encroaches into pervious parkway as needed and creates new impervious area 	
<p>7. Replacing a sidewalk or walkway that otherwise based on its condition does not require replacement for ADA compliance or adding a new sidewalk or walkway for ADA compliance. The following are common examples of when this scenario applies:</p> <ul style="list-style-type: none"> a. Replacement occurs within the same footprint. b. Replacing a sidewalk outside an existing impervious footprint, e.g., when a straight walkway is converted to a meandering walkway, or when the location of a walkway is modified. c. Adding a new sidewalk or walkway where one did not exist previously, including over area that was previously pervious. d. Creating new, shared use sidewalks, walkways, or pathways wider than the minimum width required for ADA compliance that includes one or more of the following: entire width of shared ADA walkway and pedestrian/vehicle access pathway, only the minimum ADA width portion of the pathway (i.e. 5 feet), entire width of any pathway greater than the minimum ADA width. <p><i>Note: sidewalk or walkway pavement repair or replacement that is necessary based on the condition of the sidewalk or walkway (e.g., broken concrete) is considered routine maintenance as described in scenario 1 earlier in this table. Resurfacing sidewalks or walkways is considered routine maintenance per Table 1-2.</i></p>	<p>No²</p> <p><i>(But see note at left about sidewalk or walkway work that is considered routine maintenance)</i></p>

¹ Must also meet all of the numbered criteria described in the discussion following this table to be considered routine maintenance.

² Project may use the PDP exemptions described in Section 1.4.3 if designed in a way that meets the requirements necessary to qualify for those exemptions. These PDP exemptions include, for example, hydraulically disconnected sidewalks and street improvements that follow Green Street guidance.

³ Full depth replacement of pavement that includes disturbance of uncompacted native soil is not considered routine maintenance, but may qualify for PDP Exemptions as noted in table footnote 2, above. Soil that is compacted or otherwise part of the structural pavement section is not considered native soil.

To qualify as routine maintenance, project scenarios identified as routine maintenance in Table 1-2 must also meet all of the requirements in the numbered list below.

1. The project is identified as part of the Port's regularly scheduled pavement maintenance on

existing facilities or is an existing private road or parking lot that requires scheduled maintenance only.

2. The project is not part of, or associated with, development project mitigation requirements, development project construction, development project construction agreement, or conditions of approval.
3. No street widening or other enhancements are occurring in association with the damaged pavement project that would normally trigger PDP requirements or be PDP exempt per MS4 Permit Provision E.3.b.(3) – Green Streets Exemption (see “PDP Exemption Category 2” in Section 1.4.3 for more information).
4. The project would normally be CEQA exempt.
5. Construction BMPs must be implemented to control sediment and other pollutants associated with construction activity in accordance with the requirements the Port of San Diego Jurisdictional Runoff Management Plan (JRMP). More detail about construction BMPs for projects considered routine maintenance as described in this section is provided in Section 1.3.1.1 below.
6. The Port shall maintain a list of projects that fall under this category. The Port’s project manager (capital/CIPs) or reviewer (tenant/private projects) is responsible for documenting that the project qualifies as routine maintenance per Section 1.3.1 and satisfies all the criteria in this numbered list. The Port’s project manager (capital/CIPs) or reviewer (tenant/private projects) shall keep this documentation in the project file or an equivalent location.

Form RM-1 should be completed for each project considered routine maintenance per this section as documentation that the above conditions have been met.

Different routine maintenance scenarios combined together still are considered routine maintenance as long as they are not combined with an activity type that is not routine maintenance. For example, a project that includes full depth pavement replacement (scenario 1) and curb ramp replacement that encroaches into the street (scenario 4) but no other activities would be considered routine maintenance.

Note, however, that if an activity that otherwise would be considered routine maintenance per Section 1.3.1 is combined with other activities that are classified as a PDP or use the Green Streets Exemption, then the activities that would have been considered routine maintenance are no longer considered routine maintenance since they are part of a PDP. They require treatment in that case; see Section 1.4.1 for additional information.

1.3.1.1 Construction BMP Requirements for Routine Maintenance Pavement Projects

As noted in item 6 in Section 1.3.1 above, construction BMP requirements must be met for a routine maintenance exemption to apply. All applicable BMPs from the Port of San Diego JRMP must be implemented and documented via the appropriate Construction BMP Plan. The following highlights the construction (temporary) BMPs most likely to be applicable for routine maintenance work that occurs along streets:

- Cover and berm (perimeter controls) stockpiles at the end of each work day. Stockpiles must

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be placed at least 18 inches from the face of curb and are prohibited where they obstruct flow.

- Implement at least one of the following at the end of each work day for demolished curbs, gutters, ribbon gutters, and any other concentrated flow pathways that are impacted by the project even when there is no forecasted rain. These BMPs help prevent sediment transport from non-stormwater discharges such as irrigation runoff, water main breaks, water line flushing, etc.
 - Install check dams along the impacted concentrated flow pathways.
 - Install run-on controls (e.g., gravel bag berms) to divert water around the impacted concentrated flow pathways.
 - Cover and secure the impacted concentrated flow pathways with an erosion control product such as mats, plastic sheeting (e.g., Visqueen), or equivalent.
- Implement erosion control for disturbed areas (any areas where pavement has been removed, soil or base is exposed, and any other areas where project work has disturbed soil, such as landscaping adjacent to the work area) when either (a) there is a 50% chance of rain within 24 hours, OR (b) the disturbed area is inactive (no soil disturbing activities for a period of 14 days or greater).
 - Use pavement replacement approach that results in no exposed disturbed soil at the end of the work day (e.g. full depth reclamation, or applying compacted cold mix or hot mix at the end of the day to areas where pavement has been removed).
 - Note: Contractors must obtain written approval from the Port to utilize a full depth asphalt restoration method(s) if it differs from the approved construction plans, Standard Drawings, and/or Special Provisions.

OR

- Implement and effective combination of one or more of the following:
 - Install run-on controls (e.g., gravel bag berms) and/or use by-pass method(s) to prevent run-on to areas where soil has been disturbed.
 - Cover the areas where pavement has been removed, soil or base is exposed, and any other areas where project work has disturbed soil with an erosion control product or technique such as steel traffic plates in conjunction with cold patches around the edges, mats, plastic sheeting (e.g., Visqueen), or an equivalent method.
 - Cover and secure demolished curb gutter, ribbon gutters, and any other impacted concentrated flow pathway with an erosion control product such as mats, plastic sheeting (e.g., Visqueen), or equivalent.

1.4 Is the Project a PDP?

MS4 Permit Provision E.3.b.(1)

PDP categories are defined by the MS4 Permit, but the PDP categories can be expanded by local jurisdictions, and local jurisdictions can offer specific exemptions from PDP categories.

Section 1.4.1 presents the PDP categories defined in the MS4 Permit. Section 1.4.2 presents additional PDP categories and/or expanded PDP definitions that apply to the Port. Section 1.4.3 presents specific Port exemptions.

1.4.1 PDP Categories

In the MS4 Permit, PDP categories are defined based on project size, type and design features.

Projects shall be classified as PDPs if they are in one or more of the PDP categories presented in the MS4 Permit, which are listed below. Review each category, defined in (a) through (f), below. A PDP applicability checklist for these categories is also provided in Appendix I-2. If any of the categories match the project, the entire project is a PDP. For example, if a project feature such as a parking lot falls into a PDP category, then the entire development footprint including project components that otherwise would not have been designated a PDP on their own (such as other impervious components that did not meet PDP size thresholds, and/or landscaped areas), shall be subject to PDP requirements. Note that size thresholds for impervious surface created or replaced vary based on land use, land characteristics, and whether the project is a new development or redevelopment project. Therefore, all definitions must be reviewed carefully. Also, note that categories are defined by the total quantity of “added or replaced” impervious surface, not the net change in impervious surface.

For example, consider a redevelopment project that adds 7,500 square feet of new impervious surface and removes 4,000 square feet of existing impervious surface. The project has a net increase of 3,500 square feet of impervious surface. However, the project is still classified as a PDP because the total added or replaced impervious surface is 7,500 square feet, which is greater than 5,000 square feet.

"Collectively" for the purposes of the manual means that all contiguous and non-contiguous parts of the project that represent the whole of the action must be summed up. For example, consider a development project that will include the following impervious components:

- 3,600 square feet of roadway
- 350 square feet of sidewalk
- 4,800 square feet of roofs
- 1,200 square feet of driveways
- 500 square feet of walkways/porches

The collective impervious area is 10,450 square feet.

PDP Categories defined by the MS4 Permit:

- (a) New development projects that create 10,000 square feet or more of impervious surfaces

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(collectively over the entire project site). This includes commercial, industrial, mixed-use, and capital development projects on Port tidelands.

- (b) Redevelopment projects that create and/or replace 5,000 square feet or more of impervious surface (collectively over the entire project site on an existing site of 10,000 square feet or more of impervious surfaces). This includes commercial, industrial, mixed-use, and capital development projects on Port tidelands.
- (c) New and redevelopment projects that create and/or replace 5,000 square feet or more of impervious surface (collectively over the entire project site), and support one or more of the following uses:

- (i) Restaurants. This category is defined as a facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (Standard Industrial Classification (SIC) code 5812).

Information and an SIC search function are available at <https://www.osha.gov/pls/imis/sicsearch.html>.

- (ii) Hillside development projects. This category includes development on any natural slope that is twenty-five percent or greater.
 - (iii) Parking lots. This category is defined as a land area or facility for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.
 - (iv) Streets, roads, highways, freeways, and driveways. This category is defined as any paved impervious surface used for the transportation of automobiles, trucks, motorcycles, and other vehicles.
- (d) New or redevelopment projects that create and/or replace 2,500 square feet or more of impervious surface (collectively over the entire project site), and discharging directly to an Environmentally Sensitive Area (ESA). “Discharging directly to” includes flow that is conveyed overland a distance of 200 feet or less from the project to the ESA, or conveyed in a pipe or open channel any distance as an isolated flow from the project to the ESA (i.e. not commingled with flows from adjacent lands).

Note: ESAs are areas that include but are not limited to all Clean Water Act Section 303(d) impaired water bodies; areas designated as Areas of Special Biological Significance by the State Water Board and San Diego Water Board; State Water Quality Protected Areas; water bodies designated with the RARE beneficial use by the State Water Board and San Diego Water Board; and any other equivalent environmentally sensitive areas which have been identified by the Port (see Section 1.4.2 below to determine if any other local areas have been identified). Note that San Diego Bay is identified as an ESA.

For projects adjacent to an ESA, but not discharging to an ESA, the 2,500 sq-ft threshold does not apply if the project does not physically disturb the ESA and the ESA is upstream of the project.

- (e) New development projects, or redevelopment projects that create and/or replace 5,000 square

feet or more of impervious surface, that support one or more of the following uses:

- (i) Automotive repair shops. This category is defined as a facility that is categorized in any one of the following SIC codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

Information and an SIC search function are available at <https://www.osha.gov/pls/imis/sicsearch.html>.

- (ii) Retail gasoline outlets. This category includes Retail gasoline outlets that meet the following criteria: (a) 5,000 square feet or more or (b) a projected Average Daily Traffic of 100 or more vehicles per day.
- (f) New or redevelopment projects that result in the disturbance of one or more acres of land and are expected to generate pollutants post construction.

Note: Pollutant generating development projects are those projects that generate pollutants at levels greater than background levels. Background pollutant levels means the pollutants generated from an undeveloped site. Projects disturbing one or more acres of land are presumed to generate pollutants post construction unless the applicant presents a design that demonstrates to the satisfaction of the Port that pollutants in stormwater discharges will not exceed pre-construction background levels.

Area that may be excluded from impervious area calculations for determining if the project is a PDP:

- (a) Based on guidance from the San Diego Water Board, activities defined as routine maintenance per Section 1.3.1 cannot be combined with work that is a PDP or uses the Green Streets Exemption. If combined with work that is a PDP or uses the Green Streets Exemption, work described in Section 1.3.1 that would be routine maintenance if done on its own is no longer routine maintenance, and it requires treatment as described in Section 1.3.1 for work that does not qualify as routine maintenance. For additional guidance, see Example 1 below, following this list.
- (b) Except as described in item (a), areas of a project that are considered exempt from storm water requirements (e.g., routine maintenance activities such as resurfacing, interior repair or improvements to an existing building, etc.) shall not be included as part of “added or replaced” impervious surface in determining project classification. For additional guidance, see Example 2, following this list.

Example 1: A project includes reconfiguration of an existing road for traffic calming and pedestrian improvements. This project includes creation or replacement of 15,000 square feet of pavement, and the replaced pavement areas are not damaged. This work does not qualify as routine maintenance per Section 1.3.1 but does qualify to use the Green Streets Exemption. The project also includes full depth replacement of several patches of damaged pavement in adjacent parts of the road; these full depth replacement patches are a total of 6,000 square feet. While if done by itself the 6,000 square feet of full depth damaged pavement replacement would qualify to be considered routine maintenance per Section 1.3.1, in this case it is also subject to Green Streets standards since it is combined with work that is using the Green Streets Exemption.

Example 2: A project includes replacing the roof on a 10,000 square foot commercial building. The project also includes building a new trash enclosure (150 square feet). The roof replacement work

does not expose underlying soil and is routine maintenance per Table 1-2, so the roof replacement area is not included in determining whether the project is a PDP. Because the trash enclosure work is 150 square feet of impervious area, it is considered a Standard Project. Standard Project requirements apply to the trash enclosure work, and the roof replacement work is considered routine maintenance.

Redevelopment projects may have special considerations with regards to the total area required to be treated. Refer to Section 1.7.

1.4.2 Additional Port Specified PDP Categories and/or Expanded PDP Definitions

There are no Port specific additional BMP categories or expanded PDP definitions.

1.4.3 PDP Exemptions or Alternative PDP Requirements

The following PDP exemptions are recognized for projects within the Port; all standard development requirements still apply:

- Walkways Exemption: new or retrofit paved sidewalks, bicycle lanes, or trails that meet the following criteria:
 - Designed and constructed to direct storm water runoff to adjacent vegetated areas, or other non-erodible permeable areas; OR
 - Designed and constructed to be hydraulically disconnected from paved streets or roads.
- Green Street Exemption: retrofitting or redevelopment of existing paved alleys, streets, roads, sidewalks, bicycle lanes, or trails that are designed and constructed in accordance with the USEPA Green Streets guidance ["Managing Wet Weather with Green Infrastructure – Municipal Handbook: Green Streets" (USEPA, 2008)]. See Appendix K for additional guidance on design of projects that use the Green Street Exemption. As also described in Section 1.3.1, certain project types that do not qualify as routine maintenance may be able to use the Green Street Exemption.

1.5 Determining Applicable Storm Water Management Requirements

MS4 Permit Provision E.3.c.(1)

Depending on project type and receiving water, different storm water management requirements apply.

New development or redevelopment projects that are subject to this manual requirement pursuant to Section 1.3 but are not classified as PDPs based on Section 1.4, are called "Standard Projects." Source control and site design requirements apply to all projects including Standard Projects and PDPs. Additional structural BMP requirements (i.e. pollutant control and hydromodification management)

apply only to PDPs. Storm water management requirements for a project, and the applicable sections of this manual, are summarized in Table 1-3.

TABLE 1-3. Applicability of Manual Sections for Different Project Types

Project Type	Project Development Process (Chapter 3 and 8)	Source Control and Site Design (Section 2.1 and Chapter 4)	Structural Pollutant Control (Section 2.2 and Chapter 5 and 7)	Structural Hydromodification Management (Section 2.3, 2.4 and Chapter 6 and 7)
Not a Development Project	The requirements of this manual do not apply, except that projects considered routine maintenance per Section 1.3.1 must document how they met the conditions listed in that section.			
Standard Project	☑	☑	NA	NA
Walkways Exempt Project	See Appendix K.1			NA
Green Street Exempt Project	☑	☑	See Appendix K.2	NA
PDP with only Pollutant Control Requirements*	☑	☑	☑	NA
PDPs with Pollutant Control and Hydromodification Management Requirements	☑	☑	☑	☑

* Some PDPs may be exempt from Structural Hydromodification Management BMPs, refer to Section 1.6 to determine.

1.5.1 Additional Guidance on Shoreline Projects

Due to its location along the San Diego Bay waterfront, certain types of projects that are not common in other jurisdictions may occur within the Port's jurisdiction. Those types of projects are summarized in Table 1-4 below, which also includes references to specific locations in the BMP Design Manual that provide more detail on the applicable requirements.

TABLE 1-4. Applicability of Manual Sections for Different Project Types¹

Project Type	Requirements	Reference
Shoreline protection structures: repair, replacement, or other maintenance.	Not a Development Project	Section 1.3.1

Project Type	Requirements	Reference
Work over water that does not disturb or expose soil (placed fill or native soil). This includes work on pile supported piers, such as pavement replacement, berth repair, and construction of new structures. It does not include work on mole piers that exposes underlying fill.	Not a Development Project	Section 1.2
Full depth replacement of damaged pavement on mole piers, at marine terminals, or at boat ramps.	Not a Development Project	Section 1.3.1
Pavement replacement associated with trenching for repair, maintenance, or replacement of underground utilities and/or curtain walls.	Not a Development Project	Section 1.3.1
New or replaced impervious surfaces on mole piers or at marine terminals that does not qualify as routine maintenance (“Not a Development Project”) where vehicle parking or travel takes place within the project footprint.	Green Street Exemption	Section 1.4.3, Appendix K
New or expanded boat ramps.	Green Street Exemption	Section 1.4.3, Appendix K
Redevelopment at shipyards covered by a separate NPDES permit (e.g., Order No. R9-2013-0026 or successor orders).	Requires project-specific consultation with Water Board ²	N/A

1. Development projects proposing to dredge or fill materials in waters of the U.S. must obtain a Clean Water Act Section 401 Water Quality Certification. Projects proposing to dredge or fill waters of the state must obtain waste discharge requirements.
2. Dischargers enrolled under a separate NPDES permit (e.g., Order No. R9-2013-0026) that are also subject to Port PDP requirements on a case by case basis may submit a letter request to the San Diego Water Board for a determination that the proposed post construction treatment controls designed to meet the requirements of the separate NPDES Permit also meet the post-construction requirements of the Regional MS4 Permit.

1.6 Applicability of Hydromodification Management Requirements

MS4 Permit Provision E.3.c.(2)

Hydromodification management requirements apply to PDPs only.

If the project is a Standard Project, hydromodification management requirements do not apply. Hydromodification management requirements apply to PDPs (both new and re-development) unless the project meets specific exemptions discussed below.

PDP exemptions from hydromodification management requirements are based on the receiving water system.

Copermittees have the discretion to exempt a PDP from hydromodification management

requirements where the project discharges storm water runoff to:

- (i) Existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;
- (ii) Conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean; or
- (iii) An area identified by the Copermittees as appropriate for an exemption by the optional WMAA incorporated into the Water Quality Improvement Plan (WQIP) pursuant to Provision B.3.b.(4) of the MS4 permit.

Refer to Figure 1-2 and the associated criteria describing nodes in Figure 1-2 to determine applicability of hydromodification management requirements. The criteria reflect the latest list of exemptions that are allowed under the 2013 MS4 Permit, and therefore supersede criteria found in earlier publications.

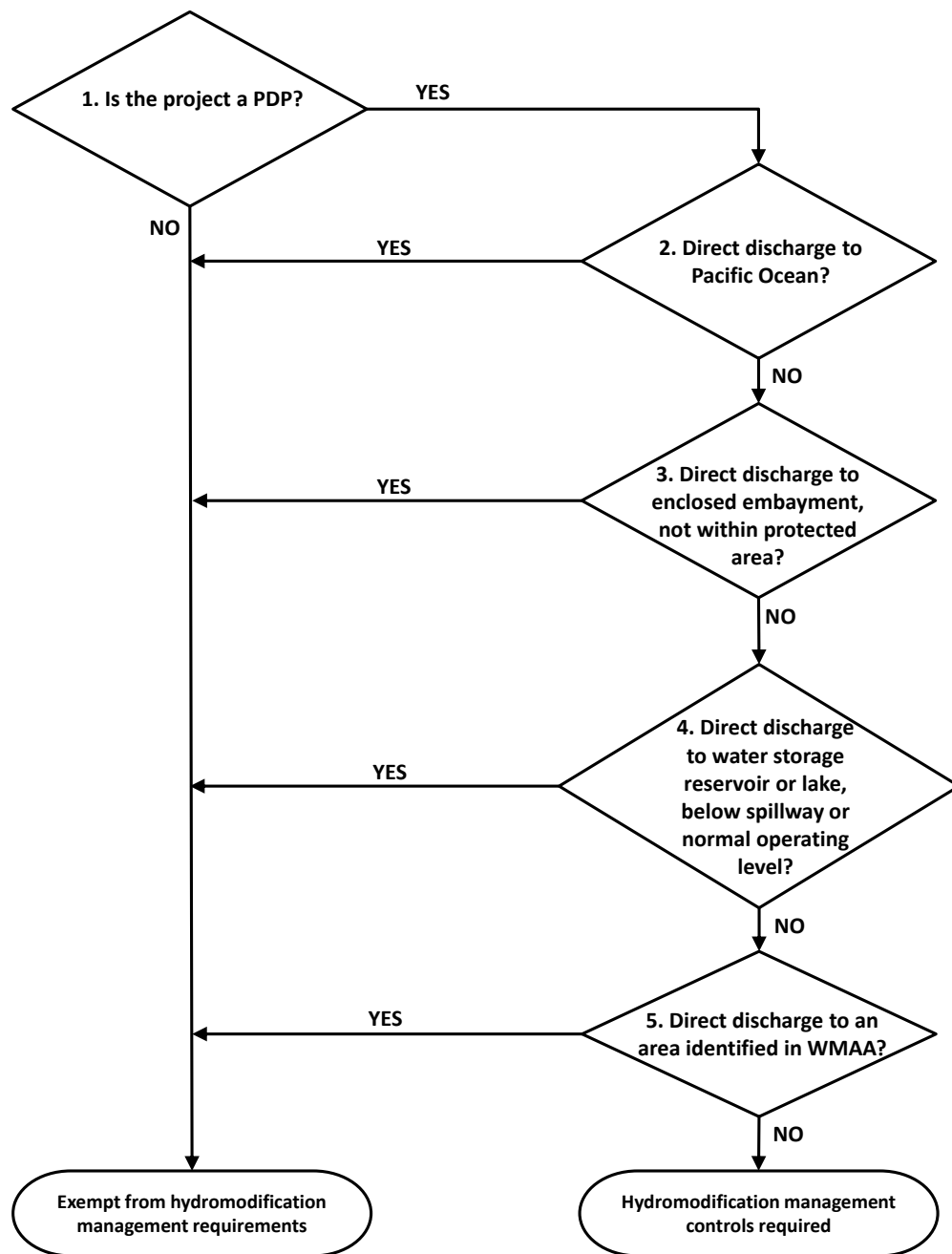
- Figure 1-2, Node 1 – Hydromodification management control measures are only required if the proposed project is a PDP.
- Figure 1-2, Node 2 – As allowed by the MS4 Permit, projects discharging directly to the Pacific Ocean, by either existing underground storm drain systems or conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the Pacific Ocean, are exempt.
 - This exemption is subject to the following additional criteria defined by this manual:
 - a) The outfall must be located on the beach (not within or on top of a bluff),
 - b) A properly sized energy dissipation system must be provided to mitigate outlet discharge velocity from the direct discharge to the ocean for the ultimate condition peak design flow of the direct discharge,
 - c) The invert elevation of the direct discharge conveyance system (at the point of discharge to the ocean) should be equal to or below the mean high tide water surface elevation at the point of discharge, unless the outfall discharges to quay or other non-erodible shore protection.
- Figure 1-2, Node 3 – As allowed by the MS4 Permit, projects discharging directly to enclosed embayments (e.g., San Diego Bay or Mission Bay), by either existing underground storm drain systems or conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the enclosed embayment, are exempt.
 - This exemption is subject to the following additional criteria defined by this manual:
 - a) The outfall must not be located within a wildlife refuge or reserve area (e.g., Kendall-Frost Mission Bay Marsh Reserve, San Diego Bay National Wildlife Refuge, San Diego National Wildlife Refuge),
 - b) A properly sized energy dissipation system must be provided to mitigate outlet discharge velocity from the direct discharge to the enclosed embayment for the ultimate condition peak design flow of the direct discharge,
 - c) The invert elevation of the direct discharge conveyance system (at the point of discharge to the enclosed embayment) should be equal to or below the mean high tide water surface elevation at the point of discharge, unless the outfall discharges to a quay or other non-erodible shore protection.

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- For cases in which the direct discharge conveyance system outlet invert elevation is above the mean high tide water surface elevation but below the 100-year water surface elevation, additional analysis is required to determine if energy dissipation should be extended between the conveyance system outlet and the elevation associated with the mean high tide water surface level.
 - No exemption may be granted for conveyance system outlet invert elevations located above the 100-year floodplain elevation.
- Figure 1-2, Node 4 – As allowed by the MS4 Permit, projects discharging directly to a water storage reservoir or lake, by either existing underground storm drain systems or conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the water storage reservoir or lake, are exempt.
 - This exemption is subject to the following additional criteria defined by this manual:
 - a) A properly sized energy dissipation system must be provided in accordance with local design standards to mitigate outlet discharge velocity from the direct discharge to the water storage reservoir or lake for the ultimate condition peak design flow of the direct discharge,
 - b) The invert elevation of the direct discharge conveyance system (at the point of discharge to the water storage reservoir or lake) should be equal to or below the lowest normal operating water surface elevation at the point of discharge, unless the outfall discharges to a quay or other non-erodible shore protection. Normal operating water surface elevation may vary by season; contact the reservoir operator to determine the elevation. For cases in which the direct discharge conveyance system outlet invert elevation is above the lowest normal operating water surface elevation but below the reservoir spillway elevation, additional analysis is required to determine if energy dissipation should be extended between the conveyance system outlet and the elevation associated with the lowest normal operating water surface level.
 - c) No exemption may be granted for conveyance system outlet invert elevations located above the reservoir spillway elevation.
- Figure 1-2, Node 5 – As allowed by the MS4 Permit, projects discharging directly to an area identified as appropriate for an exemption in the WMAA for the watershed in which the project resides, by either existing underground storm drain systems or conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the designated area, are exempt. Consult the WMAA within the WQIP for the watershed in which the project resides to determine areas identified as appropriate for an exemption. Exemption is subject to any criteria defined within the WMAA, and criteria defined below by this manual:
 - To qualify as a direct discharge to an exempt river reach:
 - a) A properly sized energy dissipation system must be provided to mitigate outlet discharge velocity from the direct discharge to the exempt river reach for the ultimate condition peak design flow of the direct discharge,
 - b) The invert elevation of the direct discharge conveyance system (at the point of discharge to the exempt river reach) should be equal to or below the 10-year floodplain elevation. Exceptions may be made at the discretion of the Port, but shall never exceed

the 100-year floodplain elevation. The Port may require additional analysis of the potential for erosion between the outfall and the 10-year floodplain elevation.

- c) No exemption may be granted for conveyance system outlet invert elevations located above the 100-year floodplain elevation.



*Direct discharge refers to an uninterrupted hardened conveyance system; Note to be used in conjunction with Node Descriptions.

FIGURE 1-2. Applicability of Hydromodification Management BMP Requirements

1.7 Special Considerations for Redevelopment Projects (50% Rule)

MS4 Permit Provision E.3.b.(2)

Redevelopment PDPs (PDPs on previously developed sites) may need to meet storm water management requirements for ALL impervious areas (collectively) within the ENTIRE project site.

If the project is a redevelopment project, the structural BMP performance requirements and hydromodification management requirements apply to redevelopment PDPs as follows:

- (a) Where redevelopment results in the creation or replacement of impervious surface in an amount of less than fifty percent of the surface area of the previously existing development, then the structural BMP performance requirements of Provision E.3.c of the MS4 permit apply only to the creation or replacement of impervious surface, and not the entire development; or
- (b) Where redevelopment results in the creation or replacement of impervious surface in an amount of more than fifty percent of the surface area of the previously existing development, then the structural BMP performance requirements of Provision E.3.c of the MS4 permit apply to the entire development.

These requirements for managing storm water on an entire redevelopment project site are commonly referred to as the "50% rule". For the purpose of calculating the ratio, the surface area of the previously existing development shall be the area of impervious surface within the previously existing development. The following steps shall be followed to estimate the area that requires treatment to satisfy the MS4 Permit requirements:

1. How much total impervious area currently exists on the site?
2. How much existing impervious area will be replaced with new impervious area?
3. How much new impervious area will be created in areas that are pervious in the existing condition?
4. Total created and/or replaced impervious surface = Step 2 + Step 3.
5. **50% rule test:** Is step 4 more than 50% of Step 1? If yes, treat all impervious surface on the site. If no, then treat only Step 4 impervious surface and any area that comes with created and/or replaced impervious surface area.

Note: Step 2 and Step 3 must not overlap as it is fundamentally not possible for a given area to be both "replaced" and "created" at the same time. Also activities that occur as routine maintenance shall not be included in Step 2 and Step 3 calculation.

For example, a 10,000 sq. ft development proposes replacement of 4,000 sq. ft of impervious area. The treated area is less than 50% of the total development area and only the 4,000 sq. ft area is required to be treated.

1.8 Alternative Compliance Program

MS4 Permit Provision E.3.c.(1),(b); E.3.c.(2),(c); E.3.c.(3)

PDPs may be allowed to participate in an alternative compliance program.

Copermittees have the discretion to independently develop an alternative compliance program for their jurisdiction.

Participation in an alternative compliance program would allow a PDP to fulfill the requirement of providing retention and/or biofiltration pollutant controls onsite that completely fulfill the performance standards specified in Chapter 5 (pollutant controls) with onsite flow-thru treatment controls and offsite mitigation of the DCV not retained onsite.

PDPs may be allowed to participate in an alternative compliance program by using onsite BMPs to treat offsite runoff. PDPs must consult the local jurisdiction manuals for specific guidelines and requirements for using onsite facilities for alternative compliance. The PDP utilizing the alternative compliance program would (at a minimum) provide flow-thru treatment control BMPs onsite, then fund, contribute to, or implement an offsite alternative compliance project deemed by the Port-specific alternative compliance program to provide a greater overall water quality benefit for the portion of the pollutants not addressed onsite through retention and/or biofiltration BMPs. Offsite alternative compliance program locations for the purpose of this manual are defined as location within the same watershed management area as the PDP. Participation in an alternative compliance program would also potentially relieve hydromodification management flow control obligations that are not provided onsite (see Chapter 6 for hydromodification management requirements). PDPs must consult the Port for specific guidelines and requirements for participation in potential alternative compliance programs.

Figure 1-3 generally represents two potential pathways for participating in alternative compliance (i.e. offsite projects that supplement the PDPs onsite BMP obligations).

- The first pathway (illustrated using solid line, left side) ultimately ends at alternative compliance if the PDP cannot meet all of the onsite pollutant control obligations via retention and/or biofiltration. This pathway requires performing feasibility analysis for retention and biofiltration BMPs prior to participation in an alternative compliance project.
- The second pathway (illustrated using dashed line, right side) is a discretionary pathway along which jurisdictions may allow for PDPs to proceed directly to an alternative compliance project without demonstrating infeasibility of retention and/or biofiltration BMPs onsite.

Participation in an alternative compliance program also requires onsite flow-thru treatment control BMPs.

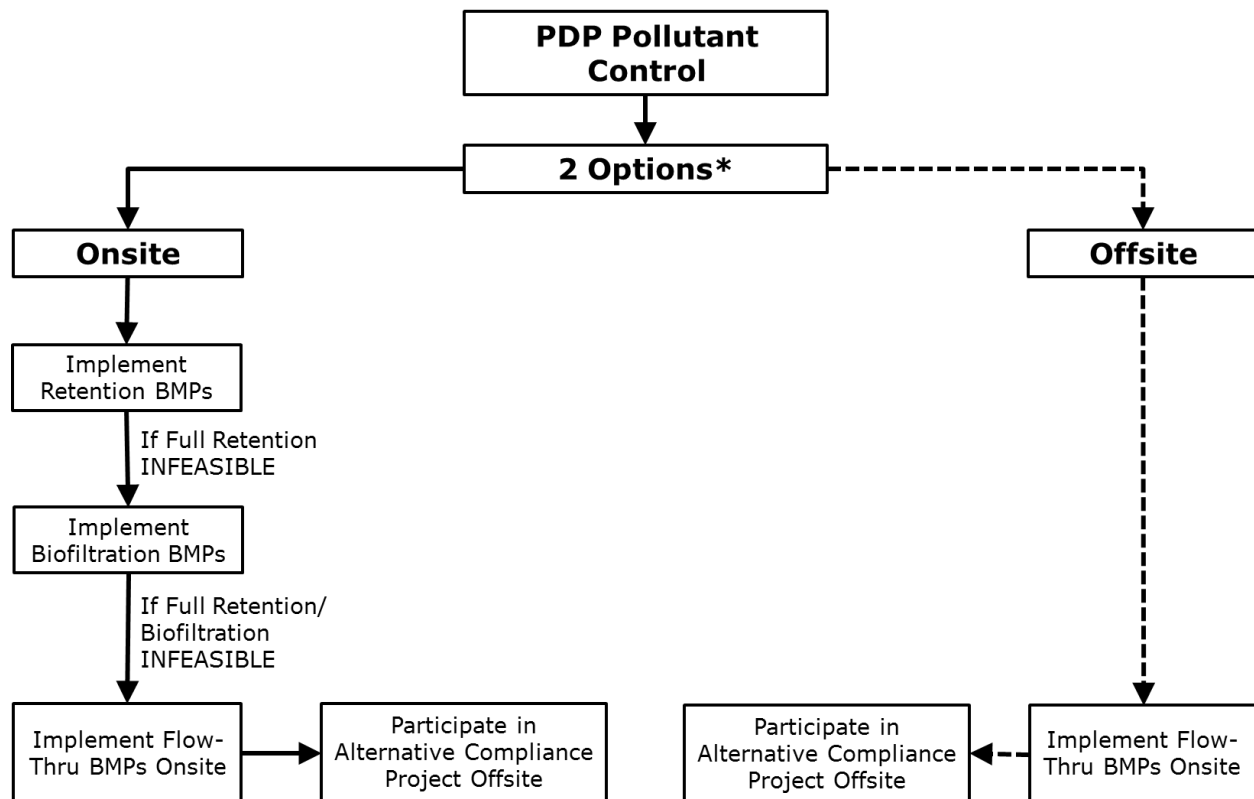
Participation in an offsite alternative compliance project **and** the obligation to implement flow-thru treatment controls for the DCV not reliably retained or biofiltered onsite, are linked and cannot be separated. Therefore, if a jurisdiction either does not have an alternative compliance program or does not allow the PDP to participate in the program or propose a project-specific offsite alternative compliance project, then the PDP may not utilize flow-thru treatment control. The PDP should consult with the jurisdiction regarding processing requirements if this is the case.

PDPs may be required to provide temporal mitigation when participating in an alternative compliance program.

Finally, if the PDP is allowed to participate in an offsite alternative compliance project that is constructed after the completion of the development project, the PDP must provide temporal mitigation to address this interim time period. Temporal mitigation must provide equivalent or better pollutant removal and/or hydrologic control (as applicable) as compared to the case where the offsite alternative compliance project is completed at the same time as the PDP.

Water Quality Equivalency calculations must be accepted by the Regional Board

The Water Quality Equivalency (WQE) calculation must be accepted by the San Diego Water Board's Executive Officer prior to administering an alternative compliance program. The Water Quality Equivalency provides currency calculations to assess water quality and hydromodification management benefits for a variety of potential offsite project types and provides regional and technical basis for demonstrating a greater water quality benefit for the watershed.



*PDP may be allowed to directly participate in an offsite project without demonstrating infeasibility of retention and/or biofiltration BMPs onsite. Consult the local jurisdiction for specific guidelines.

FIGURE 1-3. Pathways to Participating in Alternative Compliance Program

Applicability to Port Tidelands

The Port is currently evaluating options for establishing Alternative Compliance Program(s) for projects in the Port tidelands.

Applicant Implemented Alternative Compliance Project: If the Port does not establish and administer an alternative compliance program, it may allow an applicant to implement an alternative compliance project in lieu of complying on-site. In this scenario, the applicant is fully responsible for the alternative compliance project design, construction, operation and long term maintenance. Applicant proposed alternative compliance projects shall not be authorized by the Port prior to acceptance of the water quality equivalency calculations by the Regional Water Quality Board.

1.9 Relationship between this Manual and WQIPs

This manual is connected to other permit-specified planning efforts.

The MS4 Permit requires each Watershed Management Area within the San Diego Region to develop a **WQIP** that identifies priority and highest priority water quality conditions and strategies that will be implemented with associated goals to demonstrate progress towards addressing the conditions in the watershed. The MS4 Permit also provides an option to perform a **WMAA** as part of the WQIP to develop watershed specific requirements for structural BMP implementation in the watershed management area. PDPs should expect to consult either of these separate planning efforts as appropriate when using this manual as follows:

1. For PDPs that implement flow-thru treatment BMPs, selection of the type of BMP shall consider the pollutants and conditions of concerns. Among the selection considerations, the PDP must consult the highest priority water quality condition as identified in the WQIP for that particular watershed management area.
2. There may be watershed management area specific BMPs or strategies that are identified in WQIPs, for which PDPs should consult and incorporate as appropriate.
3. As part of the hydromodification management obligations that PDPs must comply with, PDPs shall consult the mapping of potential critical coarse sediment yield areas provided in the WMAA attachment to the WQIPs and design the project according to the procedures outlined in this manual if these sediments will be impacted by the project.
4. PDPs may be exempt from implementing hydromodification management BMPs (Chapter 6) based on the exemptions indicated in Section 1.6, and potentially from additional exemptions recommended in the WMAA attachment to the WQIPs. PDPs should consult the WMAA for recommended hydromodification management exemptions to determine if the project is eligible.
5. PDPs may have the option of participating in an alternative compliance program. Refer to Section 1.8.

These relationships between this manual and WQIPs are presented in Figure 1-4.

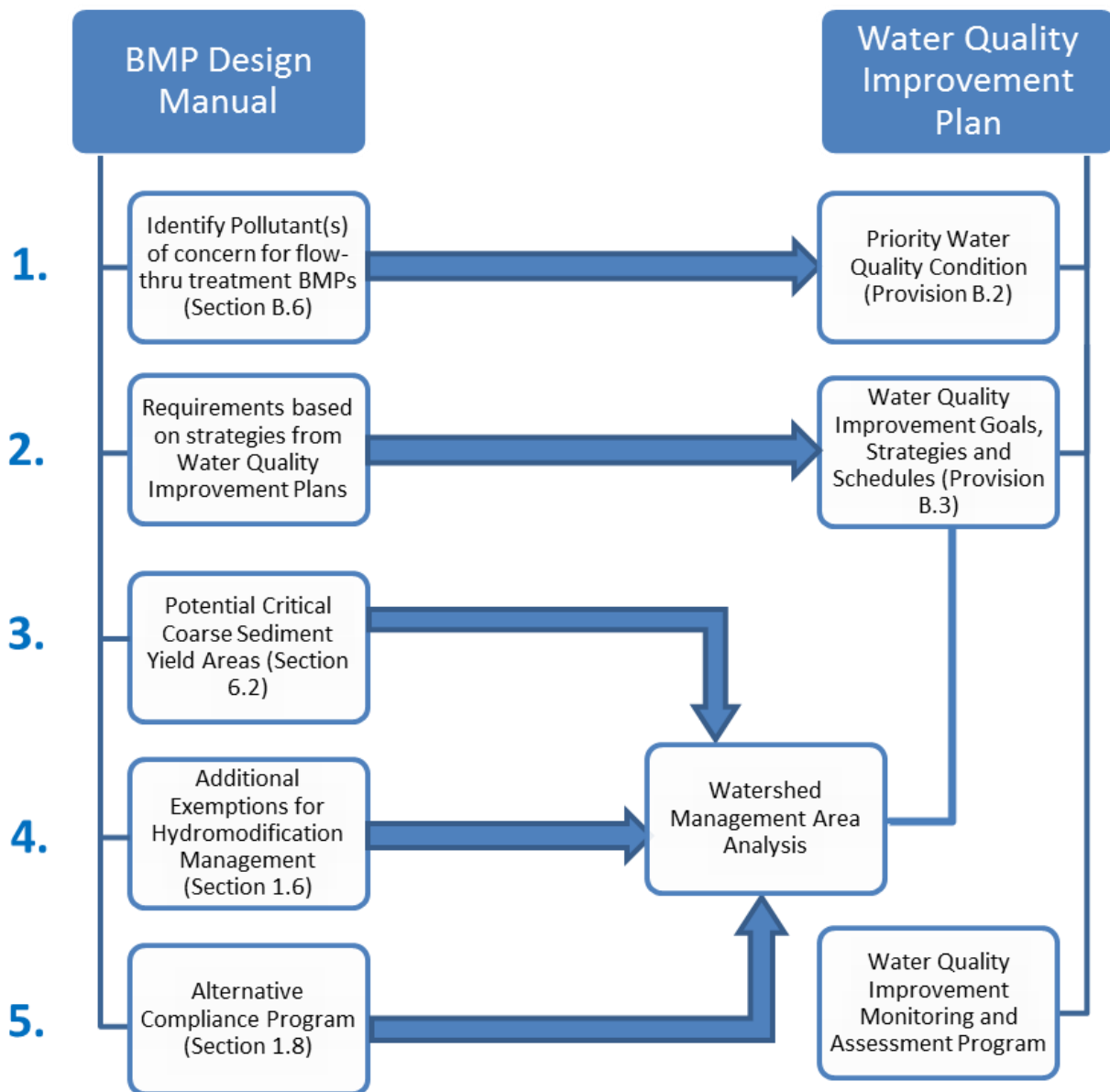


FIGURE 1-4. Relationship between this Manual and WQIP

The San Diego Bay WQIP is available at <https://projectcleanwater.org/watersheds/san-diego-bay-wma/>.

1.10 Project Review Procedures

Port of San Diego review of project plans for compliance with applicable requirements of this manual and the MS4 Permit.

SWQMPs submitted to the Port must be prepared using the templates available on the Port of San Diego website: <https://www.portofsandiego.org/stormwater-management>.

For Standard Projects, this means using forms and/or a Standard Project SWQMP or other equivalent documents approved by the Port to document that the following general requirements of the MS4

Permit are met, and showing applicable features onsite grading, building, improvement and landscaping plans:

- BMP Requirements for All Development Projects, which includes general requirements, source control BMP requirements, and narrative (i.e. not numerically-sized) site design requirements (MS4 Permit Provision E.3.a).

For PDPs, this means preparing a PDP SWQMP to document that the following general requirements of the MS4 Permit are met, and showing applicable features onsite grading and landscaping plans:

- BMP Requirements for All Development Projects, which includes general requirements for siting of permanent, post-construction BMPs, source control BMP requirements, and narrative (i.e. not numerically-sized) site design requirements (MS4 Permit Provision E.3.a);
- Storm Water Pollutant Control BMP Requirements, for numerically sized onsite structural BMPs to control pollutants in storm water (MS4 Permit Provision E.3.c.(1)); and
- Hydromodification Management BMP Requirements, which includes protection of critical sediment yield areas and numerically sized onsite BMPs to manage hydromodification that may be caused by storm water runoff discharged from a project (MS4 Permit Provision E.3.c.(2)).

Detailed submittal requirements are provided in Chapter 8 of this manual. Documentation of the permanent, post-construction storm water BMPs at the discretion of the Port must be provided with the **first** submittal of a project or another preliminary planning stage defined by the Port. Storm water requirements will directly affect the layout of the project. Therefore storm water requirements must be considered from the initial project planning phases, and will be reviewed with each submittal, beginning with the first submittal.

1.11 PDP Structural BMP Verification

MS4 Permit Provision E.3.e.(1)

Structural BMPs must be verified by the Port prior to project occupancy.

Pursuant to MS4 Permit Provision E.3.e.(1), each Copermittee must require and confirm the following with respect to PDPs constructed within their jurisdiction:

- (a) Each Copermittee must require and confirm that appropriate easements and ownerships are properly recorded in public records and the information is conveyed to all appropriate parties when there is a change in project or site ownership.
- (b) Each Copermittee must require and confirm that prior to occupancy and/or intended use of any portion of the PDP, each structural BMP is inspected to verify that it has been constructed and is operating in compliance with all of its specifications, plans, permits, ordinances, and the requirements of the MS4 permit.

For PDPs, this means that after structural BMPs have been constructed, the Port may request the tenant/project proponent provide a certification that the site improvements for the project have been constructed in conformance with the approved storm water management documents and drawings.

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The professional in responsible charge for the design of the project must inspect the structural BMPs at each significant construction stage and at completion. Following construction, an addendum to the SWQMP and As Builts are required to address any changes to the structural BMPs that occurred during construction. A final update to the O&M Plan, and/or execution of a maintenance agreement will be recorded for the property.

Certification of structural BMPs, updates to reports, and recordation of a maintenance agreement may occur concurrently with project closeout, but could be required sooner per Port practices. In all cases, it is required prior to occupancy and/or intended use of the project. Specific procedures are provided in Chapter 8 of this manual.

Performance Standards and Concepts

Projects must meet three separate performance standards, as applicable.

The MS4 Permit establishes separate performance standards for (1) source control and site design practices, (2) storm water pollutant control BMPs, and (3) hydromodification management BMPs. Chapter 1 provided guidance for determining which performance standards apply to a given project. This chapter defines these performance standards based on the MS4 Permit, and presents concepts that provide the project applicant with technical background, explains why the performance standards are important, and gives a general description of how these performance standards can be met. Detailed procedures for meeting the performance standards are presented in Chapters 4, 5, and 6.

Performance standards can be met through an integrated approach.

While three separate performance standards are defined by this manual, an overlapping set of design features can be used as part of demonstrating conformance to each standard. Further discussion of the relationship between performance standards is provided in Section 2.4.

2.1 Source Control and Site Design Requirements for All Development Projects

2.1.1 Performance Standards

MS4 Permit Provision E.3.a

This section defines performance standards for source control and site design practices that are applicable to all projects (regardless of project type or size; both Standard Projects and PDPs) when local permits are issued, including unpaved roads and flood management projects.

2.1.1.1 General Requirements

All projects shall meet the following general requirements:

- (a) Onsite BMPs must be located so as to remove pollutants from runoff prior to its discharge to any receiving waters, and as close to the source as possible;

- (b) Structural BMPs must not be constructed within waters of the United States (U.S.); and
- (c) Onsite BMPs must be designed and implemented with measures to avoid the creation of nuisance or pollution associated with vectors (e.g. mosquitos, rodents, or flies).

2.1.1.2 Source Control Requirements

Pollutant source control BMPs are features that must be implemented to address specific sources of pollutants.

The following source control BMPs must be implemented at all development projects where applicable and technically feasible:

- (a) Prevention of illicit discharges into the MS4;
- (b) Storm drain system stenciling or signage;
- (c) Protection of outdoor material storage areas from rainfall, run-on, runoff, and wind dispersal;
- (d) Protection of materials stored in outdoor work areas from rainfall, run-on, runoff, and wind dispersal;
- (e) Protection of trash storage areas from rainfall, run-on, runoff, and wind dispersal; and
- (f) Use of any additional BMPs determined to be necessary by the Port to minimize pollutant generation at each project.

Further guidance is provided in Section 2.1.2 and Chapter 4.

2.1.1.3 Site Design Requirements

Site design requirements are qualitative requirements that apply to the layout and design of ALL development project sites (Standard Projects and PDPs).

Site design performance standards define minimum requirements for how a site must incorporate LID BMPs, including the location of BMPs and the use of integrated site design practices. The following site design practices must be implemented at all development projects, where applicable and technically feasible:

- (a) Maintenance or restoration of natural storage reservoirs and drainage corridors (including topographic depressions, areas of permeable soils, natural swales, and ephemeral and intermittent streams)²;
- (b) Buffer zones for natural water bodies (where buffer zones are technically infeasible, require project applicant to include other buffers such as trees, access restrictions, etc.);
- (c) Conservation of natural areas within the project footprint including existing trees, other vegetation, and soils;
- (d) Construction of streets, sidewalks, or parking lot aisles to the minimum widths necessary, provided public safety is not compromised;

² Development projects proposing to dredge or fill materials in waters of the U.S. must obtain a Clean Water Act Section 401 Water Quality Certification. Projects proposing to dredge or fill waters of the state must obtain waste discharge requirements.

- (e) Minimization of the impervious footprint of the project;
- (f) Minimization of soil compaction to landscaped areas;
- (g) Disconnection of impervious surfaces through distributed pervious areas;
- (h) Landscaped or other pervious areas designed and constructed to effectively receive and infiltrate, retain and/or treat runoff from impervious areas, prior to discharging to the MS4;
- (i) Small collection strategies located at, or as close as possible to, the source (i.e. the point where storm water initially meets the ground) to minimize the transport of runoff and pollutants to the MS4 and receiving waters;
- (j) Use of permeable materials for projects with low traffic areas and appropriate soil conditions;
- (k) Landscaping with native or drought tolerant species; and
- (l) Harvesting and using precipitation.

A key aspect of this performance standard is that these design features must be used where applicable and feasible. Responsible implementation of this performance standard depends on evaluating applicability and feasibility. Further guidance is provided in Section 2.1.2 and Chapter 4.

Additional site design requirements may apply to PDPs.

Site design decisions may influence the ability of a PDP to meet applicable performance standards for pollutant control and hydromodification management BMPs (as defined in Section 2.2 and 2.3). For example, the layout of the site drainage and reservation of areas for BMPs relative to areas of infiltrative soils may influence the feasibility of capturing and managing storm water to meet storm water pollutant control and/or hydromodification management requirements. As such, the Port may require additional site design practices, beyond those listed above, to be considered and documented as part of demonstrating conformance to storm water pollutant control and hydromodification management requirements.

2.1.2 Concepts and References

Land development tends to increase the amount of pollutants in storm water runoff.

Land development generally alters the natural conditions of the land by removing vegetative cover, compacting soil, and/or placement of concrete, asphalt, or other impervious surfaces. These impervious surfaces facilitate entrainment of urban pollutants in storm water runoff (such as pesticides, petroleum hydrocarbons, heavy metals, and pathogens) that are otherwise not generally found in high concentrations in the runoff from the natural environment. Pollutants that accumulate on impervious surfaces and actively landscaped pervious surfaces may contribute to elevated levels of pollutants in runoff relative to the natural condition.

Land development also impacts site hydrology.

Impervious surfaces greatly affect the natural hydrology of the land because they do not allow natural infiltration, retention, evapotranspiration and treatment of storm water runoff to take place. Instead, storm water runoff from impervious surfaces is typically and has traditionally been directed through pipes, curbs, gutters, and other hardscape into receiving waters, with little treatment, at significantly increased volumes and accelerated flow rates over what would occur naturally. The increased pollutant

loads, storm water volume, discharge rates and velocities, and discharge durations from the MS4 adversely impact stream habitat by causing accelerated, unnatural erosion and scouring within creek beds and banks. Compaction of pervious areas can have a similar effect to impervious surfaces on natural hydrology.

Site Design LID involves attempting to maintain or restore the predevelopment hydrologic regime.

LID is a comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. LID designs seeks to control storm water at the source, using small-scale integrated site design and management practices to mimic the natural hydrology of a site, retain storm water runoff by minimizing soil compaction and impervious surfaces, and disconnecting storm water runoff from conveyances to the storm drain system. Site Design LID BMPs may utilize interception, storage, evaporation, evapotranspiration, infiltration, and filtration processes to retain and/or treat pollutants in storm water before it is discharged from a site. Examples of Site Design LID BMPs include using permeable pavements, rain gardens, rain barrels, grassy swales, soil amendments, and native plants.

Site design must be considered early in the design process.

Site designs tend to be more flexible in the early stages of project planning than later on when plans become more detailed. Because of the importance of the location of BMPs, site design shall be considered as early as the planning/tentative design stage. Site design is critical for feasibility of storm water pollutant control BMPs (Section 2.2) as well as coarse sediment supply considerations associated with hydromodification management (introduced in Section 2.3).

Source control and site design (LID) requirements help avoid impacts by controlling pollutant sources and changes in hydrology.

Source control and site design practices prescribed by the MS4 Permit are the minimum management practices, control techniques and system, design and engineering methods to be included in the planning procedures to reduce the discharge of pollutants from development projects, regardless of size or purpose of the development. In contrast to storm water pollutant control BMPs and hydromodification control BMPs which are intended to mitigate impacts, source control and site design BMPs are intended to avoid or minimize these impacts by managing site hydrology, providing treatment features integrated within the site, and reducing or preventing the introduction of pollutants from specific sources. Implementation of site design BMPs will result in reduction in storm water runoff generated by the site. Methods to estimate effective runoff coefficients and the storm water runoff produced by the site after site design BMPs are implemented are presented in Appendix B.2. This methodology is applicable for PDPs that are required to estimate runoff produced from the site with site design BMPs implemented so that they can appropriately size storm water pollutant control BMPs and hydromodification control BMPs.

The location of BMPs matters.

The site design BMPs listed in the performance standard include practices that either prevent runoff from occurring or manage runoff as close to the source as possible. This helps create a more hydrologically effective site and reduces the requirements that pollutant control and hydromodification control BMPs must meet, where required. Additionally, because sites may have spatially-variable conditions, the locations reserved for structural BMPs within the site can influence

whether these BMPs can feasibly retain, treat, and/or detain storm water to comply with structural pollutant control and hydromodification control requirements, where applicable. Finally, the performance standard specifies that onsite BMPs must remove pollutants from runoff prior to discharge to any receiving waters or the MS4, be located/constructed as close to the pollutant generating source as possible and must not be constructed within waters of the U.S.

The selection of BMPs also matters.

The lists of source control and site design BMPs specified in the performance standard must be used “where applicable and feasible.” This is an important concept – BMPs should be selected to meet the R9-2013-0001 permit requirements and are feasible with consideration of site conditions and project type. By using BMPs that are applicable and feasible, the project can achieve benefits of these practices, while not incurring unnecessary expenses (associated with using practices that do not apply or would not be effective) or creating undesirable conditions (for example, infiltration-related issues, vector concerns including mosquito breeding, etc.).

Methods to select and design BMPs and demonstrate compliance with source control and site design requirements are presented in Chapter 4 of this manual.

2.2 Storm Water Pollutant Control Requirements for PDPs

2.2.1 Storm Water Pollutant Control Performance Standard

MS4 Permit Provision E.3.c.(1)

Storm Water Pollutant Control BMPs for PDPs shall meet the following performance standards:

- (a) Each PDP shall implement BMPs that are designed to retain (i.e. intercept, store, infiltrate, evaporate, and evapotranspire) onsite the pollutants contained in the volume of storm water runoff produced from a 24-hour, 85th percentile storm event (Design Capture Volume (DCV)). The 24-hour, 85th percentile storm event shall be based on Figure B.1-1 in Appendix B or an approved site-specific rainfall analysis.
 - (i) If it is not technically feasible to implement retention BMPs for the full DCV onsite for a PDP, then the PDP shall utilize biofiltration BMPs or approved equivalent compact proprietary biofiltration systems for the remaining volume not reliably retained.
 - [a]. Biofiltration BMPs must be designed as described in Appendix F to have an appropriate hydraulic loading rate to maximize storm water retention and pollutant removal, as well as to prevent erosion, scour, and channeling within the BMP, and must be sized to:
 1. Treat 1.5 times the DCV not reliably retained onsite, OR
 2. Treat the DCV not reliably retained onsite with a flow-thru design that has a total volume, including pore spaces and pre-filter detention volume, sized to hold at least 0.75 times the portion of the DCV not reliably retained onsite.

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- [b]. Approved equivalent compact proprietary biofiltration systems use a combination of treatment devices and additional site design BMPs that, as a system, have an equal or greater effectiveness when compared to standard biofiltration BMPs. While these systems, unlike biofiltration BMPs, do not provide the full required amounts of both treatment and retention in the same device or site feature, because they are equally effective to biofiltration they meet the MEP standard as defined in Attachment C of the MS4 Permit. Approved equivalent compact proprietary biofiltration systems must be designed as described below:
 - 1. Demonstrate that the BMP meets applicable effectiveness certifications, e.g., Washington (State) Technology Acceptance Protocol-Ecology (TAPE), and the proposed use of the BMP is in accordance with criteria in the certification (e.g., treatment flow rate), as described in Appendix F.2.1; AND
 - 2. Treat the DCV not reliably retained onsite with a flow-thru design sized in accordance with Appendix F.2.2; AND
 - 3. Incorporate additional site design BMPs as necessary to achieve stormwater retention equivalent to what would have been achieved using biofiltration BMPs as described earlier in this section, and as described in Appendix F, Appendix B.5, and worksheet F.2-1 (Target Volume Retention Criteria). Worksheet F.2-2 (Volume Retention for Site Design BMPs) must also be completed as applicable.
- (ii) If biofiltration BMPs or approved equivalent compact proprietary biofiltration systems are not technically feasible, then the PDP shall utilize flow-thru treatment control BMPs (selected and designed per Appendix B.6) to treat runoff leaving the site, AND participate in alternative compliance to mitigate for the pollutants from the DCV not reliably retained onsite pursuant to Section 2.2.1.(b). Flow-thru treatment control BMPs must be sized and designed to:
 - [a]. Remove pollutants from storm water to the MEP (defined by the MS4 Permit) by following the guidance in Appendix B.6; and
 - [b]. Filter or treat either: 1) the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of a storm event, or 2) the maximum flow rate of runoff produced by the 85th percentile hourly rainfall intensity (for each hour of a storm event), as determined from the local historical rainfall record, multiplied by a factor of two (both methods may be adjusted for the portion of the DCV retained onsite as described in Appendix B.6) and
 - [c]. Meet the flow-thru treatment control BMP treatment performance standard described in Appendix B.6.
- (b) A PDP may be allowed to participate in an alternative compliance program in lieu of fully complying with the performance standards for storm water pollutant control BMPs onsite. The Port is currently evaluating options for establishing Alternative Compliance Programs(s) for projects in the Port tidelands, see Section 1.8. When an alternative compliance program is utilized:

- (i) The PDP must mitigate for the portion of the DCV not reliably retained onsite and
- (ii) Flow-thru treatment control BMPs must be implemented to treat the portion of the DCV that is not reliably retained onsite. Flow-thru treatment control BMPs must be selected and sized in accordance with Appendix B.6.
- (iii) A PDP may be allowed to propose an alternative compliance project not identified in the WMAA of the WQIP if the requirements in Section 1.8 are met at the discretion of the Port.

Demonstrations of feasibility findings and calculations to justify BMP selection and design shall be provided by the project applicant in the SWQMP to the satisfaction of the Port. Methodology to demonstrate compliance with the performance standards, described above, applicable to storm water pollutant control BMPs for PDPs is detailed in Chapter 5.

2.2.2 Concepts and References

Retention BMPs are the most effective type of BMPs to reduce pollutants discharging to MS4s when they are sited and designed appropriately.

Retention of the required DCV will achieve 100 percent pollutant removal efficiency (i.e. prevent pollutants from discharging directly to the MS4). Thus, retention of as much storm water onsite as technically feasible is the most effective way to reduce pollutants in storm water discharges to, and consequently from the MS4, and remove pollutants in storm water discharges from a site to the MEP.

However, in order to accrue these benefits, retention BMPs must be technically feasible and suitable for the project. Retention BMPs that fail prematurely, under-perform, or result in unintended consequences as a result of improper selection or siting may achieve performance that is inferior to other BMP types while posing other issues for the tenant/project proponent and the Port. Therefore, this manual provides criteria for evaluating feasibility and provides options for other types of BMPs to be used if retention is not technically feasible.

Biofiltration BMPs or approved equivalent compact proprietary biofiltration systems can be sized to achieve approximately the same pollutant removal as retention BMPs.

In the case, where the entire DCV cannot be retained onsite because it is not technically feasible, PDPs are required to use biofiltration BMPs with specific sizing and design criteria listed in Appendix B.5 and Appendix F or approved equivalent compact proprietary biofiltration systems. Sizing and design criteria for approved equivalent compact proprietary biofiltration systems are also included in Appendix B.5 and Appendix F, with specific details and worksheets included in Appendix F.2. These sizing and design criteria are intended to provide a level of long term pollutant removal that is reasonably equivalent to retention of the DCV.

Flow-thru treatment BMPs are required to treat the pollutant loads in the DCV not retained or biofiltered onsite to the MEP.

If the pollutant loads from the full DCV cannot feasibly be retained or biofiltered onsite, then PDPs are required to implement flow-thru treatment control BMPs to remove the pollutants to the MEP for the portion of the DCV that could not be feasibly retained or biofiltered. Flow-thru treatment BMPs may only be implemented to address onsite storm water pollutant control requirements if coupled with an offsite alternative compliance project that mitigates for the portion of the pollutant

load in the DCV not retained or biofiltered onsite.

Offsite Alternative Compliance Program may be available.

The MS4 Permit allows the Copermittee to grant PDPs permission to utilize an alternative compliance program for meeting the pollutant control performance standard. Onsite and offsite mitigation is required when a PDP is allowed to use an alternative compliance program. The existence and specific parameters of an alternative compliance program will be specific to each jurisdiction if one is available (Refer to Section 1.8).

Methods to design and demonstrate compliance with storm water pollutant control BMPs are presented in Chapter 5 of this manual. Definitions and concepts that should be understood when sizing storm water pollutant control BMPs to be in compliance with the performance standards are explained below:

2.2.2.1 Best Management Practices

To minimize confusion, this manual considers all references to “facilities,” “features,” or “controls” to be incorporated into development projects as BMPs.

2.2.2.2 DCV

The MS4 Permit requires pollutants be addressed for the runoff from the 24-hour 85th percentile storm event (“DCV”) as the design standard to which PDPs must comply.

The 85th percentile, 24-hour storm event is the event that has a precipitation total greater than or equal to 85 percent of all storm events over a given period of record in a specific area or location. For example, to determine what the 85th percentile storm event is in a specific location, the following steps would be followed:

- Obtain representative precipitation data, preferably no less than 30-years period if possible.
- Divide the recorded precipitation into 24-hour precipitation totals.
- Filter out events with no measurable precipitation (less than 0.01 inches of precipitation).
- Of the remaining events, calculate the 85th percentile value (i.e. 15 percent of the storms would be greater than the number determined to be the 85th percentile, 24-hour storm).

The 85th percentile, 24-hour storm event depth is then used in hydrologic calculations to calculate the DCV for sizing storm water pollutant control BMPs. An exhibit showing the 85th percentile, 24-hour storm depth across San Diego County and the methodology used to develop this exhibit is included in Appendix B.1.3. Guidance to estimate the DCV is presented in Appendix B.1.

2.2.2.3 Implementation of Storm Water Pollutant Control BMPs

The MS4 Permit requires that the PDP applicants proposing to meet the performance standards onsite implement storm water pollutant control BMPs in the order listed below. That is, the PDP applicant first needs to implement all feasible onsite retention BMPs needed to meet the storm water pollutant control BMP requirements prior to installing onsite biofiltration BMPs, and then onsite biofiltration BMPs prior to installing onsite flow-thru treatment control BMPs.

PDPs may be allowed to participate in an alternative compliance program. Refer to Section 1.8 for additional guidance.

Retention BMPs: Structural measures that provide retention (i.e. intercept, store, infiltrate, evaporate and evapotranspire) of storm water as part of pollutant control strategy. Examples include infiltration BMPs and cisterns, bioretention BMP's and biofiltration with partial retention BMP's.

Biofiltration BMPs: Structural measures that provide biofiltration of storm water as part of the pollutant control strategy. Example includes Biofiltration BMP's.

Approved equivalent compact proprietary biofiltration systems: Approved equivalent compact proprietary biofiltration systems use a combination of treatment devices and additional site design BMPs that, as a system, have an equal or greater effectiveness than biofiltration BMPs. While these systems, unlike biofiltration BMPs, do not provide the full required amounts of both treatment and retention in the same device or site feature, because they are equally effective to biofiltration they meet the MEP standard as defined in Attachment C of the MS4 Permit. The treatment devices in an approved equivalent compact proprietary biofiltration system must meet the requirements in Appendix B.5 and Appendix F.

Flow-thru treatment control BMPs: Structural measures that provide flow-thru treatment as part of the pollutant control strategy. Examples include vegetated swales and media filters.

For example, if the DCV from a site is 10,000 cubic feet (ft³) and it is technically feasible to implement 2,000 ft³ of retention BMPs and 9,000 ft³ of biofiltration BMPs sized using Section 2.2.1.(a)(i)[a], and the jurisdiction has an alternative compliance program to satisfy the requirements of this manual the project applicant should:

- 1) First, design retention BMPs for 2,000 ft³.
- 2) Then complete a technical feasibility form for retention BMPs (included in Appendix C and D) demonstrating that it's only technically feasible to implement retention BMPs for 2,000 ft³.
- 3) Then design biofiltration BMPs for 9,000 ft³ (calculate equivalent volume for which the pollutants are retained = $9,000 / 1.5 = 6,000$ ft³).
- 4) Then complete a technical feasibility for biofiltration BMPs and approved equivalent compact proprietary biofiltration systems demonstrating that it's only technically feasible to implement biofiltration BMPs or approved equivalent compact proprietary biofiltration systems for 9,000 ft³.
- 5) Estimate the DCV that could not be retained or biofiltered = $10,000 \text{ ft}^3 - (2,000 \text{ ft}^3 + 6,000 \text{ ft}^3) = 2,000 \text{ ft}^3$.
- 6) Implement flow-thru treatment control BMPs to treat the pollutants in the remaining 2,000 ft³. Refer to Appendix B.6 for guidance for designing flow-thru treatment control BMPs.
- 7) Also participate in an alternative compliance project for 2,000 ft³. Refer to Section 1.8 for additional guidance on participation in an alternative compliance program.

2.2.2.4 Technical Feasibility

MS4 Permit Requirement E.3.c.(5)

Analysis of technical feasibility is necessary to select the appropriate BMPs for a site.

PDPs are required to implement pollutant control BMPs in the order of priority in Section 2.2.2.3 based on determinations of technical feasibility. In order to assist the project applicant in selecting BMPs, this manual includes a defined process for evaluating feasibility. Conceptually, the feasibility criteria contained in this manual are intended to:

- Promote reliable and effective long term operations of BMPs by providing a BMP selection process that eliminates the use of BMPs that are not suitable for site conditions, project type or other factors;
- Minimize significant risks to property, human health, and/or environmental degradation (e.g. geotechnical stability, groundwater quality) as a result of selection of BMPs that are undesirable for a given site; and
- Describe circumstances under which regional and watershed-based strategies may be selected.

Steps for performing technical feasibility analyses are described in detail in Chapter 5. More specific guidance related to geotechnical investigation guidelines for feasibility of storm water infiltration and groundwater quality and water balance factors is provided in Appendices C and D, respectively.

2.2.2.5 Biofiltration BMPs

The MS4 Permit requires Biofiltration BMPs be designed to have an appropriate hydraulic loading rate to maximize storm water retention and pollutant removal, as well as to prevent erosion, scour, and channeling within the BMP. Appendix F of this manual has guidance for hydraulic loading rates and other biofiltration design criteria to meet these required goals. Appendix F also has a checklist that will need to be completed by the project SWQMP preparer during plan submittal. Guidance for sizing Biofiltration BMPs is included in Chapter 5 and Appendices B.5 and F.

2.2.2.6 Flow-thru Treatment Control BMPs (for use with Alternative Compliance)

MS4 Permit Requirement E.3.d.2-3

The MS4 Permit requires that the flow-thru treatment control BMP selected by the PDP applicant be ranked with high or medium pollutant removal efficiency for the most significant pollutant of concern. Steps to select the flow-thru treatment control BMP include:

- Step 1: Identify the pollutant(s) of concern by considering the following at a minimum a) Receiving water quality; b) Highest priority water quality conditions identified in the Watershed Management Areas Water Quality Improvement Plan; c) Land use type of the project and pollutants associated with that land use type and d) Pollutants expected to be present onsite
- Step 2: Identify the most significant pollutant of concern. A project could have multiple most significant pollutants of concerns and shall include the highest priority water quality condition identified in the watershed WQIP and pollutants expected to be presented onsite/from land use.
- Step 3: Effectiveness of the flow-thru treatment control BMP for the identified most significant pollutant of concern

Methodology for sizing flow-thru treatment control BMPs and the resources required to identify the pollutant(s) of concern and effectiveness of flow-thru treatment control BMPs are included in Chapter 5 and Appendix B.6.

2.3 Hydromodification Management Requirements for PDPs

2.3.1 Hydromodification Management Performance Standards

MS4 Permit Provision E.3.c.(2)

This section defines performance standards for hydromodification management, including flow control of post-project storm water runoff and protection of critical sediment yield areas, that shall be met by all PDPs unless exempt from hydromodification management requirements per Section 1.6 of this manual. Each PDP shall implement onsite BMPs to manage hydromodification that may be caused by storm water runoff discharged from a project as follows:

- (a) Post-project runoff conditions (flow rates and durations) must not exceed pre-development runoff conditions by more than 10 percent (for the range of flows that result in increased potential for erosion, or degraded instream habitat downstream of PDPs).
 - (i) In evaluating the range of flows that results in increased potential for erosion of natural (non-hardened) channels, the lower boundary must correspond with the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks.
 - (ii) The Copermittees may use monitoring results collected pursuant to Provision D.1.a.(2) of the MS4 permit to re-define the range of flows resulting in increased potential for erosion, or degraded instream habitat conditions, as warranted by the data.
- (b) Each PDP must avoid critical sediment yield areas known to the Copermittee or identified by the optional WMAA pursuant to Provision B.3.b.(4) of the MS4 permit, or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water.
- (c) A PDP may be allowed to utilize alternative compliance under Provision E.3.c.(3) of the MS4 permit in lieu of complying with the performance requirements of Provision E.3.c.(2)(a). The PDP must mitigate for the post-project runoff conditions not fully managed onsite if Provision E.3.c.(3) is utilized.

Hydromodification management requirements apply to both new development and redevelopment PDPs, except those that are exempt based on discharging to downstream channels or water bodies that are not subject to erosion, as defined in either the MS4 Permit (Provision E.3.c.(2)(d)) or the WMAA for the watershed in which the project resides. Exemptions from hydromodification management requirements are described in Section 1.6 of this manual.

For undisturbed sites, the existing condition shall be taken to be the pre-development runoff condition. For redevelopment PDPs or sites that have been previously disturbed, pre-development runoff conditions shall be approximated by applying the parameters of a pervious area rather than an impervious area to the existing site, using the existing onsite grade and assuming the infiltration

characteristics of the underlying soil.

For San Diego area watersheds, the range of flows that result in increased potential for erosion or degraded instream habitat downstream of PDPs and the critical channel flow shall be based on the "Final Hydromodification Management Plan Prepared for County of San Diego, California March 2011" (herein, "March 2011 Final HMP"). For PDPs subject to hydromodification management requirements, the range of flows to control depends on the erosion susceptibility of the receiving stream and shall be:

- 0.1Q₂ to Q₁₀ for streams with high susceptibility to erosion (this is the default range of flows to control when a stream susceptibility study has not been prepared);
- 0.3Q₂ to Q₁₀ for streams with medium susceptibility to erosion and which has a stream susceptibility study prepared and approved by the Port; or
- 0.5Q₂ to Q₁₀ for streams with low susceptibility to erosion and which has a stream susceptibility study prepared and approved by the Port.

Tools for assessing stream susceptibility to erosion have been developed by Southern California Coastal Water Research Project (SCCWRP). The tools are presented in the March 2011 Final HMP and also available through SCCWRP's website. If a PDP intends to select the 0.3Q₂ or 0.5Q₂ threshold, the SCCWRP screening tool must be completed and submitted with other project documentation.

The March 2011 Final HMP does not provide criteria for protection of critical sediment yield areas. The standard as presented in the MS4 Permit and shown above is: avoid critical sediment yield areas or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water.

Methods to demonstrate compliance with hydromodification management requirements, including protection of critical coarse sediment yield areas and flow control for post-project runoff from the project site, are presented in Chapter 6 of this manual. Hydromodification management concepts, theories, and references are described below.

2.3.2 Hydromodification Management Concepts and References

2.3.2.1 What is Hydromodification?

The MS4 Permit defines hydromodification as the change in the natural watershed hydrologic processes and runoff characteristics (i.e. interception, infiltration, overland flow, and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered hydromodification, due to their disruption of natural watershed hydrologic processes.

Typical impacts to natural watershed hydrologic processes and runoff characteristics resulting from new development and redevelopment include:

- Decreased interception and infiltration of rainfall at the project site due to removal of native vegetation, compaction of pervious area soils, and the addition of impervious area;

- Increased connectivity and efficiency of drainage systems serving the project site, including concentration of project-site runoff to discrete outfalls;
- Increased runoff volume, flow rate, and duration from the project site due to addition of impervious area, removal of native vegetation, and compaction of pervious area soils;
- Reduction of critical coarse sediment supply from the project site to downstream natural systems (e.g. streams) due to stabilization of developed areas, stabilization of streams, and addition of basins that trap sediment (either by design as a permanent desilting basin or storm water quality treatment basin that settles sediment, or incidentally as a peak flow management basin); and
- Interruption of critical coarse sediment transport in streams due to stream crossings such as culverts or ford crossings that incidentally slow stream flow and allow coarse sediment to settle upstream of the crossing.

Any of these changes can result in increased potential for erosion, or degraded instream habitat downstream of PDPs. The changes to delivery of runoff to streams typically modify the timing, frequency, magnitude, and duration of both storm flows and baseflow. Changes to delivery of coarse sediment and transport of coarse sediment result in increased transport capacity and the potential for adverse channel erosion.

Note that this manual is intended for design of permanent, post-construction BMPs, therefore this discussion is focused on the permanent, post-construction effects of development. The process of construction also has impacts, such as a temporary increase in sediment load produced from surfaces exposed by vegetation removal and grading, which is often deposited within stream channels, initiating aggradation and/or channel widening. Temporary construction BMPs to mitigate the sediment delivery are outside the purview of this manual.

Channel erosion resulting from PDP storm water discharge can begin at the point where runoff is discharged to natural systems, regardless of the distance from the PDP to the natural system. It could also begin some distance downstream from the actual discharge point if the stream condition is stable at the discharge point but more susceptible to erosion at a downstream location. The March 2011 HMP defines a domain of analysis for evaluation of stream susceptibility to erosion from PDP storm water discharge.

2.3.2.2 How Can Hydromodification be Controlled?

In the big picture, watershed-scale solutions are necessary to address hydromodification. Factors causing hydromodification are watershed-wide, and all of San Diego's major watersheds include some degree of legacy hydromodification effects from existing development and existing channel modifications, which cannot be reversed by onsite measures implemented at new development and redevelopment projects alone. As recommended by SCCWRP in Technical Report 667, "Hydromodification Assessment and Management in California," dated April 2012, "management strategies should be tailored to meet the objectives, desired future conditions, and constraints of the specific channel reach being addressed," and "potential objectives for specific stream reaches may include: protect, restore, or manage as a new channel form."

Development of such management strategies and objectives for San Diego watersheds will evolve over successive MS4 Permit cycles. The current MS4 Permit requires the Copermittees to prepare

WQIPs for all Watershed Management Areas within the San Diego Region. The WQIPs may include WMAAs which would assess watershed-wide hydrologic processes. These documents may be used to develop watershed-specific requirements for structural BMP implementation, including watershed-scale hydromodification management strategies.

This manual addresses development and redevelopment project-level hydromodification management measures currently required for PDPs by the MS4 Permit. Until optional watershed-specific performance recommendations or alternative compliance programs are developed, hydromodification management strategies for new development and redevelopment projects will consist of onsite measures designed to meet the performance requirements of Provisions E.3.c.(2).(a) and (b) of the MS4 Permit shown in Section 2.3.1. While development project-level measures alone will not reverse hydromodification of major streams, onsite measures are a necessary component of a watershed-wide solution, particularly while watershed-wide management strategies are still being developed. Also, development project-level measures are necessary to protect a project's specific storm water discharge points, which are typically discharging in smaller tributaries not studied in detail in larger watershed studies. Typical measures for development projects include:

- Protecting critical sediment yield areas by designing the project to avoid them or implementing measures that would allow coarse sediment to be discharged to receiving waters, such that the natural sediment supply is unaffected by the project;
- Using site design/LID measures to minimize impervious areas onsite and reduce post-project runoff; and
- Providing structural BMPs designed using continuous simulation hydrologic modeling to provide flow control of post-project runoff (e.g. BMPs that store post-project runoff and infiltrate, evaporate, harvest and use, or discharge excess runoff at a rate below the critical flow rate).

Structural BMPs for hydromodification management provide volume to control a range of flows from a fraction of Q₂ to Q₁₀. The volume determined for hydromodification management is different from the DCV for pollutant control. Methodology to demonstrate compliance with hydromodification management requirements are presented in Chapter 6 of this manual. See Section 2.4 regarding the relationship between pollutant control and hydromodification management performance standards.

2.4 Relationship between Performance Standards

An integrated approach can provide significant cost savings by utilizing design features that meet multiple standards.

Site design/LID, storm water pollutant control, and hydromodification management are separate requirements to be addressed in development project design. Each has its own purpose and each has separate performance standards that must be met. However, effective project planning involves understanding the ways in which these standards are related and how single suites of design features can meet more than one standard.

Site design features (aka LID) can be effective at reducing the runoff to downstream BMPs.

Site design BMPs serve the purpose of minimizing impervious areas and therefore reducing post-project runoff, and reducing the potential transport of pollutants offsite and reducing the potential

for downstream erosion caused by increased flow rates and durations. By reducing post-project runoff through, site design BMPs, the amount of runoff that must be managed for pollutant control and hydromodification flow control can be reduced.

Single structural BMPs, particularly retention BMPs, can meet or contribute to both pollutant control and hydromodification management objectives.

The objective of structural BMPs for pollutant control is to reduce offsite transport of pollutants, and the objective of structural BMPs for hydromodification management is to control flow rates and durations for control of downstream erosion. In either case, the most effective structural BMP to meet the objective are BMPs that are based on retention of storm water runoff where feasible. Both storm water pollutant control and flow control for hydromodification management can be achieved within the same structural BMP(s). However, demonstrating that the separate performance requirements for pollutant control and hydromodification management are met must be shown separately.

The design process should start with an assessment of the feasibility to retain or partially retain the DCV for pollutant control, then determine what kind of BMPs will be used for pollutant control and hydromodification management.

A typical design process for a single structural BMP to meet two separate performance standards at once involves (1) initiating the structural BMP design based on the performance standard that is expected to require the largest volume of storm water to be retained, (2) checking whether the initial design incidentally meets the second performance standard, and (3) adjusting the design as necessary until it can be demonstrated that both performance standards are met.

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Compliance with source control/site design, pollutant control, and hydromodification management BMPs, as applicable, requires coordination of site, landscape, and project storm water plans. It also involves provisions for O&M of structural BMPs. In order to effectively comply with applicable requirements, a step-wise approach is recommended. This chapter outlines a step-wise, systematic approach (Figure 3-1) to preparing a comprehensive storm water management design for Standard Projects and PDPs.

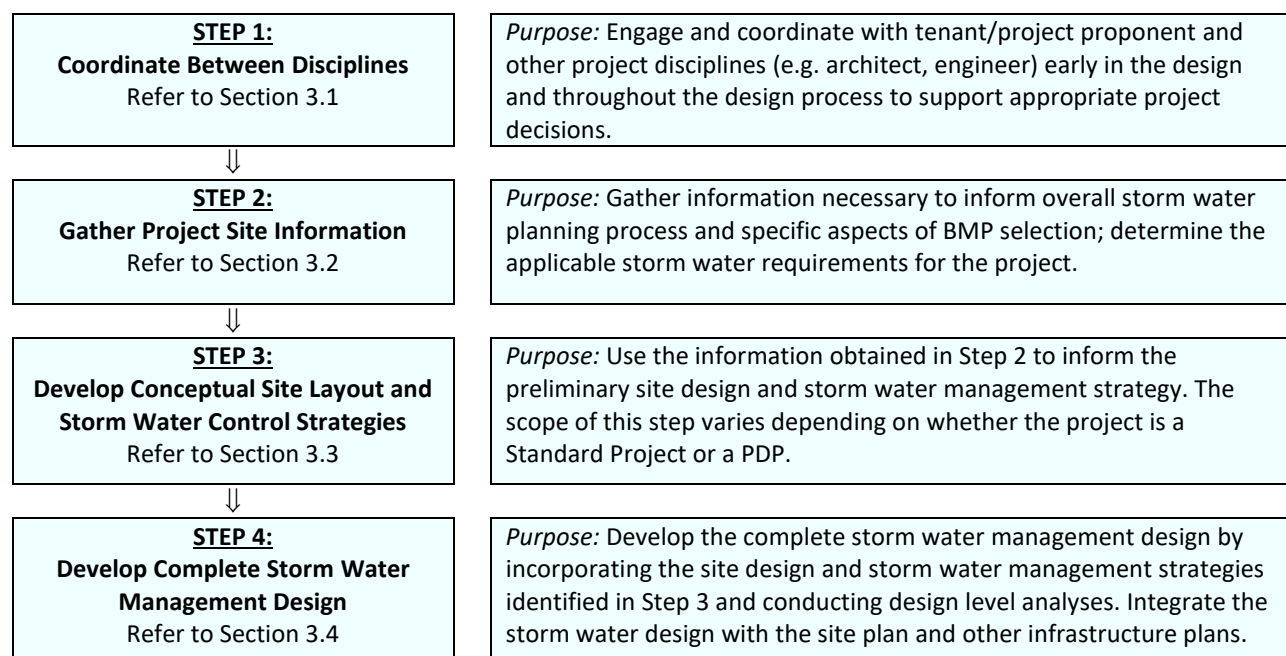


FIGURE 3-1. Approach for Developing a Comprehensive Storm Water Management Design

A step-wise approach is not mandatory, and adaptation of this step-wise approach to better fit with unique project features is encouraged. However, taking a step-wise, systematic approach of some sort for planning and design has a number of advantages. First, it helps ensure that applicable requirements and design goals are identified early in the process. Secondly, it helps ensure that key data about the site, watershed, and project are collected at the appropriate time in the project development process,

and the analyses are suited to the decisions that need to be made at each phase. Third, taking a systematic approach helps identify opportunities for retention of storm water that may not be identified in a less systematic process. Finally, a systematic approach helps ensure that constraints and unintended consequences are considered and used to inform BMP selection and design, and related project decisions.

Port specific special requirements are listed in Section 3.5 and requirements for phased projects are in Section 3.6.

3.1 Coordination Between Disciplines

Storm water management design requires close coordination between multiple disciplines, as storm water management design will affect the site layout and should therefore be coordinated among the project team as necessary from the start. The following list describes entities/disciplines that are frequently involved with storm water management design and potential roles that these entities/disciplines may plan.

Tenant/Project Proponent:

- Engage the appropriate disciplines needed for the project and facilitate exchange of information between disciplines.
- Identify who will be responsible for long term O&M of storm water management features, and initiate maintenance agreements when applicable.
- Ensure that whole lifecycle costs are considered in the selection and design of storm water management features and a source of funding is provided for long term maintenance.
- Identify the party responsible to inspect structural BMPs at each significant construction stage and at completion in order to provide certification of structural BMPs following construction.

Planner:

- Communicate overall project planning criteria to the team, such as planned development density, parking requirements, project-specific planning conditions, conditions of approval from prior entitlement actions (e.g. CEQA, 401 certifications), etc. and locations of open space and conservation easements and environmentally sensitive areas that are protected from disturbance), etc.
- Consider location of storm water facilities early in the conceptual site layout process.
- Assist in developing the site plan.

Architect:

- Participate in siting and design (architectural elements) of storm water BMPs.

Civil Engineer:

- Determine storm water requirements applicable to the site (e.g. Standard Project vs. PDP).
- Obtain site-specific information (e.g. watershed information, infiltration rates) and develop viable storm water management options that meet project requirements.
- Reconcile storm water management requirements with other site requirements (e.g. fire access, Americans with Disabilities Act accessibility, parking, open space).

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- Develop site layout and site design including preliminary and final design documents or plans.
- Select and design BMPs; conduct and document associated analyses; prepare BMP design sheets, details, and specifications.
- Prepare project SWQMP submittals.

Landscape Architect and/or Horticulturist/Agronomist:

- Select appropriate plants for vegetated storm water features, BMPs and prepare planting plans.
- Develop specifications for planting, vegetation establishment, and maintenance.
- Assist in developing irrigation plans/rates to minimize water application and non-storm water runoff from the project site.

Geotechnical Engineer

- Assist in preliminary infiltration feasibility screening of the site to help inform project layout and initial BMP selection, including characterizing soil, groundwater, geotechnical hazards, utilities, and any other factors, as applicable for the site.
- Conduct detailed analyses at proposed infiltration BMP locations to confirm or revise feasibility findings and provide design infiltration rates.
- Provide recommendations for infiltration testing that must be conducted during the construction phase, if needed to confirm pre-construction infiltration estimates.

Geomorphologist and/or Geologist

- Provide specialized services, as needed, related to sediment source assessment and/or channel stability or sensitivity assessment.

3.2 Gathering Project Site Information

To make decisions related to selection and design of storm water management BMPs, it is necessary to gather relevant project site information. This could include physical site information, proposed uses of the site, level of storm water management requirements (i.e. is it a Standard Project or a PDP?), proposed storm water discharge locations, potential/anticipated storm water pollutants based on the proposed uses of the site, receiving water sensitivity to pollutants and susceptibility to erosion, hydromodification management requirements, and other site requirements and constraints.

The amount and type of information that should be collected depends on the project type (i.e. is it a Standard Project, a PDP with all requirements or with only pollutant control requirements?). Refer to Figure 1-1 in Chapter 1 to identify the project type.

Information should only be gathered to the extent necessary to inform the storm water management design. In some cases, it is not necessary to conduct site specific analyses to precisely characterize conditions. For example, if depth to groundwater is known to be approximately 100 feet based on regional surveys, it is not necessary to also conduct site specific assessment of depth to groundwater to determine whether it is actually 90 feet or 110 feet on the project site. The difference between these values would not influence the storm water management design. In other cases, some information will not be applicable. For example, on an existing development site, there may be no natural hydrologic features remaining, therefore these features do not need to be characterized. The lack of natural

hydrologic features can be simply noted without further effort required.

Checklists (in Appendix I) and submittal templates (in Appendix A) are provided to facilitate gathering information about the project site for BMP selection and design. As part of planning for site investigation, it is helpful to review the subsequent steps (Section 3.3 and 3.4) to gain familiarity with how the site information will be used in making decisions about site layout and storm water BMP selection and design. This can help prioritize the data that are collected.

3.3 Developing Conceptual Site Layout and Storm Water Control Strategies

Once preliminary site information has been obtained, the site can be assessed for storm water management opportunities and constraints that will inform the overall site layout. Considering the project site data discussed above, it is essential to identify potential locations for storm water management features at a conceptual level during the site planning phase. Storm water management requirements must be considered as a key factor in laying out the overall site. Preliminary design of permanent storm water BMPs is partially influenced by whether the project is a Standard Project or a PDP. Table 3-1 presents the applicability of different subsections in this manual based on project type and must be used to determine which requirements apply to a given project.

TABLE 3-1. Applicability of Section 3.3 Sub-sections for Different Project Types

Project Type	Section 3.3.1	Section 3.3.2	Section 3.3.3	Section 3.3.4
Standard Project	☑	NA	NA	NA
PDP with only Pollutant Control Requirements	☑	NA	☑	☑
PDP with Pollutant and Hydromodification Management Requirements	☑	☑	☑	☑

3.3.1 Preliminary Design Steps for All Development Projects

All projects must incorporate source control and site design BMPs. The following systematic approach outlines these site planning considerations for all development projects:

- 1 Review Chapter 4 of this manual to become familiar with the menu of source control and site design practices that are required.
- 2 Review the preliminary site information gathered in Section 3.2, specifically related to:
 - a. Natural hydrologic features that can be preserved and/or protected;
 - b. Soil information;
 - c. General drainage patterns (i.e. general topography, points of connection to the storm drain or receiving water);
 - d. Pollutant sources that require source controls; and

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- e. Information gathered and summarized in the Site Information Checklist for Standard Projects (Appendix I-3A).
- 3 Create opportunities for source control and site design BMPs by developing an overall conceptual site layout that allocates space for site design BMPs and promotes drainage patterns that are effective for hydrologic control and pollutant source control. For example:
 - a. Locate pervious areas down gradient from buildings where possible to allow for dispersion.
 - b. Identify parts of the project that could be drained via overland vegetated conveyance rather than piped connections.
 - c. Develop traffic circulation patterns that are compatible with minimizing street widths.
- 4 As part of Section 3.4, refine the selection and placement of source control and site design BMPs and incorporate them into project plans. Compliance with site design and source control requirements shall be documented as described in Chapter 4.

3.3.2 Evaluation of Critical Coarse Sediment Yield Areas

For PDPs that are required to meet hydromodification management requirements, evaluate whether critical coarse sediment yield areas exist within or upstream of the project site. Identification of critical coarse sediment yield areas is discussed in Chapter 6 of this manual, [additional guidance on identification and protection of critical coarse sediment yield areas is provided in Appendix H](#). Conceptual layout of the project site must consider the following items:

- a. Have critical coarse sediment areas been identified within the project site? Does the proposed project impact these onsite critical coarse sediment areas? What measures are necessary to avoid impacts to these areas? What measures are necessary to convey critical coarse sediment from these areas through the site?
- b. Have critical coarse sediment areas been identified upstream of the project site? Does the proposed project impact upstream critical coarse sediment areas? What measures are necessary to avoid impacts to these areas or convey critical coarse sediment from these areas through the site?
- c. If impacts to onsite and offsite critical coarse sediment areas are not avoided, what mitigation practices will be implemented to ensure no net impact to the receiving water?

3.3.3 Drainage Management Areas

Drainage management areas (DMAs) provide an important framework for feasibility screening, BMP prioritization, and storm water management system configuration. BMP selection, sizing, and feasibility determinations must be made at the DMA level; therefore delineation of DMAs is highly recommended at the conceptual site planning phase and is mandatory for completing the project design and meeting submittal requirements. This section provides guidance on delineating DMAs that is intended to be used as part of Section 3.3 and 3.4.

DMAs are defined based on the proposed drainage patterns of the site and the BMPs to which they

drain. During the early phases of the project, DMAs shall be delineated based onsite drainage patterns and possible BMP locations identified in the site planning process. DMAs should not overlap and should be similar with respect to BMP opportunities and feasibility constraints. More than one DMA can drain to the same BMP. However, because the BMP sizes are determined by the runoff from the DMA, a single DMA may not drain to more than one BMP. See Figure 3-2.

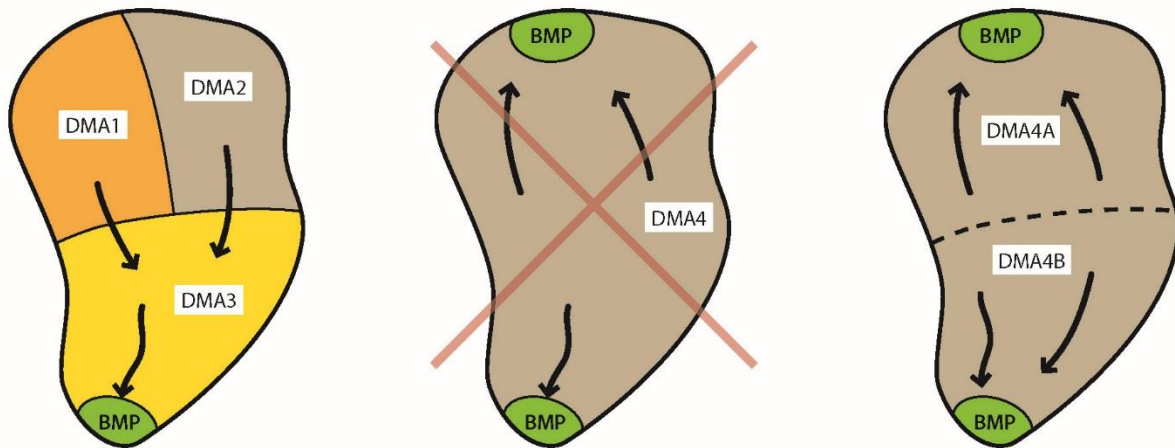


FIGURE 3-2. DMA Delineation

In some cases, in early planning phases, it may be appropriate to generalize the proposed treatment plan by simply assigning a certain BMP type to an entire planning area (e.g. Parking lot X will be treated with bioretention) and calculating the total sizing requirement without identifying the specific BMP locations at that time. This planning area would be later subdivided for design-level calculations. Section 5.2 provides additional guidance on DMA delineation. A runoff factor (similar to a “C” factor used in the rational method) should be used to estimate the runoff draining to the BMP. Appendix B.1 provides guidance in estimating the runoff factor for the drainage area draining to a BMP.

BMPs must be sized to treat the DCV from the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drains to the BMP. To minimize offsite flows treated by project BMPs, consider diverting upgradient flows subject to local drainage and flood control regulation. An example is shown in Figure 3-3.

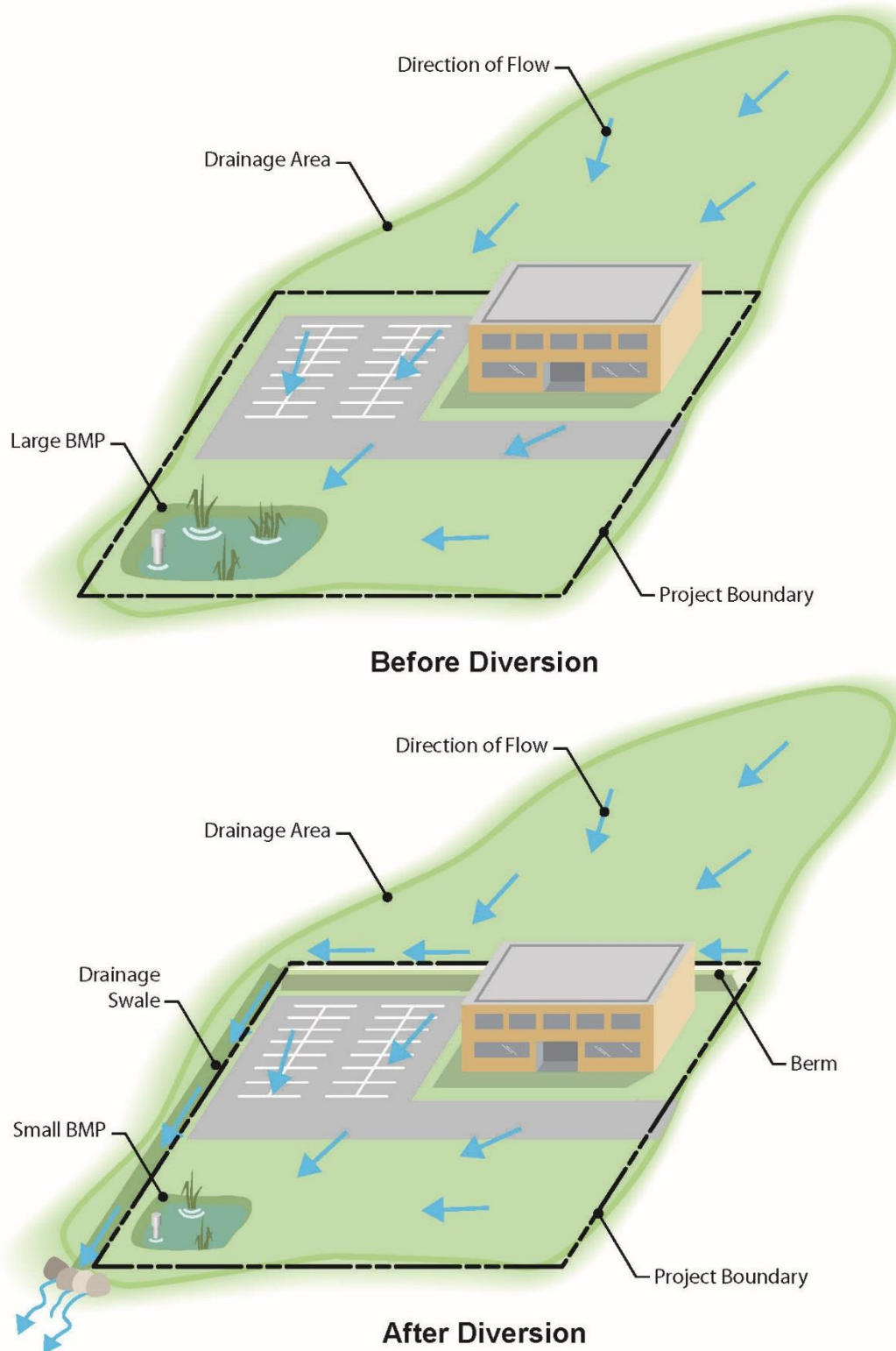


FIGURE 3-3. Tributary Area for BMP Sizing

3.3.4 Developing Conceptual Storm Water Control Strategies

This step applies to PDPs only. The goal of this step is to develop conceptual storm water control strategies that are compatible with the site conditions, including siting and preliminary selection of structural BMPs. At this phase of project planning, it is typically still possible for storm water considerations to influence the site layout to better accommodate storm water design requirements. The end product of this step should be a general, but concrete understanding of the storm water management parameters for each DMA, the compatibility of this approach with the site design, and preliminary estimates of BMP selection. For simpler sites, this step could be abbreviated in favor of skipping forward to design-level analyses in Section 3.4. However, for larger and/or more complex sites, this section can provide considerable value and help allow evaluation of storm water management requirements on common ground with other site planning considerations.

The following systematic approach is recommended:

1. Review the preliminary site information gathered in Section 3.2, specifically related to information gathered and summarized in the Site Information Checklist for PDPs (Appendix I-3B).
2. Identify self-mitigating, de minimis areas, and/or potential self-retaining DMAs that can be isolated from the remainder of the site (See Section 5.2).
3. Estimate DCV for each remaining DMAs (See Appendix B.1).
4. Determine if there is a potential opportunity for harvest and use of storm water from the project site. See Section 5.4.1 for harvest and use feasibility screening, which is based on water demand at the project site. For most sites, there is limited opportunity; therefore evaluating this factor early can help simplify later decisions.
5. Estimate potential runoff reduction and the DCV that could be achieved with site design BMPs (See Section 5.3 and Appendix B.2) and harvest and use BMPs (See Appendix B.3).
6. Based on the remaining runoff after accounting for steps 2 to 5, estimate BMP space requirements. Identify applicable structural BMP requirements (i.e. storm water pollutant control versus hydromodification management) and conduct approximate sizing calculations to determine the overall amount of storage volume and/or footprint area required for BMPs. Use worksheets presented in Appendices B.4 and B.5 to estimate sizing requirements for different types of BMPs.
7. Conduct preliminary screening of infiltration feasibility conditions. A preliminary screening of infiltration feasibility should be conducted as part of site planning to identify areas that are more or less conducive to infiltration. Recommended factors to consider include:
 - a. Soil types (determined from available geotechnical testing data, soil maps, site observations, and/or other data sources)
 - b. Approximate infiltration rates at various points on the site, obtained via approximate methods (e.g. simple pit test), if practicable
 - c. Groundwater elevations
 - d. Proposed depths of fill
 - e. New or existing utilities that will remain with development
 - f. Soil or groundwater contamination issues within the site or in the vicinity of the site

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- g. Slopes and other potential geotechnical hazards that are unavoidable as part of site development
- h. Safety and accessibility considerations

This assessment is not intended to be final or account for all potential factors. Rather, it is intended to help in identifying site opportunities and constraints as they relate to site planning. After potential BMP locations are established, a more detailed feasibility analysis is necessary (see Section 3.4 and 5.4.2). Additionally, Appendix C and D provide methods for geotechnical and groundwater assessment applicable for screening at the planning level and design-level requirements. The jurisdiction may allow alternate assessment methods with appropriate documentation at the discretion of the Port.

8. Identify tentative BMP locations based on preliminary feasibility screening, natural opportunities for BMPs (e.g. low areas of the site, areas near storm drain or stream connections), and other BMP sites that can potentially be created through effective site design (e.g. oddly configured or otherwise unbuildable parcels, easements and landscape amenities including open space and buffers which can double as locations for bioretention or biofiltration facilities).
9. Determine tentative BMP feasibility categories for infiltration for each DMA or specific BMP location. Based on the results of feasibility screening and tentative BMP locations, determine the general feasibility categories that would apply to BMPs in these locations. Categories are described in Section 5.4.2 and include:
 - a. Full infiltration condition;
 - b. Partial infiltration condition; and
 - c. No infiltration condition.

Adapt the site layout to attempt to achieve infiltration to the greatest extent feasible.

10. Consider how storm water management BMPs will be accessed for inspection and maintenance and provide necessary site planning allowances (access roads, inspection openings, setbacks, etc.) and coordinate with jurisdiction public works departments for additional design requirements or allowed BMPs if required for BMPs in public easements or are part of a community facilities district maintained by the jurisdiction. In addition consider the use of the site.
11. Document site planning and opportunity assessment activities as a record of the decisions that led to the development of the final storm water management plan. The SWQMP primarily shows the complete design rather than the preliminary steps in the process. However, to comply with the requirements of this manual, the applicant is required to describe how storm water management objectives have been considered as early as possible in the site planning process and how opportunities to incorporate BMPs have been identified.

3.4 Developing Complete Storm Water Management Design

The complete storm water management design consists of all of the elements describing the BMPs to be implemented, as well as integration of the BMPs with the site design and other infrastructure. The storm water management design shall be developed by taking into consideration the opportunities

and/or constraints identified during the site planning phase of the project and then performing the final design level analysis. The scope of this step varies depending on whether the project is a Standard Project, PDP with only pollutant control BMP requirements or PDP with pollutant control and hydromodification management requirements. The following systematic approach is recommended to develop a final site layout and storm water management design. Table 3-2 presents the applicability of different subsections based on project type and must be used to determine which requirements apply to a given project.

TABLE 3-2. Applicability of Section 3.4 Sub-sections for Different Project Types

Project Type	Section 3.4.1	Section 3.4.2	Section 3.4.3
Standard Project	☑	NA	NA
PDP with only Pollutant Control Requirements	☑	☑	NA
PDP with Pollutant Control and Hydromodification Management Requirements	☑	NA	☑

3.4.1 Steps for All Development Projects

Standard Projects need to only satisfy the source control and site design requirements of Chapter 4 of this manual, and then proceed to Chapter 8 of this manual to determine submittal requirements.

1. Select, identify and detail specific source control BMPs. See Section 4.2.
2. Select, identify and detail specific site design BMPs. See Section 4.3.
3. Document that all applicable source control and site design BMPs have been used. See Chapter 8.

3.4.2 Steps for PDPs with only Pollutant Control Requirements

The steps below primarily consist of refinements to the conceptual steps completed as part of Section 3.3, accompanied by design-level detail and calculations. More detailed instructions for selection and design of storm water pollutant treatment BMPs are provided in Chapter 5.

1. Select locations for storm water pollutant control BMPs, and delineate and characterize DMAs using information gathered during the site planning phase.
2. Conduct feasibility analysis for harvest and use BMPs. See Section 5.4.1.
3. Conduct feasibility analysis for infiltration to determine the infiltration condition. See Section 5.4.2.
4. Based on the results of steps 2 and 3, select the BMP category that is most appropriate for the site. See Section 5.5.
5. Calculate required BMP sizes and footprints. See Appendix B (sizing methods) and Appendix E (design criteria).

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6. Evaluate if the required BMP footprints will fit within the site considering the site constraints; if not, then document infeasibility and move to the next step.
7. If using biofiltration BMPs, document conformance with the criteria for biofiltration BMPs found in Appendix F, including Appendix F.1, as applicable.
8. If needed, implement flow-thru treatment control BMPs (for use with Alternative Compliance) for the remaining DCV. See Section 5.5.4 and Appendix B.6 for additional guidance.
9. If flow-thru treatment control BMPs (for use with Alternative Compliance) were implemented refer to Section 1.8.
10. Prepare SWQMP documenting site planning and opportunity assessment activities, final site layout and storm water management design. See Chapter 8.
11. Determine and document O&M requirements. See Chapters 7 and 8.

3.4.3 Steps for Projects with Pollutant Control and Hydromodification Management Requirements

The steps below primarily consist of refinements to the conceptual steps completed as part of Section 3.3, accompanied by design-level detail and calculations. More detailed instruction for selection and design of storm water pollutant treatment and hydromodification control BMPs are provided in Chapter 5 and 6, respectively.

1. If critical coarse sediment yield areas were determined to exist within or upstream of the project site (Section 3.3.2) incorporate mitigation measures when applicable (Section 6.2).
2. Select locations for storm water pollutant control and hydromodification management BMPs and delineate and characterize DMAs using information gathered during the site planning phase.
3. Conduct feasibility analysis for harvest and use BMPs. See Section 5.4.1.
4. Conduct feasibility analysis for infiltration to determine the infiltration condition. See Section 5.4.2.
5. Based on the results of steps 3 and 4, select the BMP category for pollutant treatment BMPs that is most appropriate for the site. See Section 5.5.
6. Develop the design approach for integrating storm water pollutant treatment and hydromodification control. The same location(s) can serve both functions (e.g. a biofiltration area that provides both pollutant control and flow control), or separate pollutant control and flow control locations may be identified (e.g. several dispersed retention areas for pollutant control, with overflow directed to a single location of additional storage for flow control).
7. Calculate BMP sizing requirements for pollutant control and flow control. See Appendix B (sizing methods) and Appendix E (design criteria).
 - a. When the same BMP will serve both functions, Section 6.3.6 of this manual provides recommendations for assessing the controlling design factor and initiating the design process.
8. Evaluate if the required BMP footprints will fit within the site considering the site constraints:

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- a. If they fit within the site, design BMPs to meet applicable sizing and design criteria. Document sizing and design separately for pollutant control and hydromodification management even when the same BMP is serving both functions.
 - b. If they do not fit the site then document infeasibility and move to the next step.
9. Implement flow-thru treatment control BMPs (for use with Alternative Compliance) for the remaining DCV. See Section 5.5.4 and Appendix B.6 for additional guidance.
10. If flow-thru treatment control BMPs (for use with Alternative Compliance) were implemented refer to Section 1.8.
11. Prepare a SWQMP documenting site planning and opportunity assessment activities, final site layout, storm water pollutant control design and hydromodification management design. See Chapter 8.
12. Determine and document O&M requirements. See Chapters 7 and 8.

3.5 Project Planning and Design Requirements Specific to Local Jurisdiction

The following additional design requirements apply for development projects within the Port tidelands:

Projects along jurisdictional boundaries: If portions of a project are within other jurisdictions (e.g., roadway realignment; new sidewalk), the project must submit documentation of review and acceptance of the SWQMP from the adjacent jurisdiction, for the portions of the project within their jurisdiction.

Projects within master planned areas: If a master SWQMP exists; projects shall conform to the master SWQMP, or amended the master SWQMP upon approval by the Port.

3.6 Phased Projects

Phased projects typically require a conceptual or master SWQMP followed by more detailed submittals. As part of an application for approval of a phased development project, a conceptual or master SWQMP shall be submitted; which describes and illustrates, in broad outline, how the drainage for the project will comply with the storm water performance standards. The level of detail in the conceptual or master SWQMP should be consistent with the scope and level of detail of the development approval being considered. The conceptual or master SWQMP should specify that a more detailed SWQMP for each later phase or portion of the project will be submitted with subsequent applications for discretionary approvals.

Source Control and Site Design Requirements for All Development Projects

This chapter presents the source control and site design requirements to be met by all projects, inclusive of Standard Projects and PDPs. Checklists I.4 for source control and I.5 for site design included in Appendix I can be used by both Standard Projects and PDPs to document conformance with the requirements.

4.1 General Requirements (GR)

4.1.1: Onsite BMPs must be located so as to remove pollutants from runoff prior to its discharge to any receiving waters, and as close to the source as possible.

The location of the BMP affects the ability of the BMP to retain, and/or treat, the pollutants from the contributing drainage area. BMPs must remove pollutants from runoff and should be placed as close to the pollutant source as possible.

How to comply: Projects shall comply with this requirement by implementing source control (Section 4.2) and site design BMPs (Section 4.3) that are applicable to their project and site conditions.

4.1.2: Structural BMPs must not be constructed within the Waters of the U.S.

Construction, operation, and maintenance of a structural BMP in a water body can negatively impact the physical, chemical, and biological integrity, as well as the beneficial uses, of the water body. However, alternative compliance opportunities involving restoration of areas within Waters of the U.S. may be identified by local jurisdictions.

How to comply: Projects shall comply with this requirement by preparing project plans that illustrate the location of all storm water BMPs demonstrate compliance with this requirement by showing the location of BMPs on project plans and describing or depicting the location of receiving waters.

4.1.3: Onsite BMPs must be designed and implemented with measures to avoid the creation of nuisances or pollutions associated with vectors (e.g. mosquitos, rodents, or flies).

According to the California Department of Health, structural BMPs that retain standing water for

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over 96 hours are particularly concerning for facilitating mosquito breeding. Certain site design features that hold standing water may similarly produce mosquitoes.

How to comply: Projects shall comply with this requirement by incorporating design, construction, and maintenance principles to drain retained water within **96 hours** and minimize standing water. Design calculations shall be provided to demonstrate the potential for standing water ponding at surface level and accessible to mosquitos has been addressed. For water retained in biofiltration facilities that are not accessible to mosquitoes this criteria is not applicable (i.e. water ponding in the gravel layer, water retained in the amended soil, etc.).

4.2 Source Control (SC) BMP Requirements

Source control BMPs avoid and reduce pollutants in storm water runoff. Everyday activities, such as recycling, trash disposal and irrigation, generate pollutants that have the potential to drain to the storm water conveyance system. Source control BMPs are defined as an activity that reduces the potential for storm water runoff to come into contact with pollutants. An activity could include an administrative action, design of a structural facility, usage of alternative materials, and operation, maintenance and inspection of an area. Where applicable and feasible, all development projects are required to implement source control BMPs. Source control BMPs (SC-1 through SC-6) are discussed below.

How to comply: Projects shall comply with this requirement by implementing source control BMPs listed in this section that are applicable to their project. Applicability shall be determined through consideration of the development project's features and anticipated pollutant sources. Appendix E provides guidance for identifying source control BMPs applicable to a project. The "Source Control BMP Checklist for All Development Projects" located in Appendix I-4 shall be used to document compliance with source control BMP requirements.

4.2.1: Prevent illicit discharges into the MS4

An illicit discharge is any discharge to the MS4 that is not composed entirely of storm water except discharges pursuant to a National Pollutant Discharge Elimination System permit and discharges resulting from firefighting activities. Projects must effectively eliminate discharges of non-storm water into the MS4. This may involve a suite of housekeeping BMPs which could include effective irrigation, dispersion of non-storm water discharges into landscaping for infiltration, and controlling wash water from vehicle washing. Appendix E describes the following that can be effective in preventing illicit discharges:

- SC-B – Interior floor drains and elevator shaft sump pumps plumbed to sanitary sewer;
- SC-C – Interior parking garage floor drains plumbed to sanitary sewers;
- SC-E – Pools, spas, ponds with accessible sanitary sewer cleanout;
- SC-F – Food service floor mat & equipment cleanout area exposure reduction;
- SC-G – Refuse areas exposure reduction;
- SC-H – Industrial processes performed indoors;
- SC-I – Outdoor storage of equipment or materials exposure reduction;
- SC-J – Vehicle and equipment cleaning area exposure reduction;

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- SC-K – Vehicle/Equipment Repair and Maintenance exposure reduction;
- SC-L – Fuel dispensing area coverage and grading requirements;
- SC-M – Loading dock drainage and coverage requirements;
- SC-N – Fire sprinkler test water to sanitary sewer;
- SC-O – Miscellaneous drain or wash water not to storm drain system;
- SC-6A – Large Trash Generating Facilities BMP guidance;
- SC-6B – Animal Facilities BMP guidance;
- SC-6C – Plant Nurseries and Garden Centers BMP guidance; and
- SC-6D – Automotive-related Uses BMP guidance.

4.2.2: Identify the storm drain system using stenciling or signage

Storm drain signs and stencils are visible source controls typically placed adjacent to the inlets. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Stenciling shall be provided for all storm water conveyance system inlets and catch basins within the project area. Inlet stenciling may include concrete stamping, concrete painting, placards, or other methods approved by the local municipality. In addition to storm drain stenciling, projects are encouraged to post signs and prohibitive language (with graphical icons) which prohibit illegal dumping at trailheads, parks, building entrances and public access points along channels and creeks within the project area. Storm drain inlets within the Port jurisdiction must be placarded with an official Port inlet placard. Prior to project close out, contact the Port to obtain an official inlet placard. The following factsheet provided in Appendix E provides more information:

- SC-A – Onsite storm drain inlet labeling

4.2.3: Protect outdoor material storage areas from rainfall, run-on, runoff, and wind dispersal

Materials with the potential to pollute storm water runoff shall be stored in a manner that prevents contact with rainfall and storm water runoff. Contaminated runoff shall be managed for treatment and disposal (e.g. secondary containment directed to sanitary sewer). All development projects shall incorporate the following structural or pollutant control BMPs for outdoor material storage areas, as applicable and feasible:

- Materials with the potential to contaminate storm water shall be:
 - Placed in an enclosure such as, but not limited to, a cabinet, or similar structure, or under a roof or awning that prevents contact with rainfall runoff or spillage to the storm water conveyance system; or
 - Protected by secondary containment structures such as berms, dikes, or curbs.
- The storage areas shall be paved and sufficiently impervious to contain leaks and spills, where necessary.
- The storage area shall be sloped towards a sump or another equivalent measure that is effective to contain spills.

Chapter 4: Source Control and Site Design Requirements for All Development Projects

- Runoff from downspouts/roofs shall be directed away from storage areas.
- The storage area shall have a roof or awning that extends beyond the storage area to minimize collection of storm water within the secondary containment area. A manufactured storage shed may be used for small containers.

The following fact sheets provided in Appendix E describe outdoor material storage area BMPs:

- SC-I – Outdoor storage of equipment or materials exposure reduction;
- SC-M – Loading dock drainage and coverage requirements;
- SC-O – Miscellaneous drain or wash water not to storm drain system;
- SC-6A – Large Trash Generating Facilities BMP guidance;
- SC-6B – Animal Facilities BMP guidance;
- SC-6C – Plant Nurseries and Garden Centers BMP guidance; and
- SC-6D – Automotive-related Uses BMP guidance.

4.2.4: Protect materials stored in outdoor work areas from rainfall, run-on, runoff, and wind dispersal

Outdoor work areas have an elevated potential for pollutant loading and spills. All development projects shall include the following structural or pollutant control BMPs for any outdoor work areas with potential for pollutant generation, as applicable and feasible:

- Create an impermeable surface such as concrete or asphalt, or a prefabricated metal drip pan, depending on the size needed to protect the materials.
- Cover the area with a roof or other acceptable cover.
- Berm the perimeter of the area to prevent water from adjacent areas from flowing on to the surface of the work area.
- Directly connect runoff to sanitary sewer or other specialized containment system(s), as needed and where feasible. This allows the more highly concentrated pollutants from these areas to receive special treatment that removes particular constituents. Approval for this connection must be obtained from the appropriate sanitary sewer agency.
- Locate the work area away from storm drains or catch basins.

The following fact sheets provided in Appendix E describe materials stored in outdoor work area BMPs:

- SC-F – Food service floor mat & equipment cleanout area exposure reduction;
- SC-J – Vehicle and equipment cleaning area exposure reduction;
- SC-K – Vehicle/Equipment Repair and Maintenance exposure reduction;
- SC-L – Fuel dispensing area coverage and grading requirements;
- SC-6A – Large Trash Generating Facilities BMP guidance;
- SC-6B – Animal Facilities BMP guidance;
- SC-6C – Plant Nurseries and Garden Centers BMP guidance; and

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- SC-6D – Automotive-related Uses BMP guidance

4.2.5: Protect trash storage areas from rainfall, run-on, runoff, and wind dispersal

Storm water runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. All development projects shall include the following structural or pollutant control BMPs, as applicable:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This can include berming or grading the waste handling area to prevent run-on of storm water.
- Ensure trash container areas are screened or walled to prevent offsite transport of trash.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Locate storm drains away from immediate vicinity of the trash storage area and vice versa.
- Post signs on all dumpsters informing users that hazardous material are not to be disposed.

The following fact sheets provided in Appendix E describe trash storage area BMPs:

- SC-G – Refuse areas exposure reduction;
- SC-6A – Large Trash Generating Facilities BMP guidance.

4.2.6: Use any additional BMPs determined to be necessary by the Port to minimize pollutant generation at each project site

Appendix E provides guidance on permanent controls and operational BMPs that are applicable at a project site based on potential sources of runoff pollutants at the project site or priority pollutants in the watershed. The applicant shall implement all applicable and feasible source control BMPs listed in Appendix E as required by and approved by the Port.

4.3 Site Design (SD) BMP Requirements

Site design BMPs (also referred to as LID BMPs) are intended to reduce the rate and volume of storm water runoff and associated pollutant loads. Site design BMPs include practices that reduce the rate and/or volume of storm water runoff by minimizing surface soil compaction, reducing impervious surfaces, and/or providing flow pathways that are “disconnected” from the storm drain system, such as by routing flow over pervious surfaces. Site design BMPs may incorporate interception, storage, evaporation, evapotranspiration, infiltration, and/or filtration processes to retain and/or treat pollutants in storm water before it is discharged from a site.

Site design BMPs shall be applied to all development projects as appropriate and practicable for the project site and project conditions. Site design BMPs are described in the following subsections.

Appendix E also provides the following fact sheets to assist applicants with the proper design of site

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design features:

- SD-A – Trees;
- SD-B – Impervious Area Dispersion;
- SD-C – Green Roofs;
- SD-D – Permeable Pavement (Site Design BMP);
- SD-E – Rain Barrels; and
- SD-F – Amended Soil.

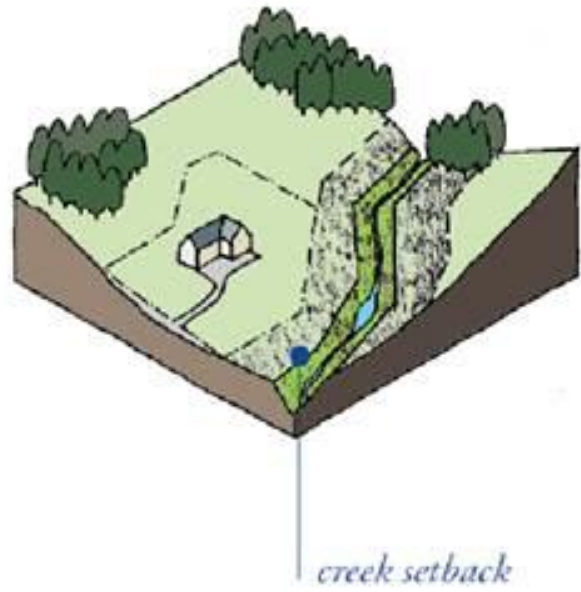
How to comply: Projects shall comply with this requirement by using all of the site design BMPs listed in this section that are applicable and practicable to their project type and site conditions. Applicability of a given site design BMP shall be determined based on project type, soil conditions, presence of natural features (e.g. streams), and presence of site features (e.g. parking areas). Explanation shall be provided by the applicant when a certain site design BMP is considered to be not applicable or not practicable/feasible. Site plans shall show site design BMPs and provide adequate details necessary for effective implementation of site design BMPs. The "Site Design BMP Checklist for All Development Projects" located in Appendix I-5 shall be used to document compliance with site design BMP requirements. In some cases, implementation of Site Design BMPs may result in quantifiable reductions in the site's DCV (refer to Appendix B.2); however, failure to meet the minimum thresholds for DCV reductions does not eliminate requirements to implement applicable Site Design BMPs. All applicable and feasible Site Design BMPs must be implemented to the maximum extent practicable.

4.3.1: Maintain natural drainage pathways and hydrologic features

- ☐ Maintain or restore natural storage reservoirs and drainage corridors (including topographic depressions, areas of permeable soils, natural swales, and ephemeral and intermittent streams)
- ☐ Buffer zones for natural water bodies (where buffer zones are technically infeasible, require project applicant to include other buffers such as trees, access restrictions, etc.)

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During the site assessment, natural drainages must be identified along with their connection to creeks and/or streams, if any. Natural drainages offer a benefit to storm water management as the soils and habitat already function as a natural filtering/infiltrating swale. When determining the development footprint of the site, altering natural drainages should be avoided. By providing a development envelope set back from natural drainages, the drainage can retain some water quality benefits to the watershed. In some situations, site constraints, regulations, economics, or other factors may not allow avoidance of drainages and sensitive areas. Projects proposing to dredge or fill materials in Waters of the U.S. must obtain Clean Water Act Section 401 Water Quality Certification. Projects proposing to dredge or fill waters of the State must obtain waste discharge requirements. Both the 401 Certification and the Waste Discharge Requirements are administered by the San Diego Water Board. The project applicant shall consult the local jurisdiction for other specific requirements.



Source: County of San Diego LID Handbook

Projects can incorporate 4.3.1 into a project by implementing the following planning and design phase techniques as applicable and practicable:

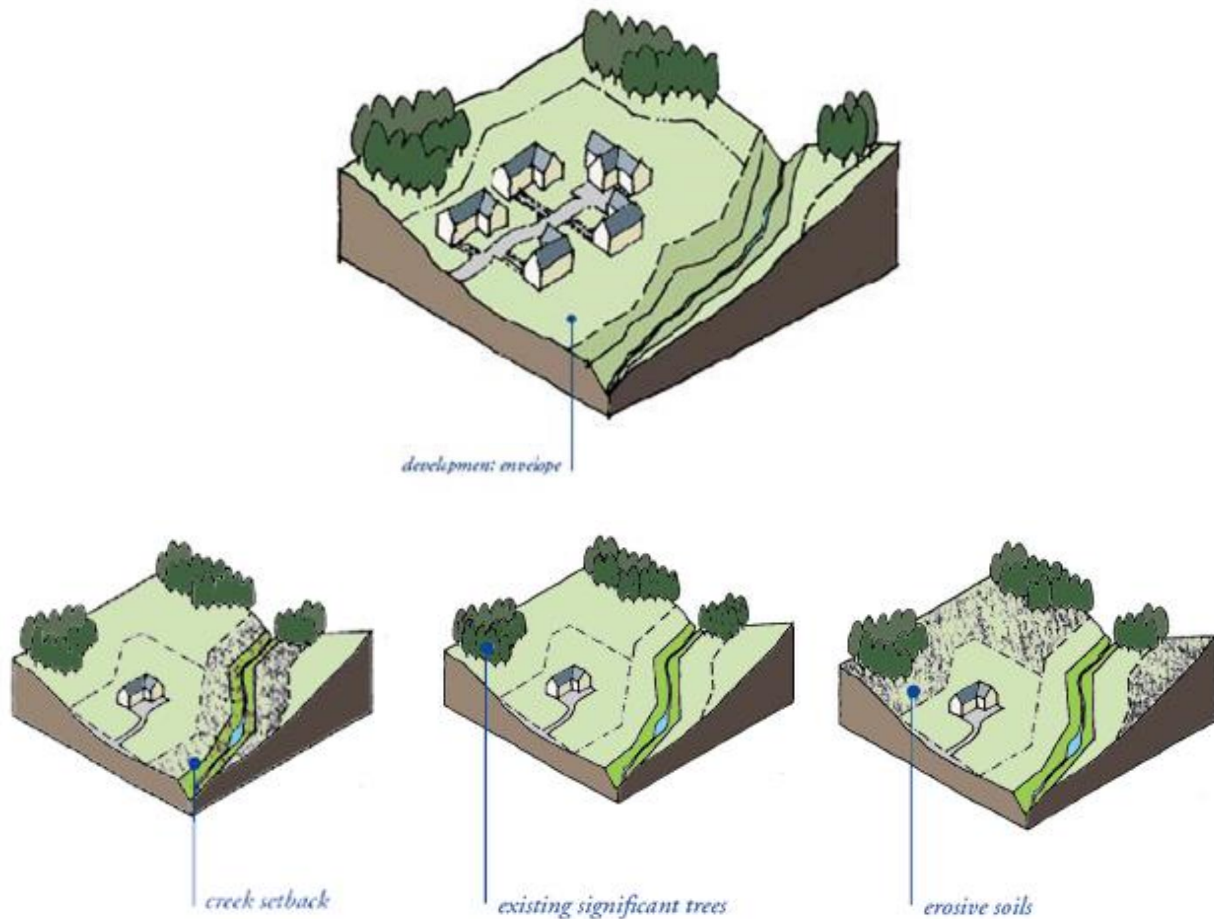
- Evaluate surface drainage and topography in considering selection of Site Design BMPs that will be most beneficial for a given project site. Where feasible, maintain topographic depressions for infiltration.
- Optimize the site layout and reduce the need for grading. Where possible, conform the site layout along natural landforms, avoid grading and disturbance of vegetation and soils, and replicate the site's natural drainage patterns. Integrating existing drainage patterns into the site plan will help maintain the site's predevelopment hydrologic function.
- Preserve existing drainage paths and depressions, where feasible and applicable, to help maintain the time of concentration and infiltration rates of runoff, and decrease peak flow.
- Structural BMPs cannot be located in buffer zones if a State and/or Federal resource agency (e.g. San Diego Water Board, California Department of Fish and Wildlife; U.S. Army Corps of Engineers, etc.) prohibits maintenance or activity in the area.

4.3.2: Conserve natural areas, soils and vegetation

- ☐ Conserve natural areas within the project footprint including existing trees, other vegetation, and soils

To enhance a site's ability to support source control and reduce runoff, the conservation and restoration of natural areas must be considered in the site design process. By conserving or restoring the natural drainage features, natural processes are able to intercept storm water, thereby reducing the amount of runoff.

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Source: County of San Diego LID Handbook

The upper soil layers of a natural area contain organic material, soil biota, vegetation, and a configuration favorable for storing and slowly conveying storm water and establishing or restoring vegetation to stabilize the site after construction. The canopy of existing native trees and shrubs also provide a water conservation benefit by intercepting rain water before it hits the ground. By minimizing disturbances in these areas, natural processes are able to intercept storm water, providing a water quality benefit. By keeping the development concentrated to the least environmentally sensitive areas of the site and set back from natural areas, storm water runoff is reduced, water quality can be improved, environmental impacts can be decreased, and many of the site's most attractive native landscape features can be retained. In some situations, site constraints, regulations, economics, and/or other factors may not allow avoidance of all sensitive areas on a project site. Project applicant shall consult the local municipality for jurisdictional specific requirements for mitigation of removal of sensitive areas.

Chapter 4: Source Control and Site Design Requirements for All Development Projects

Projects can incorporate 4.3.2 by implementing the following planning and design phase techniques as applicable and practicable:

- Identify areas most suitable for development and areas that should be left undisturbed. Additionally, reduced disturbance can be accomplished by increasing building density and increasing height, if possible.
- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.
- Avoid areas with thick, undisturbed vegetation. Soils in these areas have a much higher capacity to store and infiltrate runoff than disturbed soils, and reestablishment of a mature vegetative community can take decades. Vegetative cover can also provide additional volume storage of rainfall by retaining water on the surfaces of leaves, branches, and trunks of trees during and after storm events.
- Preserve trees, especially native trees and shrubs, and identify locations for planting additional native or drought tolerant trees and large shrubs.
- In areas of disturbance, topsoil should be removed before construction and replaced after the project is completed. When handled carefully, such an approach limits the disturbance to native soils and reduces the need for additional (purchased) topsoil during later phases.
- Avoid sensitive areas, such as wetlands, biological open space areas, biological mitigation sites, streams, floodplains, or particular vegetation communities, such as coastal sage scrub and intact forest. Also, avoid areas that are habitat for sensitive plants and animals, particularly those, State or federally listed as endangered, threatened or rare. Development in these areas is often restricted by federal, state and local laws.

LEAST SENSITIVE



MOST SENSITIVE

1. AREAS DEVOID OF VEGETATION, INCLUDING PREVIOUSLY GRADED AREAS AND AGRICULTURAL FIELDS
2. AREAS OF NON-NATIVE VEGETATION, DISTURBED HABITATS AND EUCALYPTUS WOODLANDS WHERE RECEIVING WATERS ARE NOT PRESENT
3. AREAS OF CHAMISE OR MIXED CHAPARRAL, AND NON-NATIVE GRASSLANDS.
4. AREAS CONTAINING COASTAL SCRUB COMMUNITIES
5. ALL OTHER UPLAND COMMUNITIES
6. OCCUPIED HABITAT OF SENSITIVE SPECIES AND ALL WETLANDS (AS BOTH ARE DEFINED BY THE LOCAL JURISDICTION)

4.3.3: Minimize impervious area

- ☐ Construct streets, sidewalks or parking lots aisles to the minimum widths necessary, provided public safety is not compromised
- ☐ Minimize the impervious footprint of the project

One of the principal causes of environmental impacts by development is the creation of impervious surfaces. Imperviousness links urban land development to degradation of aquatic ecosystems in two ways:

- First, the combination of paved surfaces and piped runoff efficiently collects urban pollutants and transports them, in suspended or dissolved form, to surface waters. These pollutants may originate as airborne dust, be washed from the atmosphere during rains, or may be generated by automobiles and outdoor work activities.

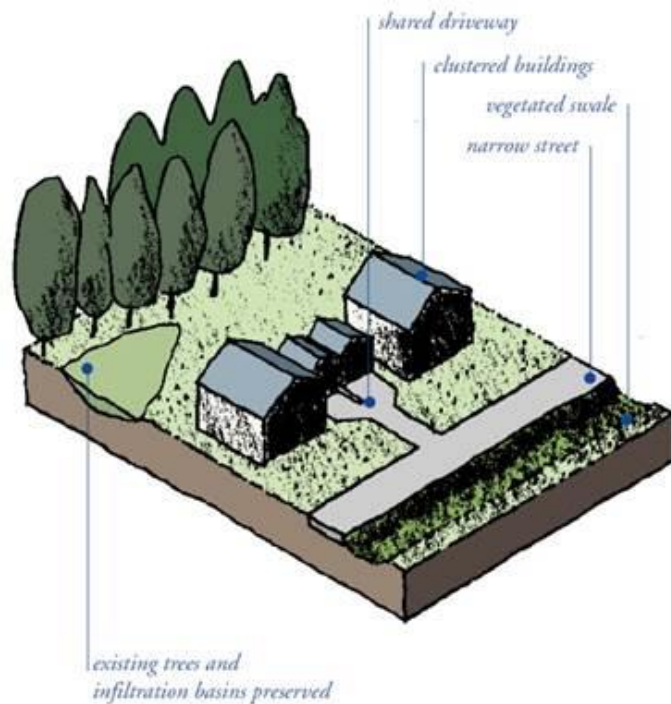
Chapter 4: Source Control and Site Design Requirements for All Development Projects

- Second, increased peak flows and runoff durations typically cause erosion of stream banks and beds, transport of fine sediments, and disruption of aquatic habitat. Measures taken to control stream erosion, such as hardening banks with riprap or concrete, may permanently eliminate habitat.

Impervious cover can be minimized through identification of the smallest possible land area that can be practically impacted or disturbed during site development. Reducing impervious surfaces retains the permeability of the project site, allowing natural processes to filter and reduce sources of pollution.

Projects can incorporate 4.3.3 by implementing the following planning and design phase techniques as applicable and practicable:

- Decrease building footprint through (the design of compact and taller structures when allowed by local zoning and design standards and provided public safety is not compromised).
- Construct walkways, trails, patios, overflow parking lots, alleys and other low-traffic areas with permeable surfaces.
- Construct streets, sidewalks and parking lot aisles to the minimum widths necessary, provided that public safety and alternative transportation (e.g. pedestrians, bikes) are not compromised.
- Consider the implementation of shared parking lots and driveways where possible.
- Landscaped area in the center of a cul-de-sac can reduce impervious area depending on configuration. Design of a landscaped cul-de-sac must be coordinated with fire department personnel to accommodate turning radii and other operational needs.
- Design smaller parking lots with fewer stalls, smaller stalls, more efficient lanes.
- Design indoor or underground parking.
- Minimize the use of impervious surfaces in the landscape design.



Source: County of San Diego LID Handbook

4.3.4: Minimize soil compaction

- Minimize soil compaction in landscaped areas

The upper soil layers contain organic material, soil biota, and a configuration favorable for storing and slowly conveying storm water down gradient. By protecting native soils and vegetation in appropriate

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areas during the clearing and grading phase of development the site can retain some of its existing beneficial hydrologic function. Soil compaction resulting from the movement of heavy construction equipment can reduce soil infiltration rates. It is important to recognize that areas adjacent to and under building foundations, roads and manufactured slopes must be compacted with minimum soil density requirements in compliance with local building and grading ordinances.

Projects can incorporate 4.3.4 by implementing the following planning and design phase techniques as applicable and practicable:

- Avoid disturbance in planned green space and proposed landscaped areas where feasible. These areas that are planned for retaining their beneficial hydrological function should be protected during the grading/construction phase so that vehicles and construction equipment do not intrude and inadvertently compact the area.
- In areas planned for landscaping where compaction could not be avoided, re-till the soil surface to allow for better infiltration capacity. Soil amendments are recommended and may be necessary to increase permeability and organic content. Soil stability, density requirements, and other geotechnical considerations associated with soil compaction must be reviewed by a qualified landscape architect or licensed geotechnical, civil or other professional engineer.

4.3.5: Disperse impervious areas

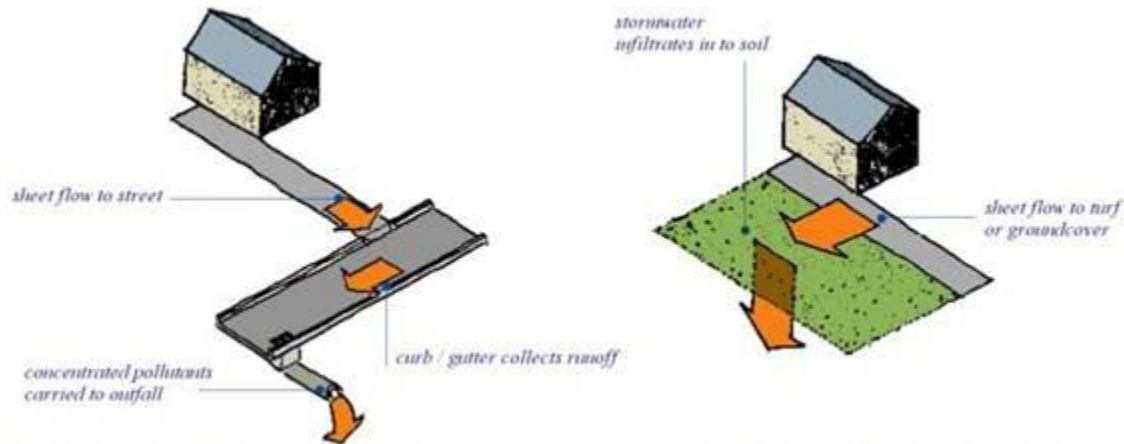
- ☐ Disconnect impervious surfaces through disturbed pervious areas
- ☐ Design and construct landscaped or other pervious areas to effectively receive and infiltrate, retain and/or treat runoff from impervious areas prior to discharging to the MS4

Impervious area dispersion (dispersion) refers to the practice of essentially disconnecting impervious areas from directly draining to the storm drain system by routing runoff from impervious areas such as rooftops, walkways, and driveways onto the surface of adjacent pervious areas. The intent is to slow runoff discharges, and reduce volumes while achieving incidental treatment. Volume reduction from dispersion is dependent on the infiltration characteristics of the pervious area and the amount of impervious area draining to the pervious area. Treatment is achieved through filtration, shallow sedimentation, sorption, infiltration, evapotranspiration, biochemical processes and plant uptake.

The effects of imperviousness can be mitigated by disconnecting impervious areas from the drainage system and by encouraging detention and retention of runoff near the point where it is generated. Detention and retention of runoff reduces peak flows and volumes and allows pollutants to settle out or adhere to soils before they can be transported downstream. Disconnection practices may be applied in almost any location, but impervious surfaces must discharge into a suitable receiving area for the practices to be effective. Information gathered during the site assessment will help determine appropriate receiving areas.

Project designs should direct runoff from impervious areas to adjacent landscaping areas that have higher potential for infiltration and surface water storage. This will limit the amount of runoff generated, and therefore the size of the mitigation BMPs downstream. The design, including consideration of slopes and soils, must reflect a reasonable expectation that runoff will soak into the soil and produce no runoff of the DCV. On hillside sites, drainage from upper areas may be collected in conventional catch basins and piped to landscaped areas that have higher potential for infiltration. Or use low retaining walls to create terraces that can accommodate BMPs.

Chapter 4: Source Control and Site Design Requirements for All Development Projects



Source: County of San Diego LID Handbook

Projects can incorporate 4.3.5 by implementing the following planning and design phase techniques as applicable and practicable:

- Implement design criteria and considerations listed in impervious area dispersion fact sheet (4.3.5) presented in Appendix E.
- Drain rooftops into adjacent landscape areas.
- Drain impervious parking lots, sidewalks, walkways, trails, and patios into adjacent landscape areas.
- Reduce or eliminate curb and gutters from roadway sections, thus allowing roadway runoff to drain to adjacent pervious areas.
- Replace curbs and gutters with roadside vegetated swales and direct runoff from the paved street or parking areas to adjacent LID facilities. Such an approach for alternative design can reduce the overall capital cost of the site development while improving the storm water quantity and quality issues and the site's aesthetics.
- Plan site layout and grading to allow for runoff from impervious surfaces to be directed into distributed permeable areas such as turf, landscaped or permeable recreational areas, medians, parking islands, planter boxes, etc.
- Detain and retain runoff throughout the site. On flatter sites, landscaped areas can be interspersed among the buildings and pavement areas. On hillside sites, drainage from upper areas may be collected in conventional catch basins and conveyed to landscaped areas in lower areas of the site.
- Pervious area that receives run on from impervious surfaces shall have a minimum width of 10 feet and a maximum slope of 5%.

SD-6: Collect runoff

- ☐ Use small collection strategies located at, or as close to as possible to the sources (i.e. the point where storm water initially meets the ground) to minimize the transport of runoff and pollutants to the MS4 and receiving waters

Chapter 4: Source Control and Site Design Requirements for All Development Projects

- Use permeable material for projects with low traffic areas and appropriate soil conditions

Distributed control of storm water runoff from the site can be accomplished by applying small collection techniques (e.g. green roofs) or integrated management practices on small sub-catchments. Small collection techniques foster opportunities to maintain the natural hydrology provide a much greater range of control practices. Integration of storm water management into landscape design and natural features of the site, reduce site development and long-term maintenance costs, and provide redundancy if one technique fails. On flatter sites, it typically works best to intersperse landscaped areas and integrate small scale retention practices among the buildings and paving.

Permeable pavements contain small voids that allow water to pass through to a gravel base. They come in a variety of forms; they may be a modular paving system (concrete pavers, grass-pave, or gravel-pave) or poured in place pavement (porous concrete, permeable asphalt). Project applicants should identify locations where permeable pavements could be substituted for impervious concrete or asphalt paving. The O&M of the site must ensure that permeable pavements will not be sealed in the future. In areas where infiltration is not appropriate, permeable paving systems can be fitted with an under drain to allow filtration, storage, and evaporation, prior to drainage into the storm drain system.

Projects can incorporate SD-6 by implementing the following planning and design phase techniques as applicable and practicable:

- Implementing distributed small collection techniques to collect and retain runoff
- Installing permeable pavements (see SD-6B in Appendix E)

SD-7: Landscape with native or drought tolerant species

All development projects are required to select a landscape design and plant palette that minimizes required resources (irrigation, fertilizers and pesticides) and pollutants generated from landscape areas. Native plants require less fertilizers and pesticides because they are already adapted to the rainfall patterns and soils conditions. Plants should be selected to be drought tolerant and not require watering after establishment (2 to 3 years). Watering should only be required during prolonged dry periods after plants are established. Final selection of plant material needs to be made by a landscape architect experienced with LID techniques. Microclimates vary significantly throughout the region and consulting local municipal resources will help to select plant material suitable for a specific geographic location. Landscaping shall be designed using Integrated Pest Management (IPM) practices.

Projects can incorporate SD-7 by landscaping with native and drought tolerant species. Recommended plant list is included in Appendix E (Fact Sheet PL).

SD-8: Harvest and use precipitation

Harvest and use BMPs capture and store storm water runoff for later use. Harvest and use can be applied at smaller scales (Standard Projects) using rain barrels or at larger scales (PDPs) using cisterns. This harvest and use technique has been successful in reducing runoff discharged to the storm drain system conserving potable water and recharging groundwater.

Rain barrels are above ground storage vessels that capture runoff from roof downspouts during rain events and detain that runoff for later reuse for irrigating landscaped areas. The temporary storage of roof runoff reduces the runoff volume from a property and may reduce the peak runoff velocity for small, frequently occurring storms. In addition, by reducing the amount of storm water runoff that flows overland into a storm water conveyance system (storm drain inlets and drain pipes), less pollutants are transported through the conveyance system into local creeks and the ocean. The reuse of the detained water for irrigation purposes leads to the conservation of potable water and the recharge of groundwater. SD-8 fact sheet in Appendix E provides additional detail for designing Harvest and Use BMPs. Projects can incorporate SD-8 by installing rain barrels or cisterns, as applicable.

Photograph Courtesy of Arid Solutions, Inc.



Storm Water Pollutant Control Requirements for PDPs

In addition to the site design and source control BMPs discussed in Chapter 4, PDPs are required to implement storm water pollutant control BMPs to reduce the quantity of pollutants in storm water discharges. Storm water pollutant control BMPs are engineered facilities that are designed to retain (i.e. intercept, store, infiltrate, evaporate and evapotranspire), biofilter and/or provide flow-thru treatment of storm water runoff generated on the project site.

This chapter describes the specific process for determining which category of pollutant control BMP, or combination of BMPs, is most appropriate for the PDP site and how to design the BMP to meet the storm water pollutant control performance standard (per Section 2.2).

This chapter by itself is not a complete design guide for project development. It is intended to provide guidance for selecting and designing storm water pollutant control BMPs. Specifically:

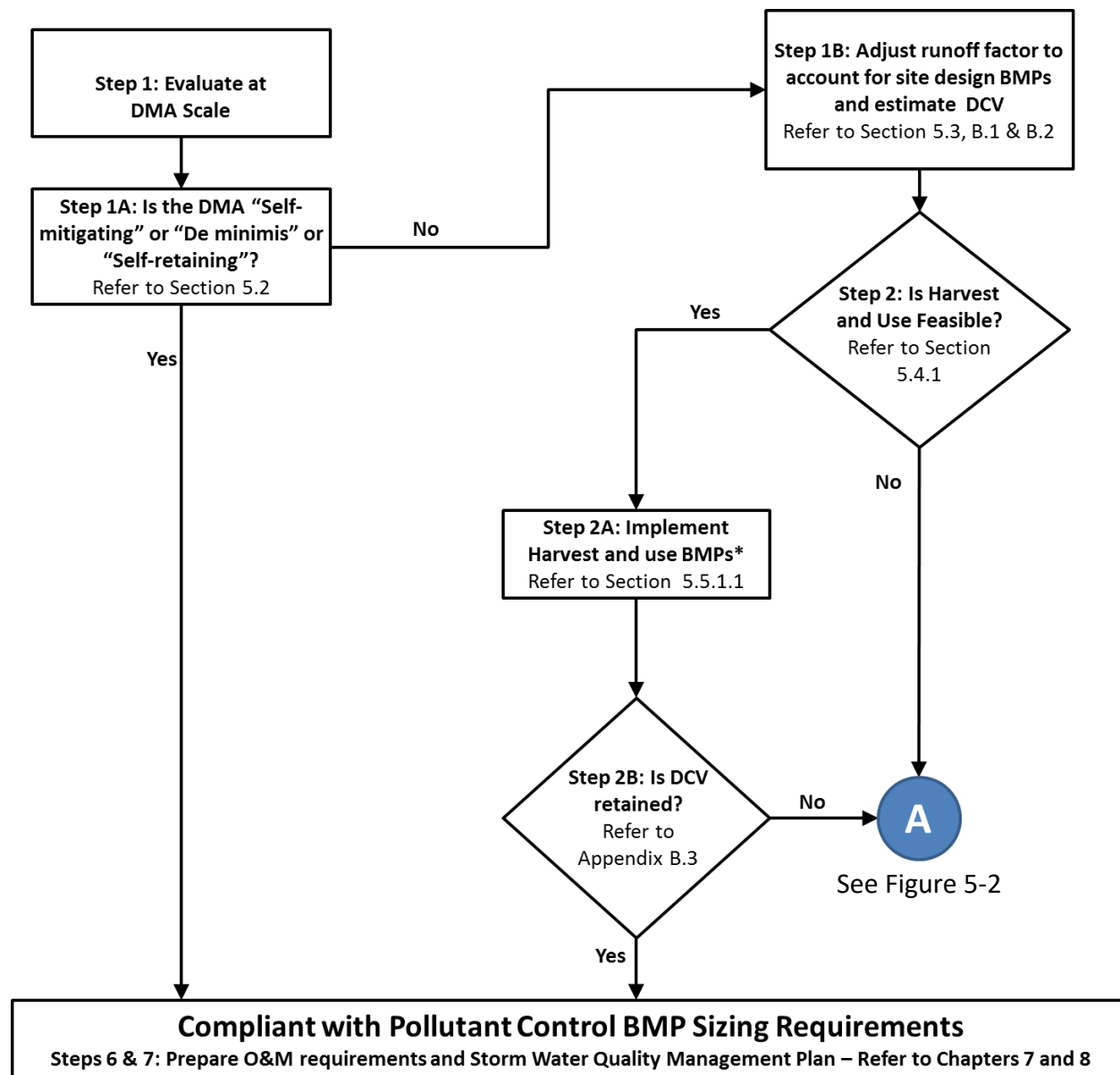
- This chapter should be followed after having conducted site planning that maximizes opportunities for storm water retention and biofiltration as discussed in Chapter 3.
- The steps in this chapter pertain specifically to storm water pollutant control BMPs. These criteria must be met regardless of whether or not hydromodification management applies, however the overall sequencing of project development may be different if hydromodification management applies. For guidance on how to integrate both hydromodification management and pollutant control BMPs (in cases where both requirements apply), see Sections 3.4.3, 5.6 and Chapter 6.

5.1 Steps for Selecting and Designing Storm Water Pollutant Control BMPs

Figures 5-1 and 5-2 present the flow chart for complying with storm water pollutant control BMP requirements. The steps associated with this flow chart are described below. A project is considered to be in compliance with storm water pollutant control performance standards if it follows and implements this flow chart and follows the supporting technical guidance referenced from this flow

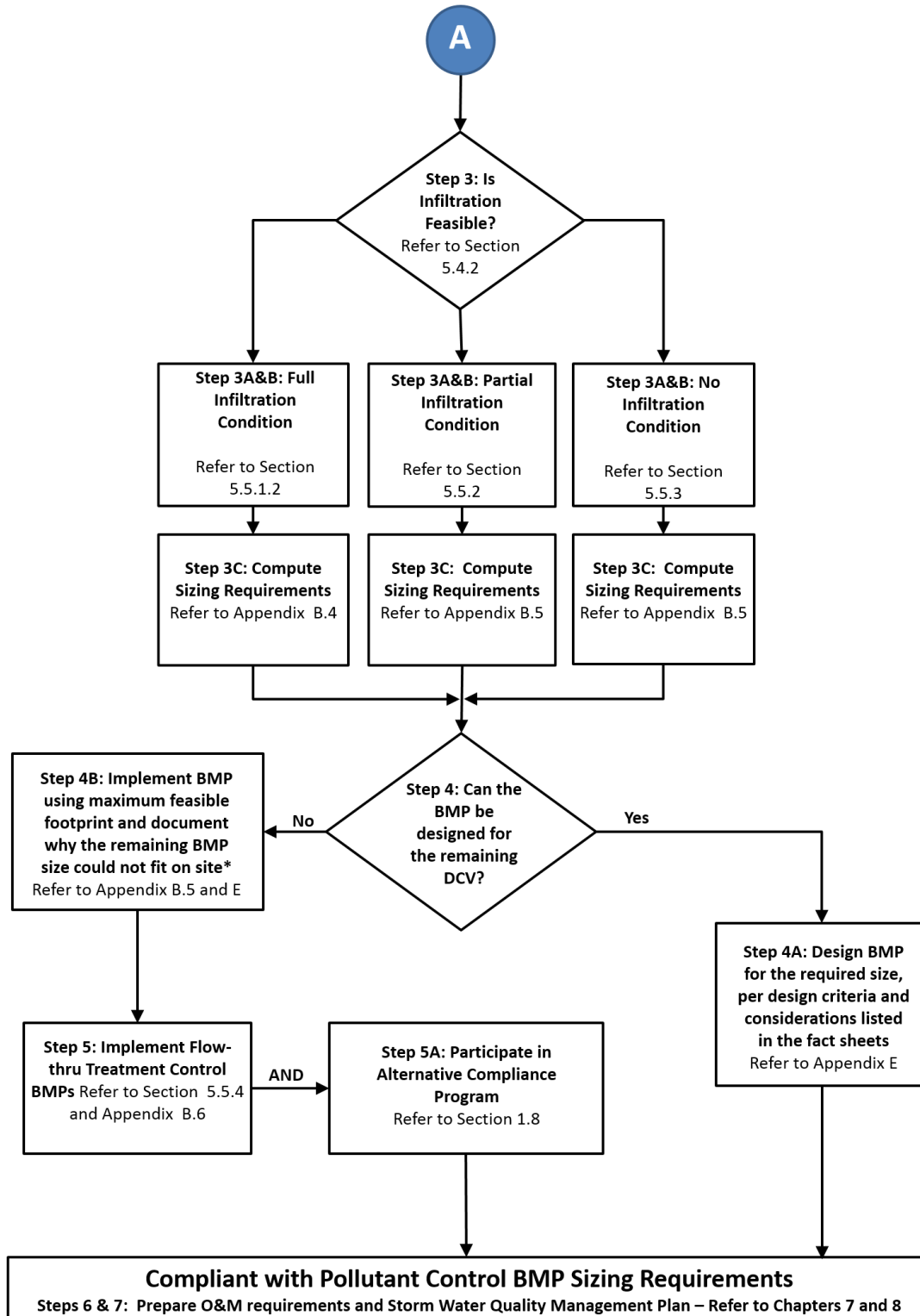
Chapter 5: Storm Water Pollutant Control Requirements for PDPs

chart. This section is applicable whether or not hydromodification management requirements apply, however the overall sequencing of project development may be different if hydromodification management requirements apply.



* Step 2C: Project applicant has an option to also conduct feasibility analysis for infiltration and if infiltration is fully or partially feasible has an option to choose between infiltration and harvest and use BMPs. But if infiltration is not feasible and harvest and use is feasible, project applicant must implement harvest and use BMPs

FIGURE 5-1. Storm Water Pollutant Control BMP Selection Flow Chart



* Project approval at the discretion of the Port

FIGURE 5-2. Storm Water Pollutant Control BMP Selection Flow Chart

Description of Steps:

- Step 1. Based on the locations for storm water pollutant control BMPs and the DMA delineations developed during the site planning phase (See Section 3.3.3), calculate the DCV.
 - A. Identify DMAs that meet the criteria in Section 5.2 (self-mitigating and/or de minimis areas and/or self-retaining via qualifying site design BMPs).
 - B. Estimate DCV for each remaining DMA. See Section 5.3.
- Step 2. Conduct feasibility screening analysis for harvest and use BMPs. See Section 5.4.1.
 - A. If it is feasible, implement harvest and use BMPs (See Section 5.5.1.1) or go to Step 3.
 - B. Evaluate if the DCV can be retained onsite using harvest and use BMPs. See Appendix B.3. If the DCV can be retained onsite then the pollutant control performance standards are met.
 - C. The applicant has an option to also conduct a feasibility analysis for infiltration and if infiltration is feasible has an option to choose between infiltration and harvest and use BMPs. But if infiltration is not feasible and harvest and use is feasible, the applicant must implement harvest and use BMPs.
- Step 3. Conduct feasibility analysis for infiltration for the BMP locations selected. See Section 5.4.2.
 - A. Determine the preliminary feasibility categories of BMP locations based on available site information. Determine the additional information needed to conclusively support findings. Use the "Categorization of Infiltration Feasibility Condition" checklist located in Appendix I-8 to conduct preliminary feasibility screening.
 - B. Select the storm water pollutant control BMP category based on preliminary feasibility condition.
 - i. Full Infiltration Condition— Implement infiltration BMP category, See Section 5.5.1.2
 - ii. Partial Infiltration Condition – Implement partial retention BMP category. See Section 5.5.2
 - iii. No Infiltration Condition – Implement biofiltration BMP category. See Section 5.5.3
 - C. After selecting BMPs, conduct design level feasibility analyses at BMP locations. The purpose of these analyses is to conform or adapt selected BMPs to maximize storm water retention and develop design parameters (e.g. infiltration rates, elevations). Document findings to substantiate BMP selection, feasibility, and design in the SWQMP. See Appendix C and D for additional guidance.
- Step 4. Evaluate if the required BMP footprint will fit considering the site design and constraints.
 - A. If the calculated footprint fits, then size and design the selected BMPs accordingly using design criteria and considerations from fact sheets presented in Appendix E. The project has met the pollutant control performance standards.

Chapter 5: Storm Water Pollutant Control Requirements for PDPs

- B. If the calculated BMP footprint does not fit, evaluate additional options to make space for BMPs. Examples include potential design revisions, reconfiguring DMAs, evaluating other or additional BMP locations and evaluating other BMP types. If no additional options are practicable for making adequate space for the BMPs, then document why the remaining DCV could not be treated onsite and then implement the BMP using the maximum feasible footprint, design criteria and considerations from fact sheets presented in Appendix E then continue to the next step. Project approval if the entire DCV could not be treated because the BMP size could not fit within the project footprint is at the discretion of the Port.
- Step 5. Implement flow-thru treatment control BMPs for the remaining DCV. See Section 5.5.4 and B.6 for additional guidance.
- A. When flow-thru treatment control BMPs are implemented the project applicant must also participate in an alternative compliance program. See Section 1.8.
- Step 6. Prepare a SWQMP documenting site planning and opportunity assessment activities, final site layout and storm water management design. See Chapter 8.
- Step 7. Identify and document O&M requirements and confirm acceptability to the responsible party. See Chapters 7 and Chapter 8.

5.2 DMAs Excluded from DCV Calculation

This manual provides project applicants the option to exclude DMAs from DCV calculations if they meet the criteria specified below. These DMAs must implement source control and site design BMPs from Chapter 4 as applicable and feasible. These exclusions will be evaluated on a case-by-case basis and approvals of these exclusions are at the discretion of the Port.

5.2.1 Self-mitigating DMAs

Self-mitigating DMAs consist of natural or landscaped areas that drain directly offsite or to the public storm drain system. Self-mitigating DMAs must meet **ALL** the following characteristics to be eligible for exclusion:

- Vegetation in the natural or landscaped area is native and/or non-native/non-invasive drought tolerant species that do not require regular application of fertilizers and pesticides.
- Soils are undisturbed native topsoil, or disturbed soils that have been amended and aerated to promote water retention characteristics equivalent to undisturbed native topsoil.
- The incidental impervious areas are less than 5 percent of the self-mitigating area.
- Impervious area within the self-mitigated area should not be hydraulically connected to other impervious areas unless it is a storm water conveyance system (such as brow ditches).
- The self-mitigating area is hydraulically separate from DMAs that contain permanent storm water pollutant control BMPs.

Figure 5.3 illustrates the concept of self-mitigating DMAs.

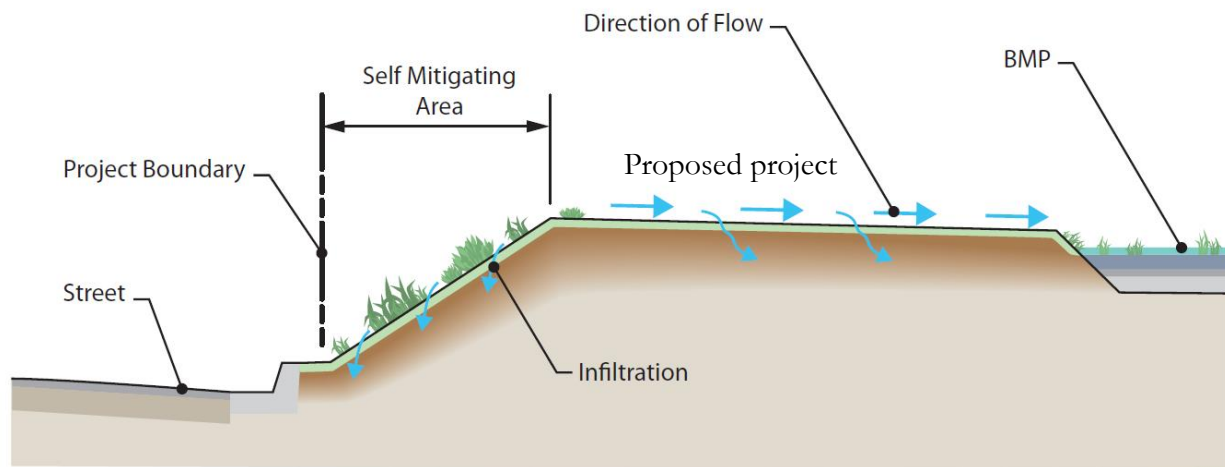


FIGURE 5-3. Self Mitigating Area

5.2.2 De Minimis DMAs

De minimis DMAs consist of areas that are very small, and therefore are not considered to be significant contributors of pollutants, and are considered by the tenant/project proponent and the Port not practicable to drain to a BMP. It is anticipated that only a small subset of projects will qualify for de minimis DMA exclusion. Examples include driveway aprons connecting to existing streets, portions of sidewalks, retaining walls at the external boundaries of a project, and similar features. De minimis DMAs must include **ALL** of the following characteristics to be eligible for exclusion:

- Areas abut the perimeter of the development site.
- Topography and land ownership constraints make BMP construction to reasonably capture runoff technically infeasible.
- The portion of the site falling into this category is minimized through effective site design
- Each DMA should be less than 250 square feet and the sum of all de minimis DMAs should represent less than 2 percent of the total added or replaced impervious surface of the project. Except for projects where 2 percent of the total added or replaced impervious surface of the project is less than 250 square feet, a de minimis DMA of 250 square feet or less is allowed.
- Two de minimis DMAs cannot be adjacent to each other and hydraulically connected.
- The SWQMP must document the reason that each de minimis area could not be addressed otherwise.

5.2.3 Self-retaining DMAs via Qualifying Site Design BMPs

Self-retaining DMAs are areas that are designed with site design BMPs to retain runoff to a level equivalent to pervious land. BMP Fact Sheets for impervious area dispersion (SD-5 in Appendix E) and permeable pavement (SD-6B in Appendix E) describe the design criteria by which BMPs can be considered self-retaining. DMAs that are categorized as self-retaining DMAs are considered to **only** meet the storm water pollutant control obligations.

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Requirements for utilizing this category of DMA:

- Site design BMPs such as impervious area dispersion and permeable pavement may be used individually or in combination to reduce or eliminate runoff from a portion of a PDP.
- If a site design BMP is used to create a self-retaining DMA, then the site design BMPs must be designed and implemented per the criteria in the applicable fact sheet. These criteria are conservatively developed to anticipate potential changes in DMA characteristics with time. The fact sheet criteria for impervious area dispersion and permeable pavement for meeting pollutant control requirement developed using continuous simulation are summarized below:
 - SD-5 Impervious Area Dispersion: a DMA is considered self-retaining if the impervious to pervious ratio is:
 - 2:1 when the pervious area is composed of Hydrologic Soil Group A
 - 1:1 when the pervious area is composed of Hydrologic Soil Group B
 - SD-6B Self-retaining permeable pavement: a DMA is considered self-retaining if the ratio of total drainage area (including permeable pavement) to area of permeable pavement of 1.5:1 or less.
 - Note: Left side of ratios presented above represents the portion of the site that receives volume reduction and the right side of the ratio represents the site design BMP that promotes the achieved volume reduction.
- Site design BMPs used as part of a self-retaining DMA or as part of reducing runoff coefficients from a DMA must be clearly called out on project plans and in the SWQMP.
- The Port may accept or reject a proposed self-retaining DMA meeting these criteria at its discretion. Examples of rationale for rejection may include the potential for negative impacts (such as infiltration or vector issues), potential for significant future alteration of this feature, inability to visually inspect and confirm the feature, etc.
- PDPs subject to hydromodification requirements should note that Self-retaining DMAs must be included in hydromodification analysis. Reductions in DCV realized through Site Design BMPs are applicable to treatment control only and do not relax hydromodification requirements.

Other site design BMPs can be considered self-retaining for meeting storm water pollutant control obligations if the long term annual runoff volume (estimated using continuous simulation following guidelines listed in Appendix G) from the DMA is reduced to a level equivalent to pervious land and the applicant provides supporting analysis and rationale for the reduction in long term runoff volume. Approval of other self-retaining areas is at the discretion of the Port. Figure 5.4 illustrates the concept of self-retaining DMAs.

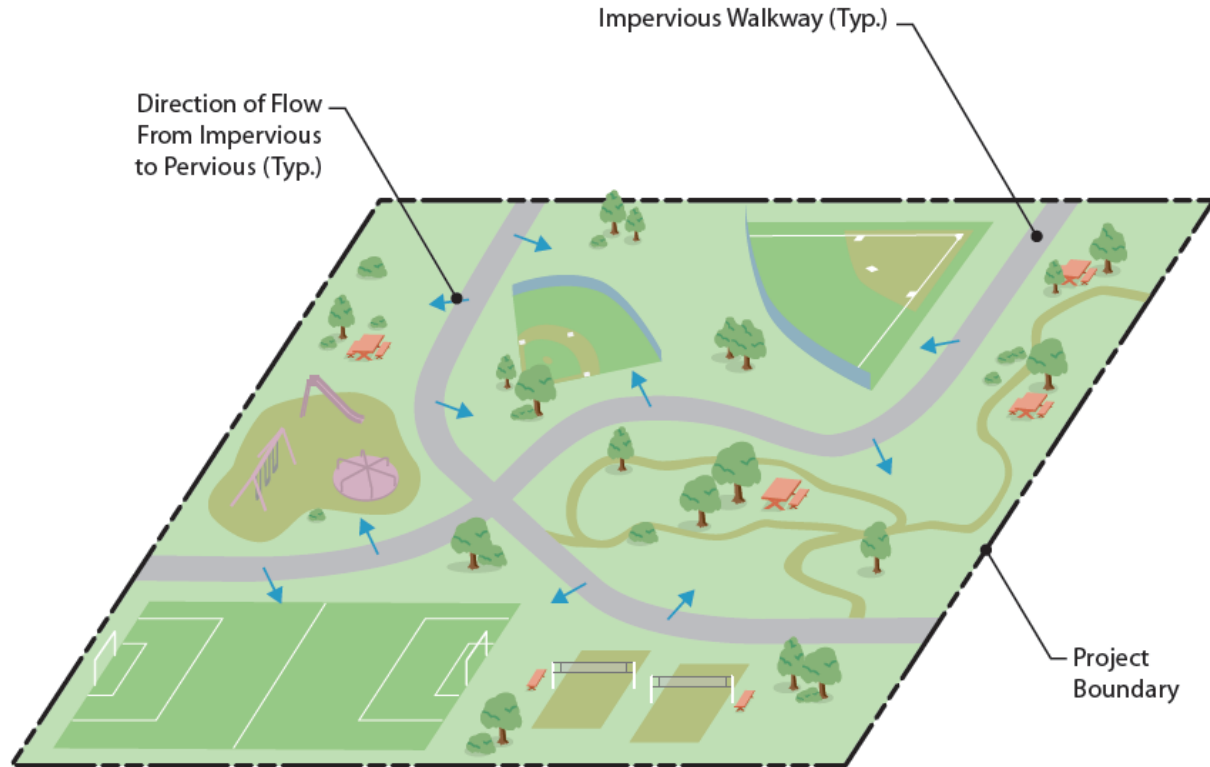


FIGURE 5-4. Self-retaining Site

5.3 DCV Reduction through Site Design BMPs

Site design BMPs as discussed in Chapter 4 reduce the rate and volume of storm water runoff from the project site. This manual provides adjustments to runoff factors for the following site design BMPs that may be incorporated into the project as part of an effective site design so that the downstream structural BMPs can be sized appropriately:

- SD-1 Street trees
- SD-5 Impervious area dispersion
- SD-6A Green roofs
- SD-6B Permeable pavement
- SD-8 Rain barrels

Methods for adjusting runoff factors for the above listed site design BMPs are presented in Appendix B.2. Site design BMPs used for reducing runoff coefficients from a DMA must be clearly called out on project plans and in the SWQMP. Approval of the claimed reduction of runoff factors is at the discretion of the Port.

5.4 Evaluating Feasibility of Storm Water Pollutant Control BMP Options

This section provides the fundamental process to establish which category, or combination of categories, of pollutant control BMP is feasible and to determine the volume of onsite retention that is feasible, either through harvest and use, or infiltration of the DCV. The feasibility screening process presented below establishes the volume of retention that can be achieved to fully or partially meet the pollutant control performance standards.

5.4.1 Feasibility Screening for Harvest and Use Category BMPs

Harvest and use is a BMP that captures and stores storm water runoff for later use. The primary question to be evaluated is:

- Is there a demand for harvested water within the project or project vicinity that can be met or partially met with rainwater harvesting in a practical manner?

Appendix B.3 provides guidance for determining the feasibility for using harvested storm water based on onsite demand. Step 2 from Section 5.1 describes how the feasibility results need to be considered in the pollutant control BMP selection process.

5.4.2 Feasibility Screening for Infiltration Category BMPs

After accounting for any potential onsite use of storm water, the next step is to evaluate how much storm water can be retained onsite primarily through infiltration of the DCV. Infiltration of storm water is dependent on many important factors that must be evaluated as part of infiltration feasibility screening. The key questions to determining the degree of infiltration that can be accomplished onsite are:

- Is infiltration potentially feasible and desirable?
- If so, what quantity of infiltration is potentially feasible and desirable?

These questions must be addressed in a systematic fashion to determine if full infiltration of the DCV is potentially feasible. If when answering these questions it is determined that full infiltration is not feasible, then the portion of the DCV that could be infiltrated must be quantified, or a determination that infiltration in any appreciable quantity is infeasible or must be avoided. **This process is illustrated in Figure 5-5.** As a result of this process, conditions can be characterized as one of the three categories listed and defined below.

- **Full Infiltration Condition:** Infiltration of the full DCV is potentially feasible and desirable. More rigorous design-level analyses should be used to confirm this classification and establish specific design parameters such as infiltration rate and factor of safety. BMPs in this category may include bioretention and infiltration basins. See Section 5.5.1.2.
- **Partial Infiltration Condition:** Infiltration of a significant portion of the DCV may be possible, but site factors may indicate that infiltration of the full DCV is either infeasible or not desirable. Select BMPs that provide opportunity for partial infiltration, e.g. biofiltration with partial retention. See Section 5.5.2.

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- **No Infiltration Condition:** Infiltration of any appreciable volume should be avoided. Some incidental volume losses may still be possible, but any appreciable quantity of infiltration would introduce undesirable conditions. Other pollutant control BMPs should be considered e.g. biofiltration or flow-thru treatment control BMPs and participation in alternative compliance (Section 1.8) for the portion of the DCV that is not retained or biofiltered onsite. See Section 5.5.3 and 5.5.4.

The "Categorization of Infiltration Feasibility Condition" checklist located in Appendix I must be used to document the findings of the infiltration feasibility assessment and must be supported by all associated information used in the feasibility findings. Appendix C and D in this manual provides additional guidance and criteria for performing feasibility analysis for infiltration. All PDPs are required to complete this worksheet. At the site planning phase, this worksheet can help guide the design process by influencing project layout and selection of infiltration BMPs, and identifying whether more detailed studies are needed. At the design and final report submittal phase, planning level categorizations related to infiltration must be confirmed or revised and rigorously documented and supported based on design-level investigations and analyses, as needed. A Geological Investigation Report must be prepared for all PDPs implementing onsite structural BMPs. This report should be attached to the SWQMP. Geotechnical and groundwater investigation report requirements are listed in Appendix C.

Chapter 5: Storm Water Pollutant Control Requirements for PDPs

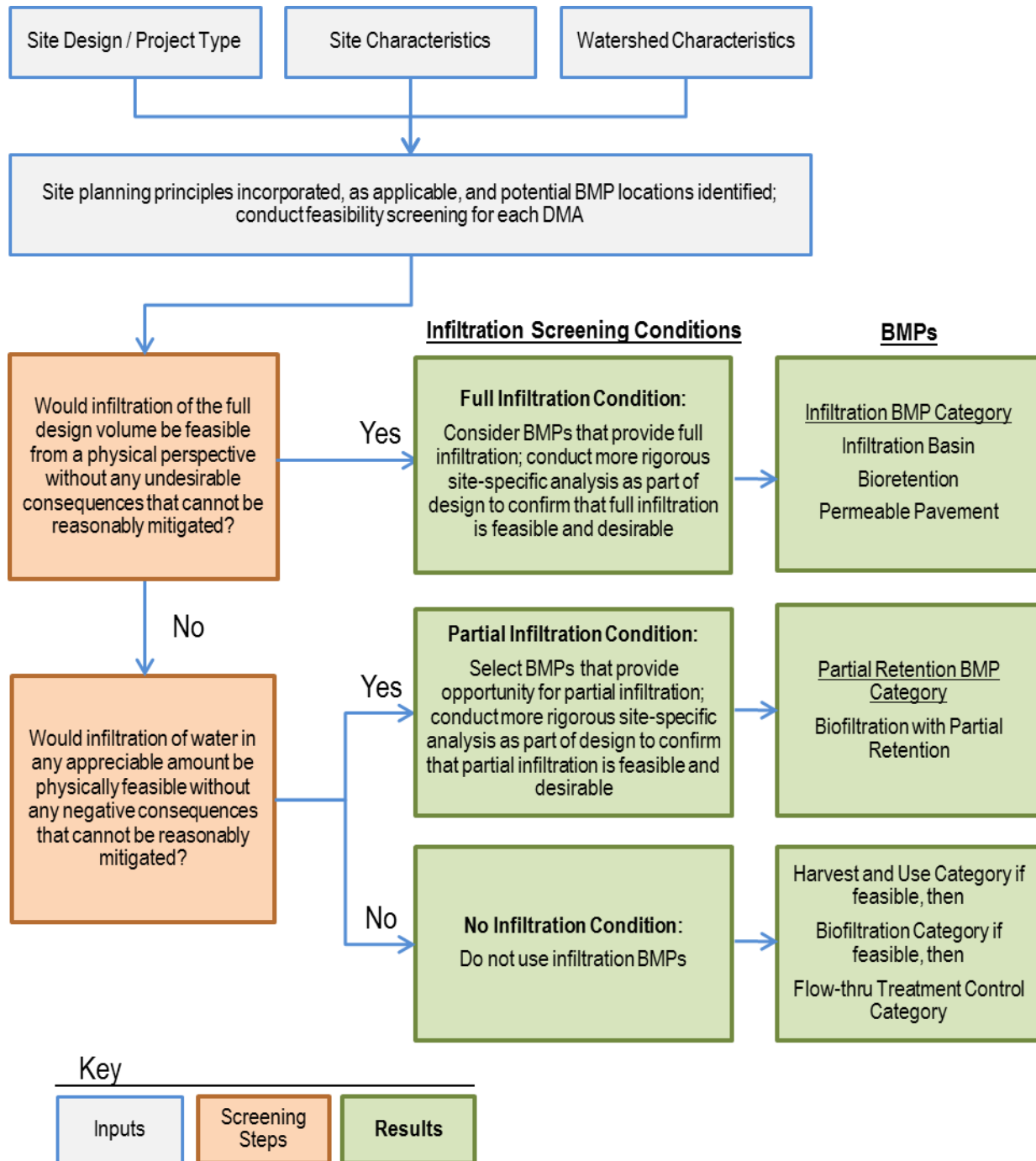


FIGURE 5-5. Infiltration Feasibility and Desirability Screening Flow Chart

5.5 BMP Selection and Design

BMP selection shall be based on steps listed in Section 5.1 and the feasibility screening process described in Section 5.4. When selecting BMPs designated for placement within public agency land, such as easements or rights-of-way, it is important to contact that public agency to inquire about additional design requirements that must be met. Selected BMPs must be designed based on accepted design standards. The BMP designs described in the BMP Fact Sheets (Appendix E) shall constitute the allowable storm water pollutant control BMPs for the purpose of meeting storm water management requirements. Other BMP types and variations on these designs may be approved at the discretion of the Port if documentation is provided demonstrating that the BMP is functionally equivalent or better than those described in this manual.

This section provides an introduction to each category of BMP and provides links to fact sheets that contain recommended criteria for the design and implementation of BMPs. Table 5-1 maps the BMP category to the fact sheets provided in Appendix E. Criteria specifically described in these fact sheets override guidance contained in outside referenced source documents. Where criteria are not specified, the applicant and the project review staff should use best professional judgment based on the recommendations of the referenced guidance material or other published and generally accepted sources. When an outside source is used, the preparer must document the source in the SWQMP.

TABLE 5-1. Permanent Structural BMPs for PDPs

MS4 Permit Category	Manual Category	BMPs
Retention	Harvest and Use (HU)	HU-1: Cistern
Retention	Infiltration (INF)	INF-1: Infiltration basin INF-2: Bioretention INF-3: Permeable pavement
NA	Partial Retention (PR)	PR-1: Biofiltration with partial retention
Biofiltration	Biofiltration (BF)	BF-1: Biofiltration BF-2: Nutrient Sensitive Media Design BF-3: Proprietary Biofiltration
Flow-thru treatment control	Flow-thru treatment control with Alternative Compliance (FT)	FT-1: Vegetated swales FT-2: Media filters FT-3: Sand filters FT-4: Dry extended detention basins FT-5: Proprietary flow-thru treatment control

5.5.1 Retention Category

5.5.1.1 Harvest and Use BMP Category

Harvest and use (typically referred to as rainwater harvesting) BMPs capture and store storm water runoff for later use. These BMPs are engineered to store a specified volume of water and have no design surface discharge until this volume is exceeded. Uses of captured water shall not result in runoff to storm drains or receiving waters. Potential uses of captured water may include irrigation demand, indoor non-potable demand, industrial process water demand, or other demands.

Selection: Harvest and use BMPs shall be selected after performing a feasibility analysis per Section 5.4.1. Based on findings from Section 5.4 if both harvest and use and full infiltration of the DCV is feasible onsite the project applicant has an option to implement either harvest and use BMPs and/or infiltration BMPs to meet the storm water requirements.

Design: A worksheet for sizing harvest and use BMPs is presented in Appendix B.3 and the fact sheet for sizing and designing the harvest and use BMP is presented in Appendix E. Figure 5-6 shows a schematic of a harvest and use BMP.

BMP option under this category:

- HU-1: Cistern

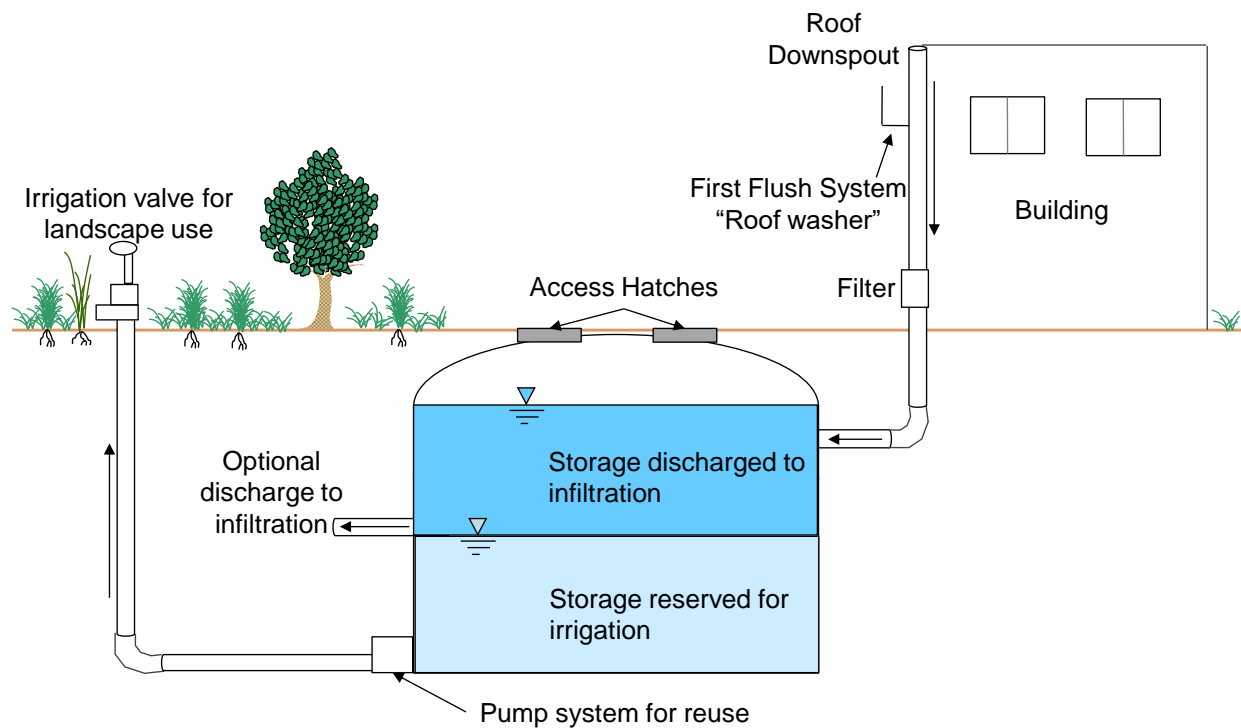


FIGURE 5-6. Schematic of a Typical Cistern

5.5.1.2 Infiltration BMP Category

Infiltration BMPs are structural measures that capture, store and infiltrate storm water runoff. These BMPs are engineered to store a specified volume of water and have no design surface discharge (underdrain or outlet structure) until this volume is exceeded. These types of BMPs may also support evapotranspiration processes but are characterized by having their most dominant volume losses due to infiltration. Pollution prevention and source control BMPs shall be implemented at a level appropriate to protect groundwater quality for areas draining to infiltration BMPs and runoff must undergo pretreatment such as sedimentation or filtration prior to infiltration.

Selection: Selection of this BMP category shall be based on analysis according to Sections 5.1 and 5.4.2. Dry wells are considered Class V injection wells and are subject to underground injection control (UIC) regulations. Dry wells are only allowed when registered with the US EPA.

Design: Appendix B.4 has a worksheet for sizing infiltration BMPs, Appendix D has guidance for estimating infiltration rates for use in design the BMP and Appendix E provides fact sheets to design the infiltration BMPs. Appendices B.6.2.1, B.6.2.2 and D.5.3 have guidance for selecting appropriate pretreatment for infiltration BMPs. Figure 5-7 shows a schematic of an infiltration basin.

BMP options under this category:

- INF-1: Infiltration basins
- INF-2: Bioretention
- INF-3: Permeable pavement
- Dry Wells

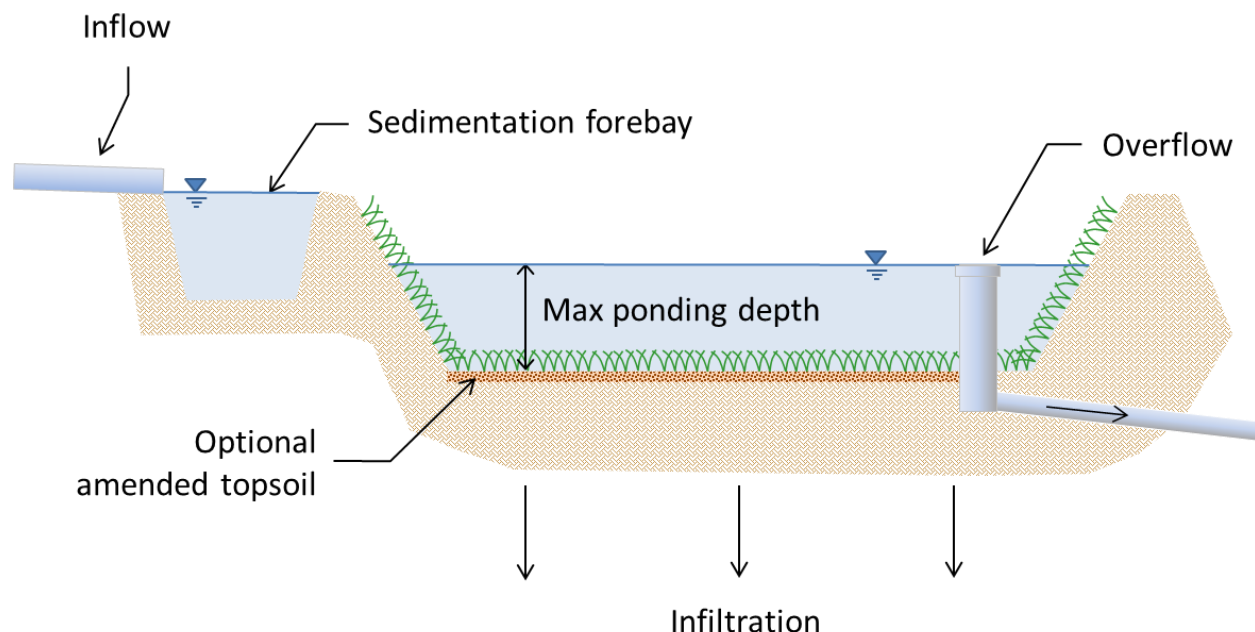


FIGURE 5-7. Schematic of a Typical Infiltration Basin

5.5.2 Partial Retention BMP Category

Partial retention category is defined by structural measures that incorporate both infiltration (in the lower treatment zone) and biofiltration (in the upper treatment zone). Example includes biofiltration with partial retention BMP.

5.5.2.1 Biofiltration with Partial Retention BMP

Biofiltration with partial retention BMPs are shallow basins filled with treatment media and drainage rock that manage storm water runoff through infiltration, evapotranspiration, and biofiltration. These BMPs are characterized by a subsurface stone infiltration storage zone in the bottom of the BMP below the elevation of the discharge from the underdrains. The discharge of biofiltered water from the underdrain occurs when the water level in the infiltration storage zone exceeds the elevation of the underdrain outlet. The storage volume can be controlled by the elevation of the underdrain outlet (shown in Figure 5-8), or other configurations. Other typical biofiltration with partial retention components include a media layer and associated filtration rates, drainage layer with associated in-situ soil infiltration rates, and vegetation.

Selection: Biofiltration with partial retention BMP shall be selected if the project site feasibility analysis performed according to Section 5.4.2 determines a partial infiltration feasibility condition.

Design: Appendix B.5 provides guidance for sizing biofiltration with partial retention BMP and Appendix E provides a fact sheet to design biofiltration with partial retention BMP.

BMP option under this category:

- PR-1: Biofiltration with partial retention

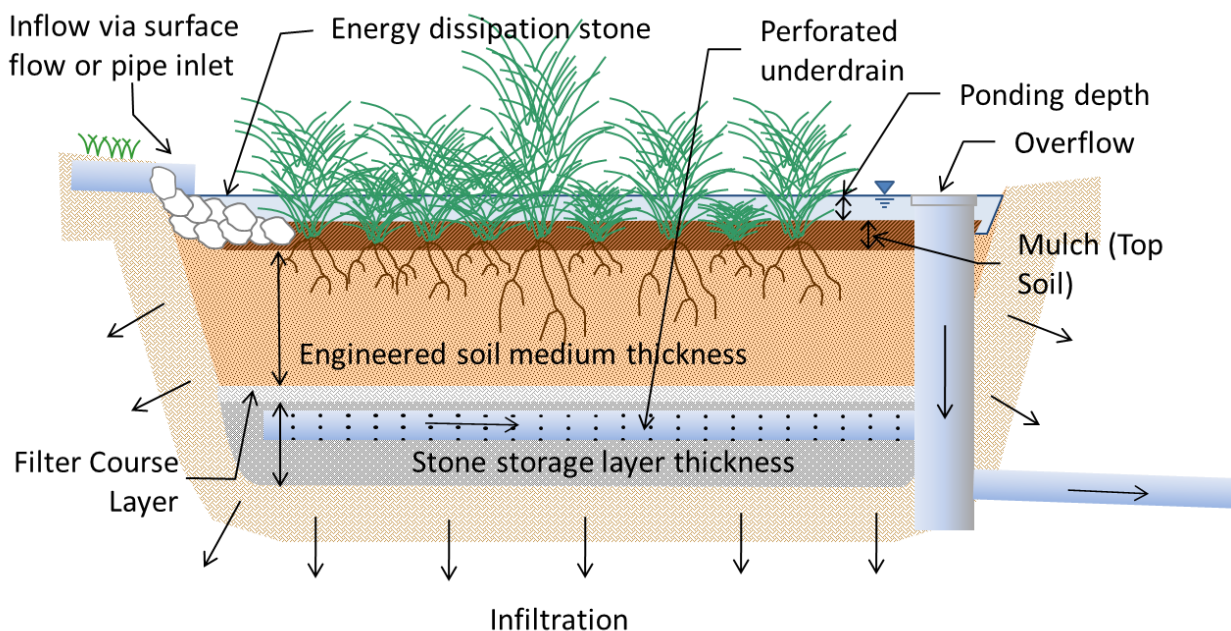


FIGURE 5-8. Schematic of a Typical Biofiltration with Partial Retention BMP

5.5.3 Biofiltration BMP Category

Biofiltration BMPs are shallow basins filled with treatment media and drainage rock that treat storm water runoff by capturing and detaining inflows prior to controlled release through minimal incidental infiltration, evapotranspiration, or discharge via underdrain or surface outlet structure. Treatment is achieved through filtration, sedimentation, sorption, biochemical processes and/or vegetative uptake. Biofiltration BMPs can be designed with or without vegetation, provided that biological treatment processes are present throughout the life of the BMP via maintenance of plants, media base flow, or other biota-supporting elements. By default, BMP BF-1 shall include vegetation unless it is demonstrated, to the satisfaction of the Port, that effective biological treatment process will be maintained without vegetation. Typical biofiltration components include a media layer with associated filtration rates, drainage layer with associated in-situ soil infiltration rates, underdrain, inflow and outflow control structures, and vegetation, with an optional impermeable liner installed on an as needed basis due to site constraints.

Selection: Biofiltration BMPs shall be selected if the project site feasibility analysis performed according to Section 5.4.2 determines a No Infiltration Feasibility Condition.

Design: Appendix B.5 has a worksheet for sizing biofiltration BMPs and Appendix E provides fact sheets to design the biofiltration BMP. Figure 5-9 shows the schematic of a biofiltration Basin.

BMP option under this category:

- BF-1: Biofiltration
- BF-2: Nutrient Sensitive Media Design
- BF-3: Proprietary Biofiltration

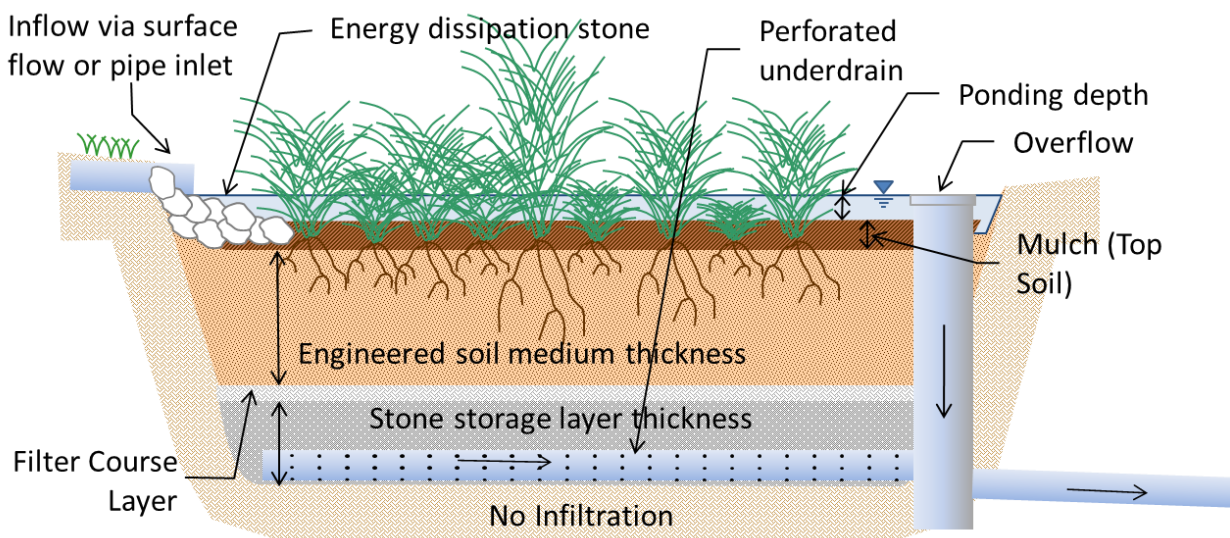


FIGURE 5-9. Schematic of a Typical Biofiltration Basin

5.5.4 Alternative Biofiltration Options:

Other BMPs, including proprietary BMPs (See fact sheet BF-3) may be classified as biofiltration BMPs if they qualify as approved equivalent compact proprietary biofiltration systems under the following

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criteria: (1) meet the minimum design criteria listed in Appendix F, including the pollutant treatment performance standard in Appendix F.1, (2) are designed and maintained in a manner consistent with their performance certifications, if applicable, (3) the overall design incorporates sufficient volume reduction to meet equivalent targets and (4) are acceptable at the discretion of the Port. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. In determining the acceptability of an alternative biofiltration BMP, Port staff should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by Port staff, a written explanation/reason will be provided to the applicant.

5.5.5 Flow-thru Treatment Control BMPs (for use with Alternative Compliance) Category

Flow-thru treatment control BMPs are structural, engineered facilities that are designed to remove pollutants from storm water runoff using treatment processes that do not incorporate significant biological methods.

Selection: Flow-thru treatment control BMPs shall be selected based on the criteria in Appendix B.6. Flow-thru treatment control BMPs may only be implemented to satisfy PDP structural BMP performance requirements if an appropriate offsite alternative compliance project is also constructed to mitigate for the pollutant load in the portion of the DCV not retained onsite. The alternative compliance program is an optional element that may be developed by each jurisdiction (See Section 1.8).

Design: Appendix B.6 provides the methodology, required tables and worksheet for sizing flow-thru treatment control BMPs and Appendix E provides fact sheets to design the following flow-thru treatment control BMPs. Figure 5-10 shows a schematic of a Vegetated Swale as an example of a flow-thru treatment control BMP.

BMP options under this category:

- FT-1: Vegetated swales
- FT-2: Media filters
- FT-3: Sand filters
- FT-4: Dry extended detention basin
- FT-5: Proprietary flow-thru treatment control

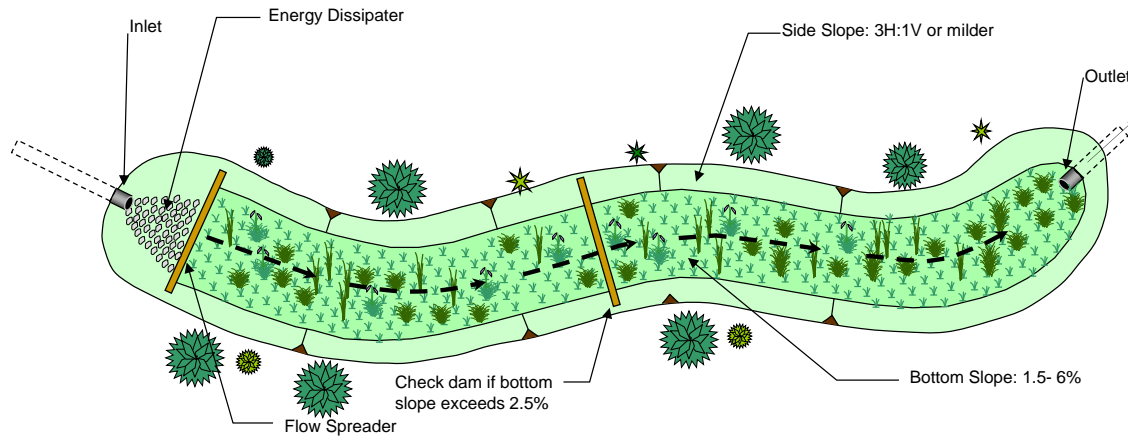


FIGURE 5-10. Schematic of a Vegetated Swale

Use of Proprietary BMP Options: A proprietary BMP (see fact sheet FT-5) can be classified as a flow-thru treatment control BMP if (1) it is demonstrated to meet the flow-thru treatment performance criteria in Appendix B.6, (2) is designed and maintained in a manner consistently with its applicable performance certifications, and (3) is acceptable at the discretion of the Port. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to justify the use of a proprietary flow-thru treatment control BMP. In determining the acceptability of an proprietary flow-thru treatment control BMP, Port staff should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by Port staff, a written explanation/reason will be provided to the applicant.

5.5.6 Alternate BMPs

New and proprietary BMP technologies may be available that meet the performance standards in Chapter 2 but are not discussed in this manual. Use of these alternate BMPs to comply with permit obligations is at the discretion of the Port. Alternate BMPs must meet the standards for biofiltration BMPs or flow-thru BMPs (depending on how they are used), as described in Appendix F and Appendix B.6, respectively.

5.6 Documenting Storm Water Pollutant Control BMP Compliance when Hydromodification Management Applies

The steps and guidance presented in Chapter 5 apply to all PDPs for demonstrating conformance to storm water pollutant control requirements regardless of whether hydromodification management applies. However, when hydromodification management applies, the approach for project design may be different. The following process can be used to document compliance with storm water pollutant

Chapter 5: Storm Water Pollutant Control Requirements for PDPs

control BMPs in cases when hydromodification management also applies:

1. Develop a combined BMP or treatment train (BMPs constructed in series) based on both storm water pollutant control and hydromodification management requirements. Appendix E provides specific examples of how storm water pollutant control BMPs can be configured to also address hydromodification management.
2. Dedicate a portion of the combined BMP or treatment train as the portion that is intended to comply with storm water pollutant control requirements.
3. Follow all of the steps in this chapter related to demonstrating that the dedicated portion of the BMP or treatment train meets the applicable storm water pollutant control criteria.
4. Check BMP design criteria in Appendix E and F to ensure that the hydromodification management design features (additional footprint, additional depth, modified outlet structure, lower discharge rates, etc.) do not compromise the treatment function of the BMP.
5. On project plans and in the O&M manual, clearly denote the portion of the BMP that serves the storm water pollutant control function.

Alternative approaches that meet both the storm water pollutant control and hydromodification management requirements may be acceptable at the discretion of the Port and shall be documented in the SWQMP. Also refer to Section 6.3.6 for additional guidance.

Hydromodification Management Requirements for PDPs

The purpose of hydromodification management requirements for PDPs is to minimize the potential of storm water discharges from the MS4 from causing altered flow regimes and excessive downstream erosion in receiving waters. Hydromodification management implementation for PDPs includes two components: protection of critical coarse sediment yield areas and flow control for post-project runoff from the project site. For PDPs subject to hydromodification management requirements, this Chapter provides guidance to meet the performance standards for the two components of hydromodification management.

The civil engineer preparing the hydromodification management study for a project will find within this Chapter and Appendix G of this manual, along with watershed-specific information in the WMAA, all necessary information to meet the MS4 Permit standards. Should unique project circumstances require an understanding beyond what is provided in this manual, then consult the March 2011 Final HMP, which documents the historical development of the hydromodification management requirements.

Guidance for flow control of post-project runoff is based on the March 2011 Final HMP, with modifications in this manual based on updated requirements in the MS4 Permit. The March 2011 Final HMP was prepared based on the 2007 MS4 Permit, not the MS4 Permit that drives this manual. In instances where there are changes to hydromodification management criteria or procedures based on the MS4 Permit, the criteria and procedures presented in this manual supersede the March 2011 Final HMP.

Protection of critical coarse sediment yield areas is a new requirement of the MS4 Permit and is not covered in the March 2011 Final HMP. The standards and management practices for protection of critical coarse sediment yield areas are presented here in the manual.

6.1 Hydromodification Management Applicability and Exemptions

As noted in Chapter 1, Section 1.6 a project may be exempt from hydromodification

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management requirements if it meets any one of the following conditions:

- The project is not a PDP;
- The proposed project will discharge runoff directly to existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;
- The proposed project will discharge runoff directly to conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean; or
- The proposed project will discharge runoff directly to an area identified by the Copermittees as appropriate for an exemption by the WMAA for the watershed in which the project resides.

The above criteria reflects the latest list of exemptions that are allowed under the MS4 Permit and therefore supersedes criteria found in earlier publications.

Applicants electing to perform an exemption analysis to exempt a project from hydromodification management requirements shall use the methodology for hydromodification management exemption presented in Attachment E of the Regional Watershed Management Area Analysis. However, any future proposed hydromodification management exemptions would need to be approved by the RWQCB through the WQIP Annual Update process (Regional MS4 Permit Section F.1.2.c.) prior to the project being exempt from hydromodification management exemptions.

Most areas within the Port are exempt from hydromodification with the exception of areas draining to San Diego Bay National Wildlife Refuge, areas that drain to undeveloped land, or areas that drain first to other receiving waters.

6.2 Protection of Critical Coarse Sediment Yield Areas

Potential critical coarse sediment yield areas for each watershed management area are delineated in the WMAA. No potential critical coarse sediment yield areas were identified within the Port jurisdiction.

6.3 Flow Control for Hydromodification Management

PDPs subject to hydromodification management requirements must provide flow control for post-project runoff to meet the flow control performance standard.

This is typically accomplished using structural BMPs that may include any combination of infiltration basins; bioretention, biofiltration with partial retention, or biofiltration basins; or detention basins. This Section will discuss design of flow control measures for hydromodification management. This Section is intended to be used following the source control and site design processes described in Chapter 4 and the storm water pollutant control design process described in Chapter 5.

The flow control performance standard is as follows:

- 1 For flow rates ranging from 10 percent, 30 percent or 50 percent of the pre-development 2-year runoff event ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) to the pre-development 10-year runoff event (Q_{10}), the post-project discharge rates and durations must not exceed

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the pre-development rates and durations by more than 10 percent. The specific lower flow threshold will depend on the erosion susceptibility of the receiving stream for the project site (see Section 6.3.4).

In this context, Q_2 and Q_{10} refer to flow rates determined based on either continuous simulation hydrologic modeling or an approved regression equation. The range from a fraction of Q_2 to Q_{10} represents the range of geomorphically significant flows for hydromodification management in San Diego. The upper bound of the range of flows to control is pre-development Q_{10} for all projects. The lower bound of the range of flows to control, or "lower flow threshold" is a fraction of pre-development Q_2 that is based on the erosion susceptibility of the stream and depends on the specific natural system (stream) that a project will discharge to. Tools have been developed in the March 2011 Final HMP for assessing the erosion susceptibility of the stream (see Section 6.3.4 below for further discussion of the lower flow threshold).

When selecting the type of structural BMP to be used for flow control, consider the types of structural BMPs that will be utilized onsite for pollutant control.

Both storm water pollutant control and flow control for hydromodification management can be achieved within the same structural BMPs. For example, a full infiltration BMP that infiltrates the DCV for pollutant control could include additional storage volume above or below ground to provide either additional infiltration of storm water or control of outflow for hydromodification management. If possible, the structural BMPs for pollutant control should be modified to meet flow control performance standards in addition to the pollutant control performance standards. See Section 6.3.6 for further discussion of integrating structural BMPs for pollutant control and flow control.

6.3.1 Point(s) of Compliance

For PDPs subject to hydromodification management requirements, the flow control performance standard must be met for each natural or un-lined channel that will receive runoff from the project.

This may require multiple structural BMPs within the project site if the project site discharges to multiple discrete outfalls. When runoff is discharged to multiple natural or un-lined channels within a project site, each natural or un-lined channel must be considered separately and points of compliance (POCs) for flow control must be provided for each natural or un-lined channel, including situations where the channels will confluence before leaving the project boundary. When runoff from the project site does not meet a natural or un-lined channel onsite, instead traveling some distance downstream of the project in storm drain systems or lined channels prior to discharge to natural or un-lined channels, the POC(s) for flow control analysis shall be placed at the project boundary (i.e., comparing the pre-development and post-project flows from the project area only, not analyzing the total watershed draining to the offsite POC), unless the project is draining to and accommodated by an approved master planned or regional flow control BMP.

For individual projects draining to approved master planned or regional flow control BMPs, the POC for flow control analysis may be offsite of the specific project application.

In these instances, the individual project draining to a master planned or regional flow control BMP shall reference the approved design documents for the BMP, and shall demonstrate that either (a) the individual project design is consistent with assumptions made for imperviousness and features of the project area when the master planned or regional BMP was designed, or (b) the master planned or

regional BMP still meets performance standards when the actual proposed imperviousness and features of the project area are considered.

6.3.2 Offsite Area Restrictions

Runoff from offsite undeveloped areas should be routed around structural BMPs for flow control whenever feasible.

Methods to route flows around structural BMPs include designing the site to avoid natural drainage courses, or using parallel storm drain systems. If geometric constraints prohibit the rerouting of flows from undeveloped areas around a structural BMP, a detailed description of the constraints must be submitted to the Port.

Structural BMPs for flow control must be designed to avoid trapping sediment from natural areas regardless of whether the natural areas are critical coarse sediment yield areas or not.

Reduction in coarse sediment supply contributes to downstream channel instability. Capture and removal of natural sediment from the downstream watercourse can create "hungry water" conditions and the increased potential for downstream erosion. Additionally, coarse or fine sediment from natural areas can quickly fill the available storage volume in the structural BMP and/or clog a small flow control outlet, which can cause the structural BMP to overflow during events that should have been controlled, and will require frequent maintenance. Failure to prevent clogging of the principal control orifice defeats the purpose of a flow control BMP, since basin inflows would simply overtop the control structure and flow unattenuated downstream, potentially worsening downstream erosion.

6.3.3 Requirement to Control to Pre-Development (Not Pre-Project) Condition

The MS4 Permit requires that post-project runoff must be controlled to match pre-development runoff conditions, not pre-project conditions, for the range of flow rates to be controlled.

Pre-development runoff conditions are defined in the MS4 Permit as "approximate flow rates and durations that exist or existed onsite before land development occurs."

- **Redevelopment PDPs:** Use available maps or development plans that depict the topography of the site prior to development, otherwise use existing onsite grades if historic topography is not available. Assume the infiltration characteristics of the underlying soil. Use available information pertaining to existing underlying soil type such as soil maps published by the Natural Resource Conservation Service (NRCS). Do not use runoff parameters for concrete or asphalt to estimate pre-development runoff conditions. If compacted soils condition exists, however, infiltration characteristics (refer to Appendix G, Table G.1.4 for allowable adjustments) for that runoff condition may be assumed.
- **New development PDPs:** The pre-development condition typically equates to runoff conditions immediately before project construction. However if there is existing impervious area onsite, as with redevelopment, the new development project must not use runoff parameters for concrete or asphalt to estimate pre-development runoff conditions. If compacted soils condition exists, however, infiltration characteristics (refer to Appendix G, Table G.1.4 for allowable adjustments) for that runoff condition may be assumed.

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When it is necessary for runoff from offsite impervious area (not a part of the project) to co-mingle with project site runoff and be conveyed through a project's structural flow control BMP, the offsite impervious area may be modeled as impervious in both the pre- and post- condition models. A project is not required to provide flow control for storm water from offsite. This also means that for redevelopment projects not subject to the 50% rule (i.e., redevelopment projects that result in the creation or replacement of impervious surface in an amount of less than 50% of the area of impervious surface of the previously existing development), comingled runoff from undisturbed portions of the previously existing development (i.e., areas that are not a part of the project) will not require flow control. Flow control facilities for comingled offsite and onsite runoff would be designed to process the total volume of the comingled runoff through the facility, but would provide mitigation for the excess runoff (difference of developed to pre-developed condition) based on onsite impervious areas only. The project applicant must clearly explain why it was not feasible or practical to provide a bypass system for storm water from offsite. The Port may request that the project applicant provide a supplemental analysis of onsite runoff only (i.e., supplemental model of the project area only).

6.3.4 Determining the Low Flow Threshold for Hydromodification Flow Control

The range of flows to control for hydromodification management depends on the erosion susceptibility of the receiving stream.

The range of flows to control is either:

- $0.1Q_2$ to Q_{10} for projects discharging to streams with high susceptibility to erosion (and this is the default range of flows to control when a stream susceptibility study has not been prepared),
- $0.3Q_2$ to Q_{10} for projects discharging to streams with medium susceptibility to erosion as determined by a stream susceptibility study approved by the Port, or
- $0.5Q_2$ to Q_{10} for projects discharging to streams with low susceptibility to erosion as determined by a stream susceptibility study approved by the Port.

The project applicant may opt to design to the default low flow threshold of $0.1Q_2$, or provide assessment of the receiving stream ("channel screening" a.k.a. "geomorphic assessment"), which may result in a higher low flow threshold of $0.3Q_2$ or $0.5Q_2$ for project hydromodification management.

Use of a higher low flow threshold of $0.3Q_2$ or $0.5Q_2$ must be supported by a channel screening report. Channel screening is based on a tool developed by the Southern California Coastal Water Research Project (SCCWRP), documented in SCCWRP's Technical Report 606 dated March 2010, "Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility." The SCCWRP channel screening tool considers channel conditions including channel braiding, mass wasting, and proximity to the erosion threshold. SCCWRP's Technical Report 606 is included in Appendix B of the March 2011 Final HMP, and can also be accessed through SCCWRP's website. The result of applying the channel screening tool will be classification of high, medium, or low susceptibility to erosion, corresponding to low flow thresholds of $0.1Q_2$, $0.3Q_2$, and $0.5Q_2$, respectively, for the receiving stream. Note that the Port may require that the channel screening study has been completed within a specific time frame prior to their review, and/or may apply a sunset date to their approval of a channel screening study.

The receiving stream is the location where runoff from the project is discharged to natural or

un-lined channels.

The receiving stream may be onsite or offsite. The POC for channel screening is the point where runoff initially meets an un-lined or natural channel, regardless of whether the POC for flow control facility sizing is at or within the project boundary or is offsite. A project may have a different POC for channel screening vs. POC for flow control facility sizing if runoff from the project site is conveyed in hardened systems from the project site to the un-lined or natural channel. The erosion susceptibility of the receiving stream must be evaluated at the POC for channel screening, and for an additional distance known as the domain of analysis, defined in SCCWRP's Technical Report 606.

6.3.5 Designing a Flow Control Facility

Flow control facilities for hydromodification management must be designed based on continuous simulation hydrologic modeling.

Continuous simulation hydrologic modeling uses an extended time series of recorded precipitation data and evapotranspiration data as input and generates hydrologic output, such as surface runoff, groundwater recharge, and evapotranspiration, for each model time step. Using the continuous flow output, peak flow frequency and duration statistics can be generated for the pre-development and post-project conditions for the purpose of matching pre-development hydrologic conditions in the range of geomorphically significant flow rates. Peak flow frequency statistics estimate how often flow rates will exceed a given threshold. Flow duration statistics determine how often a particular flow rate is exceeded. To determine if a flow control facility meets hydromodification management performance standards, peak flow frequency and flow duration curves must be generated and compared for pre-development and post-project conditions.

Flow control facilities may be designed using either sizing factors presented in Appendix B of this manual, or using project-specific continuous simulation modeling. The sizing factors were developed based on unit-area continuous simulation models. This means the continuous simulation hydrologic modeling has already been done and the project applicant needs only to apply the sizing factors to the project's effective impervious area to size a facility that meets flow control performance standards. The sizing factor method is intended for simple studies that do not include diversion, do not include significant offsite area draining through the project from upstream, and do not include offsite area downstream of the project area. Use of the sizing factors is limited to the specific structural BMPs for which sizing factors were prepared. Project-specific continuous simulation modeling offers the most flexibility in the design, but requires the project applicant to prepare and submit a complete continuous simulation hydrologic model for review.

6.3.5.1 Sizing Factor Method

A project applicant may use sizing factors that were created to facilitate sizing of certain specific BMPs for hydromodification management.

Unit runoff ratios for determination of pre-development Q_2 and sizing factors for certain specific structural BMPs were previously developed based on continuous simulation hydrologic modeling of hypothetical unit watersheds. Details and descriptions for the sizing factors and specific BMPs are presented in the "San Diego BMP Sizing Calculator Methodology," dated January 2012, prepared by Brown and Caldwell (herein "BMP Sizing Calculator Methodology"). Although the sizing factors were developed under the 2007 MS4 Permit, the unit runoff ratios and some sizing factors developed for flow control facility sizing may still be applied at the discretion of Port staff. Users should note that

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due to the MS4 Permit requirement to control flow rates to pre-development condition instead of pre-project condition, unit runoff ratios for "impervious" soil cover categories from Table 1-6 of the BMP Sizing Calculator Methodology shall not be used when determining pre-development Q_2 . Sizing factors are to be applied to the effective impervious area draining to the facility. Calculations may be prepared using either the BMP Sizing Spreadsheet that was developed by the County of San Diego and is available on the Project Clean Water website, or using hand calculations. Refer to Appendix G.2 of this manual for guidance to use the sizing factor method.

6.3.5.2 Project-Specific Continuous Simulation Modeling

A project applicant may prepare a project-specific continuous simulation model to demonstrate compliance with hydromodification management performance standards.

This option offers the most flexibility in the design. In this case, the project applicant shall prepare continuous simulation hydrologic models for pre-development and post-project conditions, and compare the pre-development and post-project (with hydromodification flow control BMPs) runoff rates and durations until compliance with the flow control performance standards is demonstrated. The project applicant will be required to quantify the long term pre-development and post-project runoff response from the site and establish runoff routing and stage-storage-discharge relationships for the planned flow control BMPs. There are several available hydrologic models that can perform continuous simulation analyses. Refer to Appendix G.1 of this manual for guidance for continuous simulation hydrologic modeling.

6.3.6 Integrating HMP Flow Control Measures with Pollutant Control BMPs

Both storm water pollutant control and flow control for hydromodification management can be achieved within the same structural BMP(s) or by a series of structural BMP(s).

The design process should start with an assessment of the controlling design factor, then the typical design process for an integrated structural BMP or series of BMPs to meet two separate performance standards at once involves (1) initiating the design based on the performance standard that is expected to require the largest volume of storm water to be retained, (2) checking whether the initial design incidentally meets the second performance standard, and (3) adjusting the design as necessary until it can be demonstrated that both performance standards are met. The following are recommendations for initiating the design process:

- **Full infiltration condition:** retention for pollutant control performance standard is the controlling design factor. For a system that is based on full retention for storm water pollutant control, first design an initial retention area to meet storm water pollutant control standards for retention, then check whether the facility meets flow control performance standards. If the initial retention facility does not meet flow control performance standards: increase the volume of the facility, increasing retention if feasible or employing outflow control for runoff to be discharged from the facility; as needed to meet the flow control performance standards.
- **Partial infiltration condition:** retention for pollutant control performance standard is the controlling design factor. For a system that is based on partial retention for storm water pollutant control, first design the retention area to maximize retention as feasible. Then design an additional runoff storage area with outflow control for runoff to be discharged from the facility; as needed

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to meet the flow control performance standards. Then address pollutant control needs for the portion of the storm water pollutant control DCV that could not be retained onsite.

- **No infiltration condition:** flow control for hydromodification management standard is the controlling design factor. For a system that is based on biofiltration with no infiltration for storm water pollutant control, first design the facility to meet flow control performance standards, then check whether the facility meets biofiltration design standards for storm water pollutant control. If the flow control biofiltration facility does not meet performance standards for storm water pollutant control by biofiltration, increase the volume of the biofiltration facility as needed to meet pollutant control performance standards, or identify other methods to address pollutant control needs for the portion of the storm water pollutant control DCV that could not be processed with biofiltration onsite.

When an integrated structural BMP or series of BMPs is used for both storm water pollutant control and flow control for hydromodification management, separate calculations are required to demonstrate that pollutant control performance standards and hydromodification management standards are met.

When an integrated structural BMP or series of BMPs is proposed to meet the storm water pollutant control and flow control for hydromodification management obligations, the applicant shall either:

- Perform separate calculations to show that both hydromodification management and pollutant control performance standards are met independently by using guidance from Appendices B and G. Calculations performed shall be documented in the SQWMP. **or**
- Develop an integrated design that meets the separate performance standards presented in Chapter 2 for both hydromodification management and pollutant control. In this option the BMP requirements to meet the pollutant control performance standard are optimized to account for the BMP storage provided for flow control, and vice versa. Calculations performed to develop an integrated design shall be documented in the SQWMP. Project approval when this option is selected is at the discretion of the Port. Proposed methods to optimize pollutant control performance to account for flow control benefits and vice versa shall be proposed by the project proponent and evaluated by the Port on a project-specific basis.

Appendix B.5.2 provides a methodology to optimize the footprint of the downstream biofiltration BMP that is required to meet the pollutant control performance standard, when there is an upstream hydromodification flow control BMP (e.g. cistern, vault, etc.)

6.3.7 Drawdown Time

The maximum recommended drawdown time for hydromodification management facilities is 96 hours based on Section 6.4.6 of the March 2011 Final HMP.

This is based on instruction from the County of San Diego Department of Environmental Health for mitigation of potential vector breeding issues and the subsequent risk to human health. This standard applies to, but is not limited to, detention basins, underground storage vaults, and the above-ground storage portion of LID facilities. When this standard cannot be met due to large stored runoff volumes with limited maximum release rates, a Vector Management Plan may be an acceptable solution if approved by the Port.

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In cases where a Vector Management Plan is necessary, it shall be incorporated into the SWQMP as an attachment. A Vector Management Plan will only be accepted after the applicant has proven infeasibility of meeting the required drawdown time using any and all allowable BMPs. The information included in the plan will vary based on the nature, extent and variety of potential vector sources. It is recommended that preparers consult with the Department of Environmental Health Vector Control Program for technical guidance. Plans should include the following information at a minimum:

- Project identification information;
- A description of the project, purpose of the report, and existing environmental conditions;
- A description of the management practices that will be employed to minimize vector breeding sources and any associated employee education required to run facilities and operations;
- A discussion of long term maintenance requirements;
- A summary of mitigation measures;
- References; and
- A list of persons and organizations contacted (project proponents are expected to obtain review and concurrence of proposed management practices from Department of Environmental Health Vector control program staff prior to submission).

The property tenant/project proponent and applicant must include and sign the following statement: “The measures identified herein are considered part of the proposed project design and will be carried out as part of project implementation. I understand the breeding of mosquitoes is unlawful under the State of California Health and Safety Code Section 2060-2067. I will permit the Vector Surveillance and Control program to place adult mosquito monitors and to enforce this document as needed.”

Refer to the sources below for additional guidance:

Report Guidance- http://www.sandiegocounty.gov/dplu/docs/Vector_Report_Formats.pdf

Department of Environmental Health Vector Control Program Department of Environmental Health
- http://www.sandiegocounty.gov/deh/pests/vector_disease.html

It should be noted that other design factors may influence the required drawdown when hydromodification management BMPs are integrated with storm water pollutant control BMPs. Since hydromodification flow control BMPs are designed based on continuous simulation modeling, which is based on a continuous rainfall record and analyzes a continuous inflow and outflow of the BMPs, inter-event drawdown time and availability of the BMP for subsequent event inflow has been accounted for in the sizing. Therefore, drawdown recommendations for hydromodification management are based on public safety, not availability of the BMP for the next inflow event. Storm water pollutant control BMPs are designed on a single-event basis for a DCV (the 85th percentile storm event). Some of the design standards presented in Chapter 5 or Appendix B require that the pollutant control portion of the BMP drain within a specific time frame to ensure the pollutant control portion of the BMP is available for subsequent storm events. When hydromodification management BMPs are integrated with storm water pollutant control BMPs, the designer must evaluate drawdown time based on both standards.

BMP DESIGN MANUAL

Long Term Operation & Maintenance

Permanent structural BMPs require on-going inspection and maintenance into perpetuity to preserve the intended pollution control and/or flow control performance.

This Chapter addresses procedural requirements for implementation of long term O&M and the typical maintenance requirements of structural BMPs presented in the manual. Specific requirements for O&M Plan reports will be discussed in Chapter 8 with the Submittal Requirements.

7.1 Need for Permanent Inspection and Maintenance

7.1.1 MS4 Permit Requirements

The MS4 Permit requires that each Copermittee implement a program that requires and confirms structural BMPs on all PDPs are designed, constructed, and maintained to remove pollutants in storm water to the MEP.

Routine inspection and maintenance of BMPs will preserve the design and MS4 Permit objective to remove pollutants in storm water to the MEP. The MS4 Permit requirement specifically applies to PDP structural BMPs. However, source control BMPs and site design / LID BMPs within a PDP are components in the storm water management scheme that determine the amount of runoff to be treated by structural BMPs; and when source control, site design, or LID BMPs are not maintained, this can lead to clogging or failure of structural BMPs due to greater delivery of runoff and pollutants than intended. Therefore, the Port may also require confirmation of maintenance of source control BMPs and site design / LID BMPs as part of their PDP structural BMP maintenance documentation requirements (see Section 7.4).

7.1.2 Practical Considerations

Why do permanent structural BMPs require on-going inspection and maintenance into perpetuity?

By design, structural BMPs will trap pollutants transported by storm water. Structural BMPs are subject to deposition of solids such as sediment, trash, and other debris. Some structural BMPs are also subject to growth of vegetation, either by design (e.g. biofiltration) or incidentally. The pollutants and any overgrown vegetation must be removed on a periodic basis for the life of the BMP to maintain the capacity of the structural BMP to process storm water and capture pollutants from every storm

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event. Structural BMP components are also subject to clogging from trapped pollutants and growth of vegetation. Clogged BMPs can result in flooding, standing water and mosquito breeding habitat. Maintenance is critical to ensure the ongoing drainage of the facility. All components of the BMP must be maintained, including both the surface and any sub-surface components.

Vegetated structural BMPs, including vegetated infiltration or partial infiltration BMPs, and above-ground detention basins, also require routine maintenance so that they don't inadvertently become wetlands, waters of the state, or sensitive species habitat under the jurisdiction of the United States Army Corps of Engineers, San Diego Water Board, California Department of Fish and Wildlife, or the United States Fish and Wildlife Service. A structural BMP that is constructed in the vicinity of, or connected to, an existing jurisdictional water or wetland could inadvertently result in creation of expanded waters or wetlands. As such, vegetated structural BMPs have the potential to come under the jurisdiction of one or more of the above-mentioned resource agencies. This could result in the need for specific resource agency permits and costly mitigation to perform maintenance of the structural BMP. Along with proper placement of a structural BMP, routine maintenance is key to preventing this scenario.

7.2 Summary of Steps to Maintenance Agreement

Ownership and maintenance responsibility for structural BMPs should be discussed at the beginning of project planning, typically at the pre-application meeting with the planning and zoning agency.

Tenant/project proponents shall be aware of their responsibilities regarding storm water BMP maintenance and need to be familiar with the contents of the O&M Plan prepared for the project. Chapter 8 provides the guidelines for preparation of a site specific O&M Plan. A maintenance mechanism must be determined prior to the issuance of any construction, grading, building permit, site development permit, or any other applicable permit. Below are typical steps and schedule for establishing a plan and mechanism to ensure on-going maintenance of structural BMPs.

TABLE 7-1. Schedule for Developing O&M Plan and Agreement

Item	Description	Time Frame
1	Identify expected maintenance actions	First submittal of a project application – identify in SWQMP
2	Develop detailed O&M Plan	As required by the Port, prior to issuance of construction, grading, building, site development, or other applicable permits
3	Update/finalize O&M Plan to reflect constructed structural BMPs with as-built plans and baseline photos	As required by the Port, upon completion of construction of structural BMPs

The Port maintains rights to access tenant properties as part of lease provisions. These rights extend to any access required related to structural BMPs.

7.3 Maintenance Responsibility

Who is responsible for the maintenance of the permanent structural BMPs into perpetuity?

The tenant/project proponent is responsible to ensure inspection, operation and maintenance of permanent structural BMPs on a leasehold or Port maintained property. As part of project review for both capital and tenant priority projects that include interim or permanent structural BMPs, the Port will verify that appropriate mechanisms are in-place.

The Port will require that a copy of a satisfactory Operation & Maintenance (O&M) plan, prepared by the tenant/project proponent is included with the SWQMP. The O&M Plan must describe the designated responsible party to manage the storm water BMP(s), any necessary employee training and duties, operating schedule, maintenance frequency, specific maintenance activities, copies of resource agency permits, and any other necessary activities. At a minimum, the O&M Plan shall require the inspection and servicing of all structural BMPs on an annual basis. Further, annual written verification of effective operation and maintenance of each approved treatment control BMP by the responsible party is required to be submitted to the Port prior to each wet season. The tenant shall document all maintenance requirements and shall retain records for at least 5 years. These documents shall be made available to the Port for inspection upon request at any time. O&M Plans will also be prepared for capital projects that include structural BMPs. The Port's O&M template is to be used to fulfill the O&M planning requirement.

7.4 Long-Term Maintenance Documentation

As part of on-going structural BMP maintenance into perpetuity, tenants are required to provide documentation of maintenance for the structural BMPs on their property to support the Port's reporting requirements to the San Diego Water Board.

The MS4 Permit requires each Copermittee to verify that structural BMPs on each PDP "are adequately maintained, and continue to operate effectively to remove pollutants in storm water to the MEP through inspections, self-certifications, surveys, or other equally effective approaches." Each Copermittee must also identify the party responsible for structural BMP maintenance for the PDP and report the dates and findings of structural BMP maintenance verifications, and corrective actions and/or resolutions when applicable, in their PDP inventory. The PDP inventory and findings of maintenance verifications must be reported to the San Diego Water Board annually. Based on these MS4 Permit requirements, the Port will require tenants to provide annual self-certification that inspection and maintenance has been performed, provide details of the inspection results and maintenance activities, and confirm or update the contact information for the party responsible to ensure inspection and maintenance is performed. All facilities are to be inspected on an annual basis at a minimum. A copy of each inspection form shall be kept by the lessee a minimum of 5 years.

7.5 Inspection and Maintenance Frequency

The minimum inspection and maintenance frequency is annual and must be reported annually.

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However, actual maintenance needs are site specific, and maintenance may be needed more frequently than annually. The need for maintenance depends on the amount and quality of runoff delivered to the structural BMP. Maintenance must be performed whenever needed, based on maintenance indicators presented in Section 7.7. The optimum maintenance frequency is each time the maintenance threshold for removal of materials (sediment, trash, debris or overgrown vegetation) is met. If this maintenance threshold has been exceeded by the time the structural BMP is inspected, the BMP has been operating at reduced capacity. This would mean it is necessary to inspect and maintain the structural BMP more frequently. Routine maintenance will also help avoid more costly rehabilitative maintenance to repair damages that may occur when BMPs have not been adequately maintained on a routine basis.

During the first year of normal operation of a structural BMP (i.e. when the project is fully built out and occupied), inspection by the property's representative is recommended at least once prior to August 31 and then monthly from September through May. Inspection during a storm event is also recommended. It is during and after a rain event when one can determine if the components of the BMP are functioning properly. After the initial period of frequent inspections, the minimum inspection and maintenance frequency can be determined based on the results of the first year inspections.

7.6 Measures to Control Maintenance Costs

Because structural BMPs must be maintained into perpetuity, it is essential to include measures to control maintenance costs.

The most effective way to reduce maintenance of structural BMPs is to prevent or reduce pollutants generated onsite and delivered to the structural BMP by implementation of source control and site design BMPs onsite, as required and described in Chapter 4 of this manual. Second, vegetated BMPs should be placed properly to reduce the potential to come under the jurisdiction of one or more resource agencies that could require permits and costly mitigation to perform maintenance of the structural BMP. Third, the structural BMP should include design features to facilitate maintenance, as listed below.

Considerations for placement of vegetated BMPs:

- Locate structural BMPs outside of floodway, floodplain, and other jurisdictional areas.
- Avoid direct connection to a natural surface water body.
- Discuss the location of the structural BMP with a wetland biologist to avoid placing a structural BMP in a location where it could become jurisdictional or be connected to a jurisdictional area.

Measures to facilitate collection of the trapped pollutants:

- Design a forebay to trap gross pollutants in a contained area that is readily accessible for maintenance. A forebay may be a dedicated area at the inlet entrance to an infiltration BMP, biofiltration BMP, or detention basin, or may be a gross pollutant separator installed in the storm drain system that drains to the primary structural BMP.

Measures to access the structural BMP:

- The BMP must be accessible to equipment needed for maintenance. Access requirements for maintenance will vary with the type of facility selected.

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- Infiltration BMPs, biofiltration BMPs and most above-ground detention basins and sand filters will typically require routine landscape maintenance using the same equipment that is used for general landscape maintenance. At times these BMPs may require excavation of clogged media (e.g. bioretention soil media, or sand for the sand filter), and should be accessible to appropriate equipment for excavation and removal/replacement of media.
- Above-ground detention basins should include access ramps for trucks to enter the basin to bring equipment and to remove materials.
- Underground BMPs such as detention vaults, media filters, or gross pollutant separators used as forebays to other BMPs, typically require access for a vactor truck to remove materials. Proprietary BMPs such as media filters or gross pollutant separators may require access by a forklift or other truck for delivery and removal of media cartridges or other internal components. Access requirements must be verified with the manufacturer of proprietary BMPs.
- Vactor trucks are large, heavy, and difficult to maneuver. Structural BMPs that are maintained by vactor truck must include a level pad adjacent to the structural BMP, preferably with no vegetation or irrigation system (otherwise vegetation or irrigation system may be destroyed by the vactor truck).
- The sump area of a structural BMP should not exceed 20 feet in depth due to the loss of efficiency of a vactor truck. The water removal rate is three to four times longer when the depth is greater than 20 feet. Deep structures may require additional equipment (stronger vactor trucks, ladders, more vactor pipe segments).
- All manhole access points to underground structural BMPs must include a ladder or steps.

Measures to facilitate inspection of the structural BMP

- Structural BMPs shall include inspection ports for observing all underground components that require inspection and maintenance.
- Silt level posts or other markings shall be included in all BMP components that will trap and store sediment, trash, and/or debris, so that the inspector may determine how full the BMP is, and the maintenance personnel may determine where the bottom of the BMP is. Posts or other markings shall be indicated and described on structural BMP plans.
- Vegetation requirements including plant type, coverage, and minimum height when applicable shall be provided on the structural BMP and/or landscaping plans as appropriate or as required by the Port.
- Signage indicating the location and boundary of the structural BMP is recommended.

When designing a structural BMP, the engineer should review the typical structural BMP maintenance actions listed in Section 7.7 to determine the potential maintenance equipment and access needs.

When selecting permanent structural BMPs for a project, the engineer and tenant/project proponent should consider the long term cost of maintenance and what type of maintenance contracts a future tenant will need to manage. The types of materials used (e.g. proprietary vs. non-proprietary parts), equipment used (e.g. landscape equipment vs. vactor truck), actions/labor expected in the maintenance process and required qualifications of maintenance personnel (e.g. confined space entry) affect the cost of long term O&M of the structural BMPs presented in the manual.

7.7 Maintenance Indicators and Actions for Structural BMPs

This Section presents typical maintenance indicators and expected maintenance actions (routine and corrective) for typical structural BMPs.

There are many different variations of structural BMPs, and structural BMPs may include multiple components. For the purpose of maintenance, the structural BMPs have been grouped into four categories based on common maintenance requirements:

- Vegetated infiltration or filtration BMPs
- Non-vegetated infiltration BMPs
- Non-vegetated filtration BMPs
- Detention BMPs

The project civil engineer is responsible for determining which categories are applicable based on the components of the structural BMP, and identifying the applicable maintenance indicators from within the category. Maintenance indicators and actions shall be shown on the construction plans and in the project-specific O&M Plan.

During inspection, the inspector checks the maintenance indicators. If one or more thresholds are met or exceeded, maintenance must be performed to ensure the structural BMP will function as designed during the next storm event.

7.7.1 Maintenance of Vegetated Infiltration or Filtration BMPs

"Vegetated infiltration or filtration BMPs" are BMPs that include vegetation as a component of the BMP. Applicable Fact Sheets may include INF-2 (bioretention), PR-1 (biofiltration with partial retention), BF-1 (biofiltration) or FT-1 (vegetated swale). The vegetated BMP may or may not include amended soils, subsurface gravel layer, underdrain, and/or impermeable liner. The project civil engineer is responsible for determining which maintenance indicators and actions shown below are applicable based on the components of the structural BMP.

7.7.2 Maintenance of Non-Vegetated Infiltration BMPs

"Non-vegetated infiltration BMPs" are BMPs that store storm water runoff until it infiltrates into the ground, and do not include vegetation as a component of the BMP (refer to the "vegetated BMPs" category for infiltration BMPs that include vegetation). Non-vegetated infiltration BMPs generally include non-vegetated infiltration trenches and infiltration basins, dry wells, underground infiltration galleries, and permeable pavement with underground infiltration gallery. Applicable Fact Sheets may include INF-1 (infiltration basin) or INF-3 (permeable pavement). The non-vegetated infiltration BMP may or may not include a pre-treatment device, and may or may not include above-ground storage of runoff. The project civil engineer is responsible for determining which maintenance indicators and actions shown below are applicable based on the components of the structural BMP.

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TABLE 7-2. Maintenance Indicators and Actions for Vegetated BMPs

Typical Maintenance Indicator(s) for Vegetated BMPs	Maintenance Actions
Accumulation of sediment, litter, or debris	Remove and properly dispose of accumulated materials, without damage to the vegetation.
Poor vegetation establishment	Re-seed, re-plant, or re-establish vegetation per original plans.
Overgrown vegetation	Mow or trim as appropriate, but not less than the design height of the vegetation per original plans when applicable (e.g. a vegetated swale may require a minimum vegetation height).
Erosion due to concentrated irrigation flow	Repair/re-seed/re-plant eroded areas and adjust the irrigation system.
Erosion due to concentrated storm water runoff flow	Repair/re-seed/re-plant eroded areas, and make appropriate corrective measures such as adding erosion control blankets, adding stone at flow entry points, or minor re-grading to restore proper drainage according to the original plan. If the issue is not corrected by restoring the BMP to the original plan and grade, the Port shall be contacted prior to any additional repairs or reconstruction.
Standing water in vegetated swales	Make appropriate corrective measures such as adjusting irrigation system, removing obstructions of debris or invasive vegetation, loosening or replacing top soil to allow for better infiltration, or minor re-grading for proper drainage. If the issue is not corrected by restoring the BMP to the original plan and grade, the Port shall be contacted prior to any additional repairs or reconstruction.
Standing water in bioretention, biofiltration with partial retention, or biofiltration areas, or flow-through planter boxes for longer than 96 hours following a storm event*	Make appropriate corrective measures such as adjusting irrigation system, removing obstructions of debris or invasive vegetation, clearing underdrains (where applicable), or repairing/replacing clogged or compacted soils.
Obstructed inlet or outlet structure	Clear obstructions.
Damage to structural components such as weirs, inlet or outlet structures	Repair or replace as applicable.
*These BMPs typically include a surface ponding layer as part of their function which may take 96 hours to drain following a storm event.	

TABLE 7-3. Maintenance Indicators and Actions for Non-Vegetated Infiltration BMPs

Typical Maintenance Indicator(s) for Non-Vegetated Infiltration BMPs	Maintenance Actions
Accumulation of sediment, litter, or debris in infiltration basin, pre-treatment device, or on permeable pavement surface	Remove and properly dispose accumulated materials.
Standing water in infiltration basin without subsurface infiltration gallery for longer than 96 hours following a storm event	Remove and replace clogged surface soils.
Standing water in subsurface infiltration gallery for longer than 96 hours following a storm event	This condition requires investigation of why infiltration is not occurring. If feasible, corrective action shall be taken to restore infiltration (e.g. flush fine sediment or remove and replace clogged soils). BMP may require retrofit if infiltration cannot be restored. If retrofit is necessary, the Port shall be contacted prior to any repairs or reconstruction.
Standing water in permeable paving area	Flush fine sediment from paving and subsurface gravel. Provide routine vacuuming of permeable paving areas to prevent clogging.
Damage to permeable paving surface	Repair or replace damaged surface as appropriate.
Note: When inspection or maintenance indicates sediment is accumulating in an infiltration BMP, the DMA draining to the infiltration BMP should be examined to determine the source of the sediment, and corrective measures should be made as applicable to minimize the sediment supply.	

7.7.3 Maintenance of Non-Vegetated Filtration BMPs

"Non-vegetated filtration BMPs" include media filters (FT-2) and sand filters (FT-3). These BMPs function by passing runoff through the media to remove pollutants. The project civil engineer is responsible for determining which maintenance indicators and actions shown below are applicable based on the components of the structural BMP.

TABLE 7-4. Maintenance Indicators and Actions for Filtration BMPs

Typical Maintenance Indicator(s) for Filtration BMPs	Maintenance Actions
Accumulation of sediment, litter, or debris	Remove and properly dispose accumulated materials.
Obstructed inlet or outlet structure	Clear obstructions.
Clogged filter media	Remove and properly dispose filter media, and replace with fresh media.
Damage to components of the filtration system	Repair or replace as applicable.
Note: For proprietary media filters, refer to the manufacturer's maintenance guide.	

7.7.4 Maintenance of Detention BMPs

"Detention BMPs" includes basins, cisterns, vaults, and underground galleries that are primarily designed to store runoff for controlled release to downstream systems. For the purpose of the maintenance discussion, this category does not include an infiltration component (refer to "vegetated infiltration or filtration BMPs" or "non-vegetated infiltration BMPs" above). Applicable Fact Sheets may include HU-1 (cistern) or FT-4 (extended detention basin). There are many possible configurations of above ground and underground detention BMPs, including both proprietary and non-proprietary systems. The project civil engineer is responsible for determining which maintenance indicators and actions shown below are applicable based on the components of the structural BMP.

TABLE 7-5. Maintenance Indicators and Actions for Detention BMPs

Typical Maintenance Indicator(s) for Detention Basins	Maintenance Actions
Poor vegetation establishment	Re-seed, re-establish vegetation.
Overgrown vegetation	Mow or trim as appropriate.
Erosion due to concentrated irrigation flow	Repair/re-seed/re-plant eroded areas and adjust the irrigation system.
Erosion due to concentrated storm water runoff flow	Repair/re-seed/re-plant eroded areas and make appropriate corrective measures such as adding erosion control blankets, adding stone at flow entry points, or re-grading where necessary.
Accumulation of sediment, litter, or debris	Remove and properly dispose of accumulated materials.
Standing water	Make appropriate corrective measures such as adjusting irrigation system, removing obstructions of debris or invasive vegetation, or minor re-grading for proper drainage.
Obstructed inlet or outlet structure	Clear obstructions.
Damage to structural components such as weirs, inlet or outlet structures	Repair or replace as applicable.

Submittal Requirements

It is necessary for the Port to review project plans for compliance with applicable requirements of this manual and the MS4 Permit.

The review process must verify that storm water management objectives were considered in the project planning process and that opportunities to incorporate BMPs have been identified. The review process must confirm the site plan, landscape plan, and project storm water documents are congruent. Therefore, every jurisdiction in San Diego County requires a submittal documenting the storm water management design for every project that is subject to the requirements of this manual. Herein the submittal is called a "SWQMP." A complete and thorough project submittal will facilitate and expedite the review and approval, and may result in fewer submittals by the applicant. The Sections below discuss submittal requirements. In all cases the project applicant must provide sufficient documentation to demonstrate that applicable requirements of this manual and the MS4 Permit will be met.

8.1 Submittal Requirement for Standard Projects

8.1.1 Standard Project SWQMP

For Standard Projects, the project submittal shall include a "Standard Project SWQMP."

The Standard Project SWQMP is a compilation of checklists that document that all permanent source control and site design BMPs have been considered for the project and implemented where feasible. All applicable features shall be shown on site plans and landscaping plans. The Standard Project SWQMP shall consist of the following forms and/or checklists included in Appendix I of this manual:

- Form I-1: Applicability of Permanent BMP Requirements
- Form I-2: Project Type Determination (Standard Project or PDP)
- Form I-3A: Site Information for Standard Projects
- Form I-4: Source Control BMP Checklist
- Form I-5: Site Design BMP Checklist

The Standard Project SWQMP shall also include copies of the relevant plan sheets showing source control and site design BMPs.

8.2 Submittal Requirements for PDPs

8.2.1 PDP SWQMP

For PDPs, the project submittal shall include a "PDP SWQMP."

The PDP SWQMP shall document that all permanent source control and site design BMPs have been considered for the project and implemented where feasible; document the planning process and the decisions that led to the selection of structural BMPs; provide the calculations for design of structural BMPs to demonstrate that applicable performance standards are met by the structural BMP design; identify O&M requirements of the selected structural BMPs; and identify the maintenance mechanism (see Sections 7.2 and 7.3) for long term O&M of structural BMPs. PDPs shall use the PDP SWQMP Template provided in Appendix A, which will include forms and/or checklists included in Appendix I of this manual as well as checklists for documentation of pollutant control and hydromodification management structural BMP design. The PDP SWQMP shall include copies of the relevant plan sheets showing site design, source control, and structural BMPs, and structural BMP maintenance requirements.

A PDP SWQMP must be provided with the first submittal of project drawings.

Storm water requirements will directly affect the layout of the project. Storm water requirements must be considered from the initial project planning or in project concept stage, and will be reviewed upon each submittal, beginning with the first submittal. The process from initial project application through approval of the project plans often includes design changes to the site layout and features. Changes may be driven by storm water management requirements or other site requirements. Each time the site layout is adjusted, whether the adjustment is directly due to storm water management requirements identified during the Port review of the storm water submittal, or is driven by other site requirements, the storm water management design must be revisited to ensure the revised project layout and features meet the requirements of this manual and the MS4 Permit. An updated PDP SWQMP must be provided with each submittal of revised project plans. The updated PDP SWQMP should include documentation of changes to the site layout and features, and reasons for the changes. In the event that other site requirements identified during plan review render certain proposed storm water features infeasible (e.g. if fire department access requirements were identified that precluded use of certain surfaces or landscaping features that had been proposed), this must be documented as part of the decisions that led to the development of the final storm water management design.

8.2.1.1 PDP O&M Plan

While the PDP SWQMP must include general O&M requirements for structural BMPs, the PDP SWQMP may not be the final O&M Plan.

The O&M requirements documented in the PDP SWQMP must be sufficient to show that O&M requirements have been considered in the project planning and design. However, a final O&M Plan should reflect actual constructed structural BMPs to be maintained. Photographs and as-built plans for the constructed structural BMPs should be included. See Section 8.2.3 for project closeout procedures including local requirements for final O&M Plans, and Section 8.2.4 for additional requirements for private entity O&M of structural BMPs.

8.2.2 Requirements for Construction Plans

8.2.2.1 BMP Identification and Display on Construction Plans

Plans for construction of the project (grading plans, improvement plans, and landscaping plans, as applicable) must show all permanent site design, source control, and structural BMPs, and must be congruent with the PDP SWQMP.

BMPs, including source control and site design BMPs shall be incorporated into the civil drawing set complete with designated DMA. The following information shall be provided on the SWQMP exhibit:

- a) Entire property included on one map (use key map if multi-sheets)
- b) BMP sheet which includes the following (BMP type, size, dimensions for location, cross section and elevation detail); global positioning system coordinates of property
- c) Drainage areas and direction of flow
- d) Storm drain system(s)
- e) Nearby water bodies and municipal storm drain inlets
- f) Location and details of storm water conveyance systems (ditches, inlets, outlets, storm drains, overflow structures, etc.)
- g) Location of existing and proposed storm water controls
- h) Location of “impervious” areas- paved areas, buildings, covered areas
- i) Locations where materials would be directly exposed to storm water
- j) Location of building and activity areas (e.g. fueling islands, garages, waste container area, wash racks, hazardous material storage areas, etc.)
- k) Areas of potential soil erosion (including areas downstream of project)
- l) Location of existing drinking water wells
- m) Location of existing vegetation to be preserved
- n) Location of LID landscaping features, site design BMPs.

8.2.2.2 Structural BMP Maintenance Information on Construction Plans

Plans for construction of the project must provide sufficient information to describe maintenance requirements (thresholds and actions) for structural BMPs such that in the event all other separate O&M documents were lost, a new party studying plans for the project could identify the structural BMPs and identify the required maintenance actions based on the plans.

For the purpose of long term O&M, the project plans must identify the following:

- How to access the structural BMP to inspect and perform maintenance;
- Features that are provided to facilitate inspection (e.g. observation ports, cleanouts, silt posts, or other features that allow the inspector to view necessary components of the structural BMP and compare to maintenance thresholds);

- Manufacturer and part number for proprietary parts;
- Maintenance thresholds specific to the structural BMP, with a location-specific frame of reference (e.g. level of accumulated materials that triggers removal of the materials, to be identified based on viewing marks on silt posts or measured with a survey rod with respect to a fixed benchmark within the BMP);
- Recommended equipment to perform maintenance; and
- When applicable, necessary special training or certification requirements for inspection and maintenance personnel such as confined space entry or hazardous waste management.

8.2.3 Design Changes During Construction and Project Closeout Procedures

8.2.3.1 Design Changes During Construction

Prior to occupancy and/or intended use of any portion of a PDP, the site must be in compliance with the requirements of this manual and the MS4 Permit.

Therefore during construction, any changes that affect the design of storm water management features must be reviewed and approved by the Port. Approved documents and additional design may be required prior to implementation of design changes during construction. This might include changes to drainage patterns that occurred based on actual site grading and construction of storm water conveyance structures, or substitutions to storm water management features. Just as during the design phase, when there are changes to the site layout and features, the storm water management design must be revisited to ensure the revised project layout and features meet the requirements of this manual and the MS4 Permit.

Design changes must be reviewed and approved by the Engineer of Record and the Port prior to continuing construction.

8.2.3.2 Certification of Constructed BMPs

As part of the "Structural BMP Approval and Verification Process" required by the MS4 Permit, each structural BMP must be inspected to verify that it has been constructed and is operating in compliance with all of its specifications, plans, permits, ordinances, and the requirements of the MS4 Permit.

Since some portions of the structural BMP will not be readily visible after completion of construction (e.g. subsurface layers), the Port will require inspections during construction, photographs taken during construction, and/or other certification that the BMP has been constructed in conformance with the approved plans. The Port may require forms or other documentation be submitted prior to the inspection in order to facilitate the structural BMP inspection.

8.2.3.3 Final O&M Plan

Upon completion of project construction, the Port may require a final O&M Plan to be submitted.

A final O&M Plan reflects project-specific constructed structural BMPs with project-specific

drawings, photographs, and maps, and identifies specific maintenance requirements and actions for the constructed structural BMPs.

8.2.4 Additional Requirements for Tenant BMP O&M

This Section discusses tenant structural BMPs to be operated and maintained on tenant property by the tenant or manager.

8.2.4.1 O&M Agreements for Tenant Structural BMP Maintenance

For tenant operated structural BMPs, the Port requires execution of an O&M Agreement document.

An O&M Agreement is a recorded document signed by the Port and the tenant committing the tenant to maintain the permanent structural BMPs into perpetuity. The O&M Agreement may provide that, if the tenant fails to maintain the storm water facilities, the Port may enter the property, restore the storm water facilities to operable condition, and obtain reimbursement, including administrative costs, from the tenant.

The Port maintains rights to access tenant properties as part of lease provisions. These rights extend to any access required related to structural BMPs.

8.2.4.2 Interim Security Period of Maintenance Funding for Tenant Structural BMP Maintenance

For tenant operated structural BMPs, the Port may require an interim security period of maintenance funding in the event that the tenant fails to maintain the storm water features.

The Port will assure stormwater BMP maintenance, repair and replacement of tenant projects through conditions in tenant leases.

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Submittal Templates

Appendix A Submittal Templates

Port-specific SWQMP templates can be found at <https://www.portofsandiego.org/stormwater-management>

BMP DESIGN MANUAL

**Storm Water Pollutant Control
Hydrologic Calculations and Sizing
Methods**

Appendix B Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

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- B.1. DCV
- B.2. Adjustments to Account for Site Design BMPs
- B.3. Harvest and Use BMPs
- B.4. Infiltration BMPs
- B.5. Biofiltration BMPs
- B.6. Flow-Thru Treatment Control BMPs (for use with Alternative Compliance)

Appendix B: Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

B.1 DCV

DCV is defined as the volume of storm water runoff resulting from the 85th percentile, 24-hr storm event. The following hydrologic method shall be used to calculate the DCV:

$$DCV = C \times d \times A \times 43,560 \text{ sf/ac} \times 1/12 \text{ in/ft}$$
$$DCV = 3,630 \times C \times d \times A$$

Where:

DCV = Design Capture Volume in cubic feet

C = Runoff factor (unitless); refer to section B.1.1

d = 85th percentile, 24-hr storm event rainfall depth (inches), refer to section B.1.3

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drains to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects consult section 1.4.3.

B.1.1 Runoff Factor

Estimate the area weighted runoff factor for the tributary area to the BMP using runoff factor (from Table B.1-1) and area of each surface type in the tributary area and the following equation:

$$C = \frac{\sum C_x A_x}{\sum A_x}$$

Where:

C_x = Runoff factor for area X

A_x = Tributary area X (acres)

These runoff factors apply to areas receiving direct rainfall only. For conditions in which runoff is routed onto a surface from an adjacent surface, see Section B.2 for determining composite runoff factors for these areas.

Appendix B: Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

Table B.1-1: Runoff factors for surfaces draining to BMPs – Pollutant Control BMPs

Surface	Runoff Factor
Roofs ¹	0.90
Concrete or Asphalt ¹	0.90
Unit Pavers (grouted) ¹	0.90
Decomposed Granite	0.30
Cobbles or Crushed Aggregate	0.30
Amended, Mulched Soils or Landscape	0.10
Compacted Soil (e.g., unpaved parking)	0.30
Natural (A Soil)	0.10
Natural (B Soil)	0.14
Natural (C Soil)	0.23
Natural (D Soil)	0.30

1. Surface is considered impervious and could benefit from use of Site Design BMPs and adjustment of the runoff factor per Section B.2.1.

B.1.2 Offline BMPs

Diversion flow rates for offline BMPs shall be sized to convey the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The following hydrologic method shall be used to calculate the diversion flow rate for off-line BMPs:

$$Q = C \times i \times A$$

Where:

Q = Diversion flow rate in cubic feet per second

C = Runoff factor, area weighted estimate using Table B.1

i = Rainfall intensity of 0.2 in/hr

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects also consult Section 1.4.3.

B.1.3 85th Percentile, 24-Hour Storm Event

The 85th percentile, 24-hour isopleth map is provided as Figure B.1-1. The rainfall depth to estimate the DCV shall be determined using Figure B.1-1. The methodology used to develop this map is presented below:

Appendix B: Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

B.1.3.1 Gage data and calculation of 85th percentile

The method of calculating the 85th percentile is to produce a list of values, order them from smallest to largest, and then pick the value that is 85 percent of the way through the list. Only values that are capable of producing run off are of interest for this purpose. Lacking a legislative definition of rainfall values capable of producing runoff, Flood Control staff in San Diego County have observed that the point at which significant runoff begins is rather subjective, and is affected by land use type and soil moisture. In highly-urbanized areas, the soil has a high impermeability and runoff can begin with as little as 0.02" of rainfall. In rural areas, soil impermeability is significantly lower and even 0.30" of rain on dry soil will frequently not produce significant runoff. For this reason, San Diego County has chosen to use the more objective method of including all non-zero 24-hour rainfall totals when calculating the 85th percentile. To produce a statistically significant number, only stations with 30 years or greater of daily rainfall records are used.

B.1.3.2 Mapping the gage data

A collection of 56 precipitation gage points was developed with 85th percentile precipitation values based on multiple years of gage data. A raster surface (grid of cells with values) was interpolated from that set of points. The surface initially did not cover the County's entire jurisdiction. A total of 13 dummy points were added. Most of those were just outside the County boundary to enable the software to generate a surface that covered the entire County. A handful of points were added to enforce a plausible surface. In particular, one point was added in the desert east of Julian, to enforce a gradient from high precipitation in the mountains to low precipitation in the desert. Three points were added near the northern boundary of the County to adjust the surface to reflect the effect of elevation in areas lacking sufficient operating gages.

Several methods of interpolation were considered. The method chosen is named by Environmental Systems Research Institute as the Natural Neighbor technique. This method produces a surface that is highly empirical, with the value of the surface being a product of the values of the data points nearest each cell. It does not produce peaks or valleys of surface based on larger area trends, and is free of artifacts that appeared with other methods.

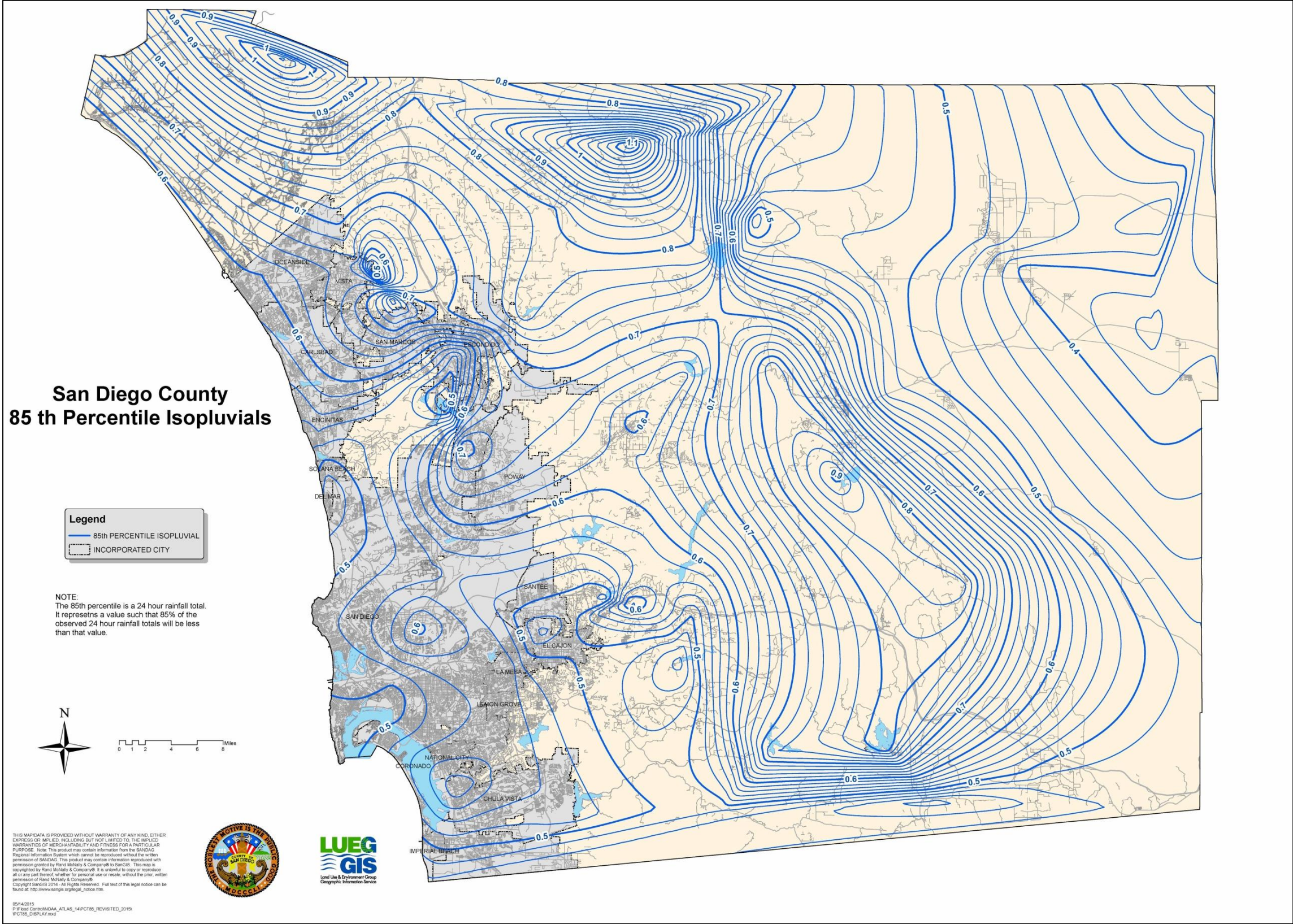


Figure B.1-1: 85th Percentile 24-hour Isopluvial Map

B.2 Adjustments to Account for Site Design BMPs

This section provides methods to adjust the DCV (for sizing pollutant control BMPs) as a result of implementing site design BMPs. The adjustments are provided by one of the following two methods:

- Adjustment to impervious runoff factor
- Adjustment to DCV

B.2.1 Adjustment to Impervious Runoff Factor

When one of the following site design BMPs is implemented the runoff factor of 0.9 for impervious surfaces identified in Table B.1-1 should be adjusted using the factors listed below and an adjusted area weighted runoff factor shall be estimated following guidance from Section B.1.1 and used to calculate the DCV.

- SD-5 Impervious area dispersion
- SD-6A Green roofs
- SD-6B Permeable pavement

B.2.1.1 Impervious area dispersion (SD-5)

Dispersion of impervious areas through pervious areas: The following adjustments are allowed to impervious runoff factors when dispersion is implemented in accordance with the SD-5 fact sheet (Appendix E). Adjustments are only credited up to a 4:1 maximum ratio of impervious to pervious areas. In order to adjust the runoff factor, the pervious area shall have a minimum width of 10 feet and a maximum slope of 5%. Based on the ratio of **impervious area to pervious area** and the hydrologic soil group of the pervious area, the adjustment factor from Table B.2-1 shall be multiplied with the unadjusted runoff factor (Table B.1-1) of the impervious area to estimate the adjusted runoff factor for sizing pollutant control BMPs. The adjustment factors in Table B.2-1 are only valid for impervious surfaces that have an unadjusted runoff factor of 0.9.

Table B.2-1: Impervious area adjustment factors that accounts for dispersion

Pervious area hydrologic soil group	Ratio = Impervious area/Pervious area			
	<=1	2	3	4
A	0.00	0.00	0.23	0.36
B	0.00	0.27	0.42	0.53
C	0.34	0.56	0.67	0.74
D	0.86	0.93	0.97	1.00

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Continuous simulation modeling in accordance with Appendix G is required to develop adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9. Approval of adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9 is at the discretion of the Port.

The adjustment factors in Table B.2-1 were developed by performing continuous simulations in SWMM with default parameters from Appendix G and impervious to pervious area ratios of 1, 2, 3, and 4. When using adjustment factors from Table B.2-1:

- **Linear interpolation** shall be performed if the impervious to pervious area ratio of the site is in between one of ratios for which an adjustment factor was developed;
- Use adjustment factor for a ratio of 1 when the impervious to pervious area ratio is less than 1; and
- Adjustment factor is not allowed when the impervious to pervious area ratio is greater than 4, when the pervious area is designed as a site design BMP.

Example B.2-1: DMA is comprised of one acre of impervious area that drains to a 0.4 acre hydrologic soil group B pervious area and then the pervious area drains to a BMP. Impervious area dispersion is implemented in the DMA in accordance with SD-5 factsheet. Estimate the adjusted runoff factor for the DMA.

- Baseline Runoff Factor per Table B.1-1 = $[(1*0.9+0.4*0.14)/1.4] = 0.68$.
- Impervious to Pervious Ratio = 1 acre impervious area/ 0.4 acre pervious area = 2.5; since the ratio is 2.5 adjustment can be claimed.
- From Table B.2-1 the adjustment factor for hydrologic soil group B and a ratio of 2 = 0.27; ratio of 3 = 0.42.
- Linear interpolated adjustment factor for a ratio of 2.5 = $0.27 + \{[(0.42 - 0.27)/(3-2)]*(2.5-2)\} = 0.345$.
- Adjusted runoff factor for the DMA = $[(1*0.9*0.345+0.4*0.14)/1.4] = 0.26$.
- Note only the runoff factor for impervious area is adjusted, there is no change made to the pervious area.

B.2.1.2 Green Roofs

When green roofs are implemented in accordance with the SD-6A factsheet the green roof footprint shall be assigned a runoff factor of 0.10 for adjusted runoff factor calculations.

B.2.1.3 Permeable Pavement

When a permeable pavement is implemented in accordance with the SD-6B factsheet and it does not have an impermeable liner and has storage greater than the 85th percentile depth below the underdrain, if an underdrain is present, then the footprint of the permeable pavement shall be assigned a runoff factor of 0.10 for adjusted runoff factor calculations.

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Permeable Pavement can also be designed as a structural BMP to treat run on from adjacent areas. Refer to INF-3 factsheet and Appendix B.4 for additional guidance.

B.2.2 Adjustment to DCV

When the following site design BMPs are implemented the anticipated volume reduction from these BMPs shall be deducted from the DCV to estimate the volume for which the downstream structural BMP should be sized for:

- SD-1: Street trees
- SD-8 Rain barrels

B.2.2.1 Street Trees

Street tree credit volume from tree trenches or boxes (tree BMPs) is a sum of three runoff reduction volumes provided by trees that decrease the required DCV for a tributary area. The following reduction in DCV is allowed per tree based on the mature diameter of the tree canopy, when trees are implemented in accordance with SD-1 factsheet and meet the following criteria:

- Total tree credit volume is less than 0.25DCV of the project footprint and
- Single tree credit volume is less than 400 ft³

Credit for trees that do not meet the above criteria shall be based on the criteria for sizing the tree as a storm water pollutant control BMP in SD-1 fact sheet.

Mature Tree Canopy Diameter (ft)	Tree Credit Volume (ft ³ /tree)
5	10
10	40
15	100
20	180
25	290
30	420

Basis for the reduction in DCV:

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Tree credit volume was estimated based on typical characteristics of street trees as follows:

It is assumed that each tree and associated trench or box is considered a single BMP, with calculations based on the media storage volume and/or the individual tree within the tree BMP as appropriate. Tree credit volume is calculated as:

$$TCV = TIV + TCIV + TETV$$

Where:

- TCV = Tree credit volume (ft³)
- TIV = Total infiltration volume of all storage layers within tree BMPs (ft³)
- $TCIV$ = Total canopy interception volume of all individual trees within tree BMPs (ft³)
- $TETV$ = Total evapotranspiration volume, sums the media evapotranspiration storage within each tree BMP (ft³)

Total infiltration volume was calculated as the total volume infiltrated within the BMP storage layers. Infiltration volume was assumed to be 20% of the total BMP storage layer volume, the available pore space in the soil volume (porosity – field capacity). Total canopy interception volume was calculated for all street trees within the tributary area as the average interception capacity for the entire mature tree total canopy projection area. Interception capacity was determined to be 0.04 inches for all street tree sizes, an average from the findings published by Breuer et al (2003) for coniferous and deciduous trees. Total evapotranspiration volume is the available evapotranspiration storage volume (field capacity – wilting point) within the BMP storage layer media. TEVT is assumed to be 10% of the minimum soil volume. The minimum soil volume as required by SD-1 fact sheet of 2 cubic feet per unit canopy projection area was assumed for estimating reduction in DCV.

B.2.2.2 Rain Barrels

Rain barrels are containers that can capture rooftop runoff and store it for future use. Credit can be taken for the full rain barrel volume when each barrel volume is smaller than 100 gallons, implemented per SD-8 fact sheet and meet the following criteria:

- Total rain barrel volume is less than 0.25 DCV and
- Landscape areas are greater than 30 percent of the project footprint.

Credit for harvest and use systems that do not meet the above criteria shall be based on the criteria in Appendix B.3 and HU-1 fact sheet.

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Worksheet B.2-1. DCV

Design Capture Volume		Worksheet B-2.1		
1	85 th percentile 24-hr storm depth from Figure B.1-1	d=		inches
2	Area tributary to BMP (s)	A=		acres
3	Area weighted runoff factor (estimate using Appendix B.1.1 and B.2.1)	C=		unitless
4	Street trees volume reduction	TCV=		cubic-feet
5	Rain barrels volume reduction	RCV=		cubic-feet
6	Calculate DCV = $(3630 \times C \times d \times A) - TCV - RCV$	DCV=		cubic-feet

B.3 Harvest and Use BMPs

The purpose of this section is to provide guidance for evaluating feasibility of harvest and use BMPs, calculating harvested water demand and sizing harvest and use BMPs.

B.3.1 Planning Level Harvest and Use Feasibility

Harvest and use feasibility should be evaluated at the scale of the entire project, and not limited to a single DMA. For the purpose of initial feasibility screening, it is assumed that harvested water collected from one DMA could be used within another. Types of non-potable water demand that may apply within a project include:

- Toilet and urinal flushing
- Irrigation
- Vehicle washing
- Evaporative cooling
- Dilution water for recycled water systems
- Industrial processes
- Other non-potable uses

Worksheet B.3-1 provides a screening process for determining the preliminary feasibility for harvest and use BMPs. This worksheet should be completed for the overall project.

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Worksheet B.3-1. Harvest and Use Feasibility Screening

Harvest and Use Feasibility Screening		Worksheet B.3-1
<p>1. Is there a demand for harvested water (check all that apply) at the project site that is reliably present during the wet season?</p> <p><input type="checkbox"/> Toilet and urinal flushing</p> <p><input type="checkbox"/> Landscape irrigation</p> <p><input type="checkbox"/> Other: _____</p>		
<p>2. If there is a demand; estimate the anticipated average wet season demand over a period of 36 hours. Guidance for planning level demand calculations for toilet/urinal flushing and landscape irrigation is provided in Section B.3.2.</p> <p>[Provide a summary of calculations here]</p>		
<p>3. Calculate the DCV using worksheet B-2.1.</p> <p>[Provide a results here]</p>		
<p>3a. Is the 36-hour demand greater than or equal to the DCV?</p> <p>Yes / No ➡</p> <p>↓</p>	<p>3b. Is the 36-hour demand greater than 0.25DCV but less than the full DCV?</p> <p>Yes / No ➡</p> <p>↓</p>	<p>3c. Is the 36-hour demand less than 0.25DCV?</p> <p>Yes</p> <p>↓</p>
<p>Harvest and use appears to be feasible. Conduct more detailed evaluation and sizing calculations to confirm that DCV can be used at an adequate rate to meet drawdown criteria.</p>	<p>Harvest and use may be feasible. Conduct more detailed evaluation and sizing calculations to determine feasibility. Harvest and use may only be able to be used for a portion of the site, or (optionally) the storage may need to be upsized to meet long term capture targets while draining in longer than 36 hours.</p>	<p>Harvest and use is considered to be infeasible.</p>

B.3.2 Harvested Water Demand Calculation

The following sections provide technical references and guidance for estimating the harvested water demand of a project. These references are intended to be used for the planning phase of a project for feasibility screening purposes.

B.3.2.1 Toilet and Urinal Flushing Demand Calculations

The following guidelines should be followed for computing harvested water demand from toilet and urinal flushing:

- If reclaimed water is planned for use for toilet and urinal flushing, then the demand for harvested storm water is equivalent to the total demand minus the reclaimed water supplied, and should be reduced by the amount of reclaimed water that is available during the wet season.
- Demand calculations for toilet and urinal flushing should be based on the average rate of use during the wet season for a typical year.
- Demand calculations should include changes in occupancy over weekends and around holidays and changes in attendance/enrollment over school vacation periods.
- For facilities with generally high demand, but periodic shut downs (e.g., for vacations, maintenance, or other reasons), a project specific analysis should be conducted to determine whether the long term storm water capture performance of the system can be maintained despite shut downs.
- Such an analysis should consider the statistical distributions of precipitation and demand, most importantly the relationship of demand to the wet seasons of the year.

Table B.3-1 provides planning level demand estimates for toilet and urinal flushing per resident, or employee, for a variety of project types. The per capita use per day is based on daily employee or resident usage. For non-residential types of development, the “visitor factor” and “student factor” (for schools) should be multiplied by the employee use to account for toilet and urinal usage for non-employees using facilities.

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Table B.3-1. Toilet and Urinal Water Usage per Resident or Employee

Land Use Type	Toilet User Unit of Normalization	Per Capita Use per Day		Visitor Factor ⁴	Water Efficiency Factor	Total Use per Resident or Employee
		Toilet Flushing ^{1, 2}	Urinals ³			
Residential	Resident	18.5	NA	NA	0.5	9.3
Office	Employee (non-visitor)	9.0	2.27	1.1	0.5	7 (avg)
Retail	Employee (non-visitor)	9.0	2.11	1.4	0.5	
Schools	Employee (non-student)	6.7	3.5	6.4	0.5	33
Various Industrial Uses (excludes process water)	Employee (non-visitor)	9.0	2	1	0.5	5.5

1 - Based on American Waterworks Association Research Foundation, 1999. Residential End Uses of Water. Denver, CO: AWWARF

2 - Based on use of 3.45 gallons per flush and average number of per employee flushes per subsector, Table D-1 for MWD (Pacific Institute, 2003)

3 - Based on use of 1.6 gallons per flush, Table D-4 and average number of per employee flushes per subsector, Appendix D (Pacific Institute, 2003)

4 - Multiplied by the demand for toilet and urinal flushing for the project to account for visitors. Based on proportion of annual use allocated to visitors and others (includes students for schools; about 5 students per employee) for each subsector in Table D-1 and D-4 (Pacific Institute, 2003)

5 - Accounts for requirements to use ultra low flush toilets in new development projects; assumed that requirements will reduce toilet and urinal flushing demand by half on average compared to literature estimates. Ultra low flush toilets are required in all new construction in California as of January 1, 1992. Ultra low flush toilets must use no more than 1.6 gallons per flush and Ultra low flush urinals must use no more than 1 gallon per flush. Note: If zero flush urinals are being used, adjust accordingly.

B.3.2.2 General Requirements for Irrigation Demand Calculations

The following guidelines should be followed for computing harvested water demand from landscape irrigation:

- If reclaimed water is planned for use for landscape irrigation, then the demand for harvested storm water should be reduced by the amount of reclaimed water that is available during the wet season.
- Irrigation rates should be based on the irrigation demand exerted by the types of landscaping that are proposed for the project, with consideration for water conservation requirements.
- Irrigation rates should be estimated to reflect the average wet season rates (defined as October through April) accounting for the effect of storm events in offsetting harvested water demand. In the absence of a detailed demand study, it should be assumed that irrigation demand is not present during days with greater than 0.1 inches of rain and the subsequent 3-day period. This irrigation shutdown period is consistent with standard practice in land application of wastewater and is applicable to storm water to prevent irrigation from resulting in dry weather

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runoff. Based on a statistical analysis of San Diego County rainfall patterns, approximately 30 percent of wet season days would not have a demand for irrigation.

- If land application of storm water is proposed (irrigation in excess of agronomic demand), then this BMP must be considered to be an infiltration BMP and feasibility screening for infiltration must be conducted. In addition, it must be demonstrated that land application would not result in greater quantities of runoff as a result of saturated soils at the beginning of storm events. Agronomic demand refers to the rate at which plants use water.

The following sections describe methods that should be used to calculate harvested water irrigation demand. While these methods are simplified, they provide a reasonable estimate of potential harvested water demand that is appropriate for feasibility analysis and project planning. These methods may be replaced by a more rigorous project-specific analysis that meets the intent of the criteria above.

B.3.2.2.1 Demand Calculation Method

This method is based on the San Diego Municipal Code Land Development Code Landscape Standards Appendix E which includes a formula for estimating a project's annual estimated total water use based on reference evaporation, plant factor, and irrigation efficiency.

For the purpose of calculating harvested water irrigation demand applicable to the sizing of harvest and use systems, the estimated total water use has been modified to reflect typical wet-season irrigation demand. This method assumes that the wet season is defined as October through April. This method further assumes that no irrigation water will be applied during days with precipitation totals greater than 0.1 inches or within the 3 days following such an event. Based on these assumptions and an analysis of Lake Wohlford, Lindbergh and Oceanside precipitation patterns, irrigation would not be applied during approximately 30 percent of days from October through April.

The following equation is used to calculate the Modified Estimated Total Water Usage:

$$\text{Modified ETWU} = \text{ET}_{\text{Wet}} \times \left[\left[\frac{\sum(\text{PF} \times \text{HA})}{\text{IE}} \right] + \text{SLA} \right] \times 0.015$$

Where:

Modified ETWU = Estimated daily average water usage during wet season

ET_{Wet} = Average reference evapotranspiration from October through April (use 2.8 inches per month, using CIMS Zone 4 from Table G.1-1)

PF = Plant Factor

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Table B.3-2. Planning Level Plant Factor Recommendations

Plant Water Use	Plant Factor	Also Includes
Low	< 0.1 – 0.2	Artificial Turf
Moderate	0.3 – 0.7	
High	0.8 and greater	Water features
Special Landscape Area	1.0	

HA = Hydrozone Area (sq-ft); A section or zone of the landscaped area having plants with similar water needs.

$\Sigma(PF \times HA)$ = The sum of PF x HA for each individual Hydrozone (accounts for different landscaping zones).

IE = Irrigation Efficiency (assume 90 percent for demand calculations)

SLA = Special Landscape Area (sq-ft); Areas used for active and passive recreation areas, areas solely dedicated to the production of fruits and vegetables, and areas irrigated with reclaimed water.

In this equation, the coefficient (0.015) accounts for unit conversions and shut down of irrigation during and for the three days following a significant precipitation event:

$$0.015 = (1 \text{ mo}/30 \text{ days}) \times (1 \text{ ft}/12 \text{ in}) \times (7.48 \text{ gal}/\text{cu-ft}) \times (\text{approximately } 7 \text{ out of } 10 \text{ days with irrigation demand from October through April})$$

B.3.2.2.2 Planning Level Irrigation Demands

To simplify the planning process, the method described above has been used to develop daily average wet season demands for a one-acre irrigated area based on the plant/landscape type. These demand estimates can be used to calculate the drawdown of harvest and use systems for the purpose of LID BMP sizing calculations.

Table B.3-3. Planning Level Irrigation Demand by Plant Factor and Landscape Type

General Landscape Type	36-Hour Planning Level Irrigation Demand (gallons per irrigated acre per 36 hour period)
Hydrozone – Low Plant Water Use	390
Hydrozone – Moderate Plant Water Use	1,470
Hydrozone – High Plant Water Use	2,640
Special Landscape Area	2,640

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B.3.2.3 Calculating Other Harvested Water Demands

Calculations of other harvested water demands should be based on the knowledge of land uses, industrial processes, and other factors that are project-specific. Demand should be calculated based on the following guidelines:

- Demand calculations should represent actual demand that is anticipated during the wet season (October through April).
- Sources of demand should only be included if they are reliably and consistently present during the wet season.
- Where demands are substantial but irregular, a more detailed analysis should be conducted based on a statistical analysis of anticipated demand and precipitation patterns.

B.3.3 Sizing Harvest and Use BMPs

Sizing calculations shall demonstrate that one of two equivalent performance standards is met:

1. Harvest and use BMPs are sized to drain the tank in 36 hours following the end of rainfall. The size of the BMP is dependent on the demand (Section B.3.2) at the site.
2. Harvest and use BMP is designed to capture at least 80 percent of average annual (long term) runoff volume.

It is rare cisterns can be sized to capture the full DCV and use this volume in 36 hours. So when using Worksheet B.3-1 if it is determined that harvest and use BMP is feasible then the BMP should be sized to the estimated 36-hour demand.

B.4 Infiltration BMPs

Sizing calculations shall demonstrate that one of two equivalent performance standards is met:

1. The BMP or series of BMPs captures the DCV and infiltrates this volume fully within 36 hours following the end of precipitation. This can be demonstrated through the Simple Method (Section B.4.1).
2. The BMP or series of BMPs infiltrates at least 80 percent of average annual (long term) runoff volume. This can be demonstrated using the percent capture method (Section B.4.2), through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to the Port. This method is **not** applicable for sizing biofiltration BMPs.

The methods to show compliance with these standards are provided in the following sections.

B.4.1 Simple Method

Stepwise Instructions:

1. Compute DCV using Worksheet B.4-1
2. Estimate design infiltration rate using Worksheet D.5-1
3. Design BMP(s) to ensure that the DCV is fully retained (i.e., no surface discharge during the design event) and the stored effective depth draws down in no longer than 36 hours.

Worksheet B.4-1: Simple Sizing Method for Infiltration BMPs

Simple Sizing Method for Infiltration BMPs		Worksheet B.4-1		
1	DCV (Worksheet B-2.1)	DCV=		cubic-feet
2	Estimated design infiltration rate (Worksheet D.5-1)	K_{design} =		in/hr
3	Available BMP surface area	A_{BMP} =		sq-ft
4	Average effective depth in the BMP footprint ($\text{DCV}/A_{\text{BMP}}$)	D_{avg} =		feet
5	Drawdown time, T ($D_{\text{avg}} * 12 / K_{\text{design}}$)	T=		hours
6	Provide alternative calculation of drawdown time, if needed.			

Notes:

- Drawdown time must be less than 36 hours. This criterion was set to achieve average annual capture of 80% to account for back to back storms (See rationale in Section B.4.3). In order to use a different drawdown time, BMPs should be sized using the percent capture method (Section B.4.2).
- The average effective depth calculation should account for any aggregate/media in the BMP. For example, 4 feet of stone at a porosity of 0.4 would equate to 1.6 feet of effective depth.
- This method may overestimate drawdown time for BMPs that drain through both the bottom and walls of the system. BMP specific calculations of drawdown time may be provided that account for BMP-specific geometry.

B.4.2 Percent Capture Method

This section describes the recommended method of sizing volume-based BMPs to achieve the 80 percent capture performance criterion. This method has a number of potential applications for sizing BMPs, including:

- Use this method when a BMP can draw down in less than 36 hours and it is desired to demonstrate that 80 percent capture can be achieved using a BMP volume smaller than the DCV.
- Use this method to determine how much volume (greater than the DCV) must be provided to achieve 80 percent capture when the drawdown time of the BMP exceeds 36 hours.
- Use this method to determine how much volume should be provided to achieve 80 percent capture when upstream BMP(s) have achieved some capture, but have not achieved 80 percent capture.

By nature, the percent capture method is an iterative process that requires some initial assumptions about BMP design parameters and subsequent confirmation that these assumptions are valid. For example, sizing calculations depend on the assumed drawdown time, which depends on BMP depth, which may in turn need to be adjusted to provide the required volume within the allowable footprint. In general, the selection of reasonable BMP design parameters in the first iteration will result in minimal required additional iterations. Figure B.4-1 presents the nomograph for use in sizing retention BMPs in San Diego County.

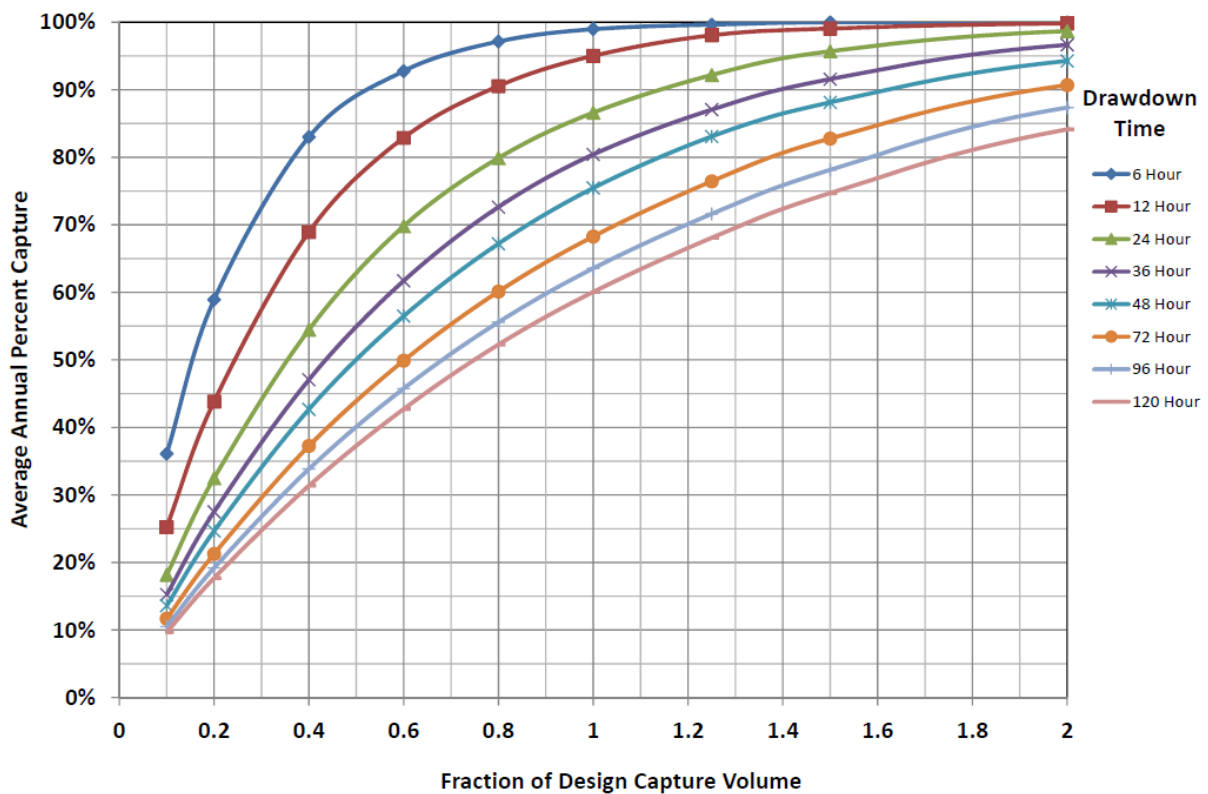


Figure B.4-1: Percent Capture Nomograph

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B.4.2.1 Stepwise Instructions for sizing a single BMP:

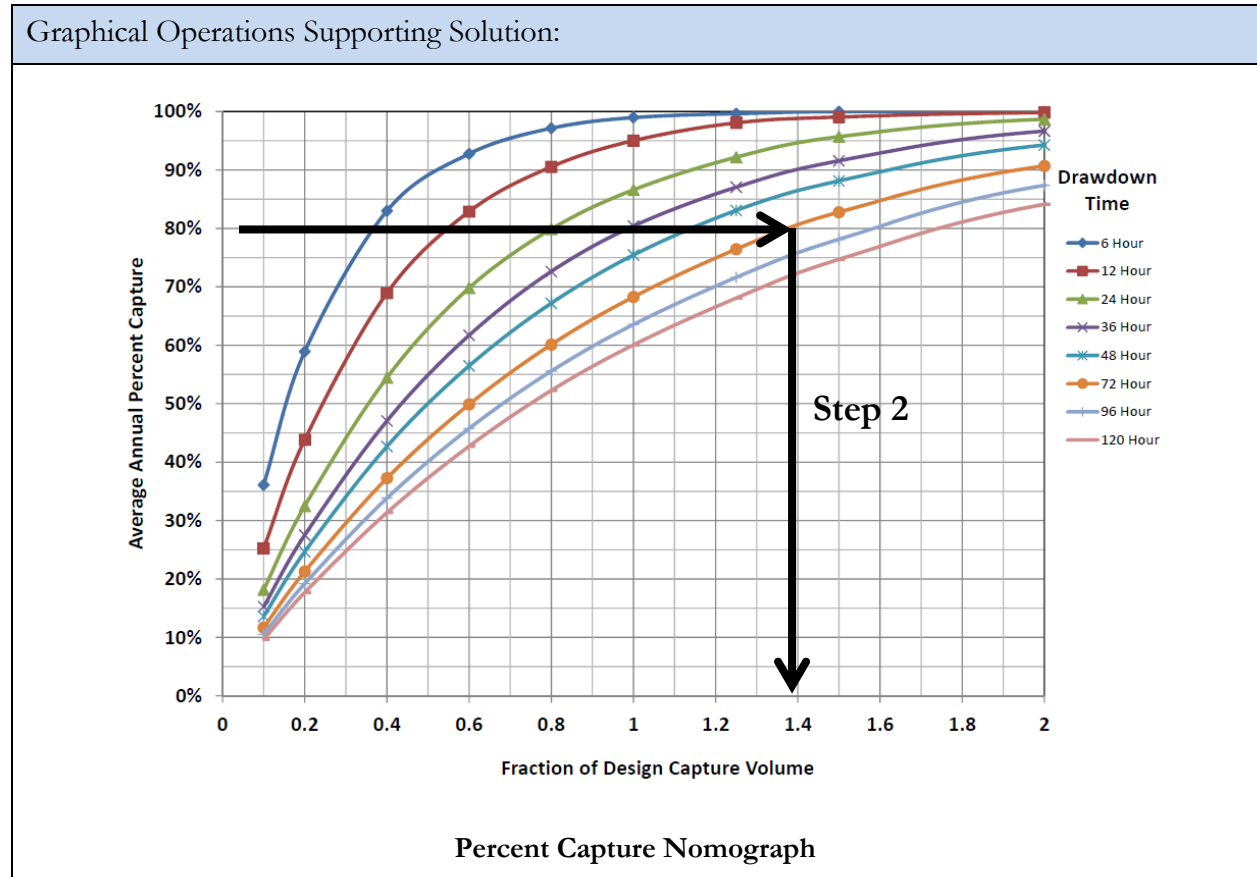
1. Estimate the drawdown time of the proposed BMP by estimating the design infiltration rate (Worksheet D.5-1) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time.
2. Using the estimated drawdown time and the nomograph from Figure B.4-1 locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the X axis and read the fraction of the DCV that needs to be provided in the BMP to achieve this level of capture.
3. Calculate the DCV using Worksheet B.2-1.
4. Multiply the result of Step 2 by the DCV (Step 3). This is the required BMP design volume.
5. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 1. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 1 and revise the initial drawdown time assumption.

See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time. The above method can also be used to size and/or evaluate the performance of other retention BMPs (evapotranspiration, harvest and use) that have a drawdown rate that can be approximated as constant throughout the year or over the wet season. In order to use this method for other retention BMPs, drawdown time in Step 1 will need to be evaluated using an applicable method for the type of BMP selected. After completing Step 1 continue to Step 2 listed above.

Example B.4.2.1 Percent Capture Method for Sizing a Single BMP:

Given:
<ul style="list-style-type: none">• Estimated drawdown time: 72 Hours• DCV: 3000 ft³
Required:
<ul style="list-style-type: none">• Determine the volume required to achieve 80 percent capture.
Solution:
<ol style="list-style-type: none">1. Estimated drawdown time = 72 Hours2. Fraction of DCV required = 1.353. DCV = 3000 ft³ (Given for this example; To be estimated using Worksheet B.2-1)4. Required BMP volume = 1.35 x 3000 = 4050 ft³5. Design BMP and confirm drawdown Time is \leq 90 Hours (72 Hours +25%)

Example B.4.2.1 Continued:



B.4.2.2 Stepwise Instructions for sizing BMPs in series:

For projects where BMPs in series have to be implemented to meet the performance standard the following stepwise procedure shall be used to size the downstream BMP to achieve the 80 percent capture performance criterion:

1. Using the upstream BMP parameters (volume and drawdown time) estimate the average annual capture efficiency achieved by the upstream BMP using the nomograph.
2. Estimate the drawdown time of the proposed downstream BMP by estimating the design infiltration rate (Worksheet D.5-1) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time. Use the nomograph and locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the horizontal axis and read the fraction of the DCV that needs to be provided in the BMP. This is referred to as X_1 .
3. Trace a horizontal line on the nomograph using the capture efficiency of the upstream BMP estimated in Step 1. Find where the line traced intersects with the drawdown time of the downstream BMP (Step 2). Pivot and read down to the horizontal axis to yield the fraction of the DCV already provided by the upstream BMP. This is referred to as X_2 .

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4. Subtract X_2 (Step 3) from X_1 (Step 2) to determine the fraction of the design volume that must be provided in the downstream BMP to achieve 80 percent capture to meet the performance standard.
5. Multiply the result of Step 4 by the DCV. This is the required downstream BMP design volume.
6. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 2. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 2 and revise the initial drawdown time assumption.

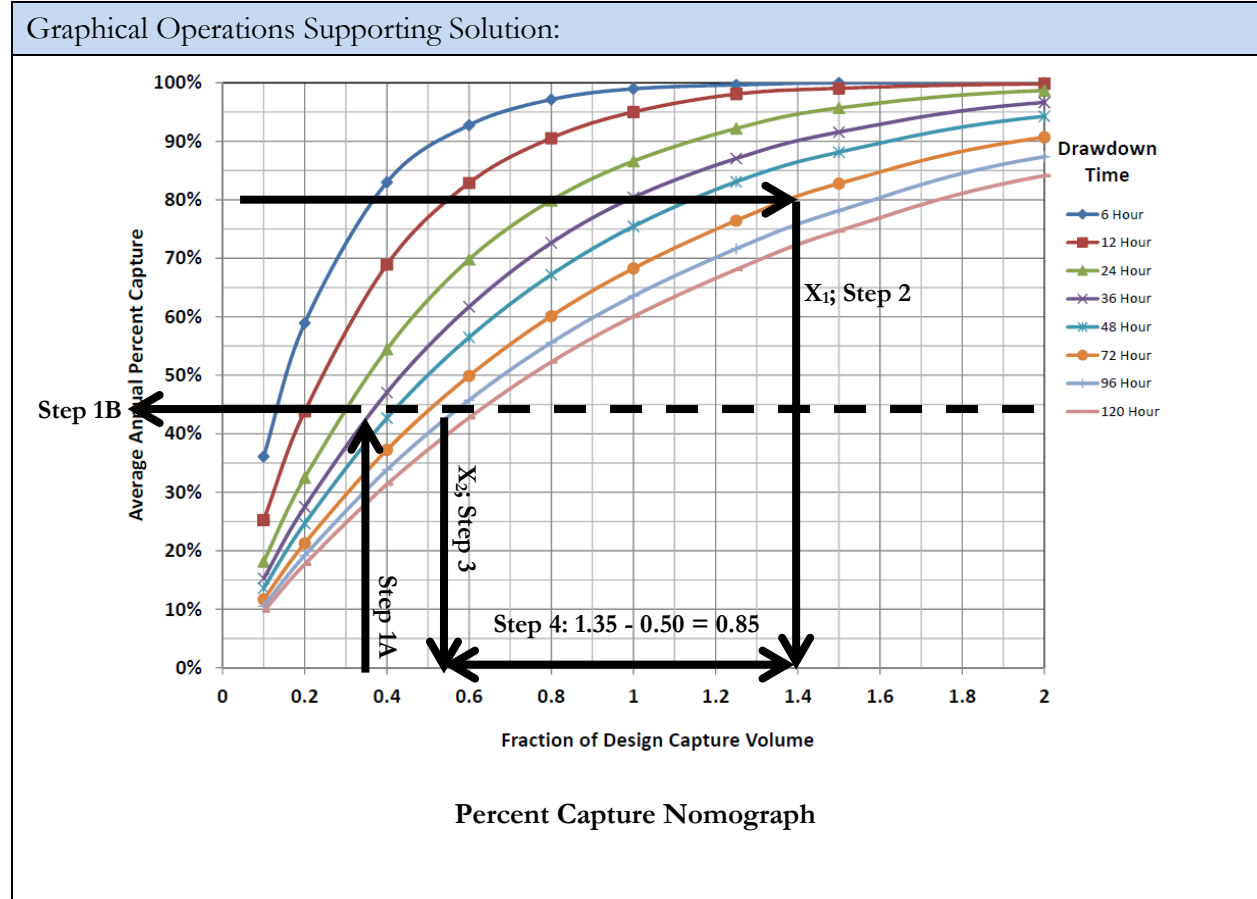
See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time.

Example B.4.2.2 Percent Capture Method for Sizing BMPs in Series:

Given:
<ul style="list-style-type: none"> Estimated drawdown time for downstream BMP: 72 Hours DCV for the area draining to the BMP: 3000 ft³ Upstream BMP volume: 900 ft³ Upstream BMP drawdown time: 24 Hours
Required:
<ul style="list-style-type: none"> Determine the volume required in the downstream BMP to achieve 80 percent capture.
Solution:
<ol style="list-style-type: none"> Step 1A: Upstream BMP Capture Ratio = $900/3000 = 0.3$; Step 1B: Average annual capture efficiency achieved by upstream BMP = 44% Downstream BMP drawdown = 72 hours; Fraction of DCV required to achieve 80% capture = 1.35 Locate intersection of design capture efficiency and drawdown time for upstream BMP (See Graph); Fraction of DCV already provided (X_2) = 0.50 (See Graph) Fraction of DCV Required by downstream BMP = $1.35 - 0.50 = 0.85$ DCV (given) = 3000 ft³; Required downstream BMP volume = $3000 \text{ ft}^3 \times 0.85 = 2,550 \text{ ft}^3$ Design BMP and confirm drawdown Time is ≤ 90 Hours (72 Hours +25%)

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Example B.4.2.2 Continued:



B.4.3 Technical Basis for Equivalent Sizing Methods

Storm water BMPs can be conceptualized as having a storage volume and a treatment rate, in various proportions. Both are important in the long-term performance of the BMP under a range of actual storm patterns, depths, and inter-event times. Long-term performance is measured by the operation of a BMP over the course of multiple years, and provides a more complete metric than the performance of a BMP during a single event, which does not take into account antecedent conditions, including multiple storms arriving in short timeframes. A BMP that draws down more quickly would be expected to capture a greater fraction of overall runoff (i.e., long-term runoff) than an identically sized BMP that draws down more slowly. This is because storage is made available more quickly, so subsequent storms are more likely to be captured by the BMP. In contrast a BMP with a long drawdown time would stay mostly full, after initial filling, during periods of sequential storms. The volume in the BMP that draws down more quickly is more “valuable” in terms of long term performance than the volume in the one that draws down more slowly. The MS4 permit definition of the DCV does not specify a drawdown time, therefore the definition is not a complete indicator of a

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BMP's level of performance. An accompanying performance-based expression of the BMP sizing standard is essential to ensure uniformity of performance across a broad range of BMPs and helps prevents BMP designs from being used that would not be effective.

An evaluation of the relationships between BMP design parameters and expected long term capture efficiency has been conducted to address the needs identified above. Relationships have been developed through a simplified continuous simulation analysis of precipitation, runoff, and routing, that relate BMP design volume and storage recovery rate (i.e., drawdown time) to an estimated long term level of performance using United States Environmental Protection Agency (USEPA) SWMM and parameters listed in Appendix G for Lake Wohlford, Lindbergh, and Oceanside rain gages. Comparison of the relationships developed using the three gages indicated that the differences in relative capture estimates are within the uncertainties in factors used to develop the relationships. For example, the estimated average annual capture for the BMP sized for the DCV and 36 hour drawdown using Lake Wohlford, Lindbergh, and Oceanside are 80%, 76% and 83% respectively. In an effort to reduce the number of curves that are made available, relationships developed using Lake Wohlford are included in this manual for use in the whole San Diego County region.

Figure B.4-1 demonstrated that a BMP sized for the runoff volume from the 85th percentile, 24-hour storm event (i.e., the DCV), which draws down in 36 hours is capable of managing approximately 80 percent of the average annual. There is long precedent for 80 percent capture of average annual runoff as approximately the point at which larger BMPs provide decreasing capture efficiency benefit (also known as the “knee of the curve”) for BMP sizing. The characteristic shape of the plot of capture efficiency versus storage volume in Figure B.4-1 illustrates this concept.

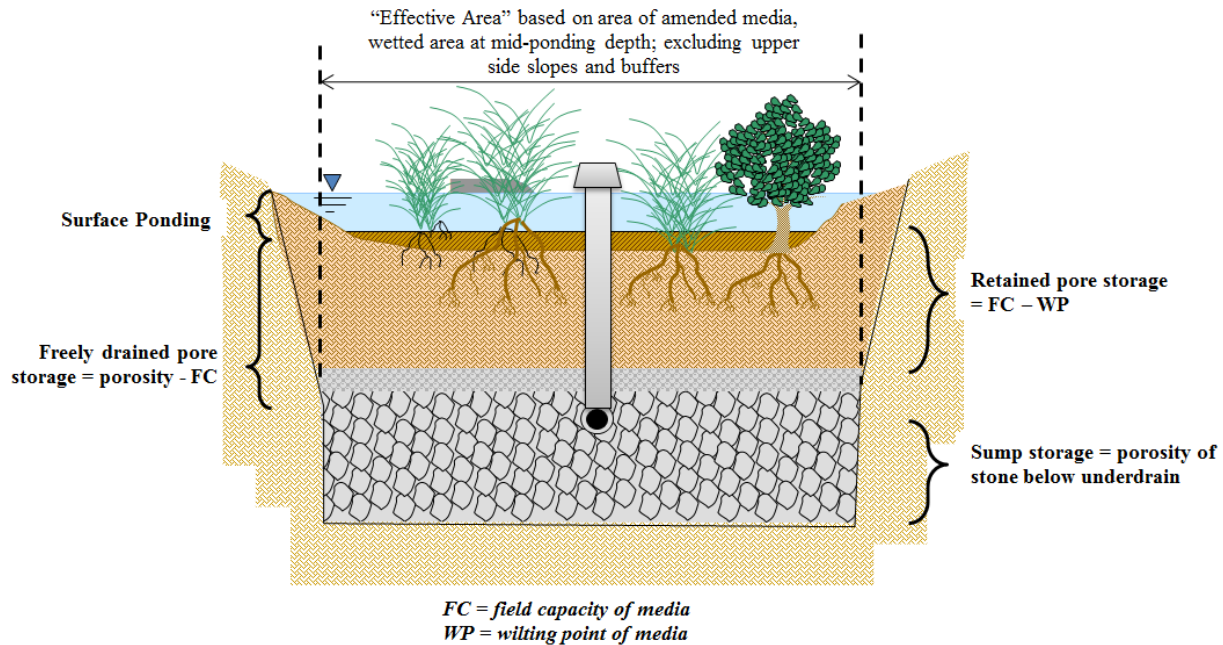
As such, this equivalency (between DCV draw down in 36-hours and 80 percent capture) has been utilized to provide a common currency between volume-based BMPs with a wide range of drawdown rates. This approach allows flexibility in the design of BMPs while ensuring consistent performance.

B.5 Biofiltration BMPs

Biofiltration BMPs shall be sized by one of the following sizing methods:

Option 1: Treat 1.5 times the portion of the DCV not reliably retained onsite, OR

Option 2: Treat 1.0 times the portion of the DCV not reliably retained onsite; and additionally check that the system has a total static (i.e., non-routed) storage volume, including pore spaces and pre-filter detention volume, equal to at least 0.75 times the portion of the DCV not reliably retained onsite.



Explanation of Biofiltration Volume Compartments for Sizing Purposes

Worksheet B.5-1 provides a simple sizing method for sizing biofiltration BMP with partial retention and biofiltration BMP.

When using sizing option 1 a routing period of 6 hours is allowed. The routing period was estimated based on 50th percentile storm duration for storms similar to 85th percentile rainfall depth. It was estimated based on inspection of continuous rainfall data from Lake Wohlford, Lindbergh and Oceanside rain gages.

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Worksheet B.5-1: Simple Sizing Method for Biofiltration BMPs

Simple Sizing Method for Biofiltration BMPs		Worksheet B.5-1 (Page 1 of 2)	
1	Remaining DCV after implementing retention BMPs		cubic-feet
Partial Retention			
2	Infiltration rate from Worksheet D.5-1 if partial infiltration is feasible		in/hr.
3	Allowable drawdown time for aggregate storage below the underdrain	36	hours
4	Depth of runoff that can be infiltrated [Line 2 x Line 3]		inches
5	Aggregate pore space	0.40	in/in
6	Required depth of gravel below the underdrain [Line 4/ Line 5]		inches
7	Assumed surface area of the biofiltration BMP		sq-ft
8	Media retained pore storage	0.1	in/in
9	Volume retained by BMP $[(\text{Line 4} + (\text{Line 12} \times \text{Line 8}))/12] \times \text{Line 7}$		cubic-feet
10	DCV that requires biofiltration [Line 1 – Line 9]		cubic-feet
BMP Parameters			
11	Surface Ponding [6 inch minimum, 12 inch maximum]		inches
12	Media Thickness [18 inches minimum], also add mulch layer thickness to this line for sizing calculations		inches
13	Aggregate Storage above underdrain invert (12 inches typical) – use 0 inches for sizing if the aggregate is not over the entire bottom surface area		inches
14	Media available pore space	0.2	in/in
15	Media filtration rate to be used for sizing (5 in/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate)	5	in/hr.
Baseline Calculations			
16	Allowable Routing Time for sizing	6	hours
17	Depth filtered during storm [Line 15 x Line 16]	30	inches
18	Depth of Detention Storage [Line 11 + (Line 12 x Line 14) + (Line 13 x Line 5)]		inches
19	Total Depth Treated [Line 17 + Line 18]		inches

Appendix B: Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

Worksheet B.5-1: Simple Sizing Method for Biofiltration BMPs (continued)

Simple Sizing Method for Biofiltration BMPs		Worksheet B.5-1 (Page 2 of 2)	
Option 1 – Biofilter 1.5 times the DCV			
20	Required biofiltered volume [1.5 x Line 10]		cubic-feet
21	Required Footprint [Line 20/ Line 19] x 12		sq-ft
Option 2 - Store 0.75 of remaining DCV in pores and ponding			
22	Required Storage (surface + pores) Volume [0.75 x Line 10]		cubic-feet
23	Required Footprint [Line 22/ Line 18] x 12		sq-ft
Footprint of the BMP			
24	Area draining to the BMP		sq-ft
25	Adjusted Runoff Factor for drainage area (Refer to Appendix B.1 and B.2)		
26	BMP Footprint Sizing Factor (Default 0.03 or an alternative minimum footprint sizing factor from Worksheet B.5-2, Line 11)		unitless
27	Minimum BMP Footprint [Line 24 x Line 25 x Line 26]		sq-ft
28	Footprint of the BMP = Maximum(Minimum(Line 21, Line 23), Line 27)		sq-ft
Check for Volume Reduction [Not applicable for No Infiltration Condition]			
29	Calculate the fraction of the DCV retained by the BMP [Line 9/ Line 1]		unitless
30	Minimum required fraction of DCV retained for partial infiltration condition	0.375	unitless
31	Is the retained DCV > 0.375? If the answer is no increase the footprint sizing factor in Line 26 until the answer is yes for this criterion.	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Note:

1. Line 7 is used to estimate the amount of volume retained by the BMP. Update assumed surface area in Line 7 until its equivalent to the required biofiltration footprint (either Line 21 or Line 23)
2. The DCV fraction of 0.375 is based on a 40% average annual percent capture and a 36-hour drawdown time.
3. The increase in footprint for volume reduction can be optimized using the approach presented in Appendix B.5.2. The optimized footprint cannot be smaller than the alternative minimum footprint sizing factor from Worksheet B.5-2.
4. If the proposed biofiltration BMP footprint is smaller than the alternative minimum footprint sizing factor from Worksheet B.5-2, but satisfies Option 1 or Option 2 sizing, it is considered a compact biofiltration BMP and may be allowed at the discretion of the Port, if it meets the requirements in Appendix F.

B.5.1 Basis for Minimum Sizing Factor for Biofiltration BMPs

B.5.1.1 Introduction

MS4 Permit Provision E.3.c.(1)(a)(i)

The MS4 Permit describes conceptual performance goals for biofiltration BMPs and specifies numeric criteria for sizing biofiltration BMPs (See Section 2.2.1 of this Manual).

However, the MS4 Permit does not define a specific footprint sizing factor or design profile that must be provided for the BMP to be considered “biofiltration.” Rather, the MS4 Permit specifies (Footnote 25):

As part of the Copermittee’s update to its BMP Design Manual, pursuant to Provision E.3.d, the Copermittee must provide guidance for hydraulic loading rates and other biofiltration design criteria necessary to maximize storm water retention and pollutant removal.

To meet this provision, this manual includes specific criteria for design of biofiltration BMPs. Among other criteria, a minimum footprint sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) is specified. The purpose of this section is to provide the technical rationale for this 3 percent minimum sizing factor.

B.5.1.2 Conceptual Need for Minimum Sizing Factor

Under the 2011 Model SUSMP, a sizing factor of 4 percent was used for sizing biofiltration BMPs. This value was derived based on the goal of treating the runoff from a 0.2 inch per hour uniform precipitation intensity at a constant media flow rate of 5 inches per hour. While this method was simple, it was considered to be conservative as it did not account for significant transient storage present in biofiltration BMPs (i.e., volume in surface storage and subsurface storage that would need to fill before overflow occurred). Under this manual, biofiltration BMPs will typically provide subsurface storage to promote infiltration losses; therefore typical BMP profiles will tend to be somewhat deeper than those provided under the 2011 Model SUSMP. A deeper profile will tend to provide more transient storage and allow smaller footprint sizing factors while still providing similar or better treatment capacity and pollutant removal. Therefore a reduction in the minimum sizing factor from the factor used in the 2011 Model SUSMP is supportable. However, as footprint decreases, issues related to potential performance, operations, and/or maintenance can increase for a number of reasons:

- 1) As the surface area of the media bed decreases, the sediment loading per unit area increases, increasing the risk of clogging. While vigorous plant growth can help maintain permeability

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of soil, there is a conceptual limit above which plants may not be able to mitigate for the sediment loading. Scientific knowledge is not conclusive in this area.

- 2) With smaller surface areas and greater potential for clogging, water may be more likely to bypass the system via overflow before filling up the profile of the BMP.
- 3) As the footprint of the system decreases, the amount of water that can be infiltrated from subsurface storage layers and evapotranspire from plants and soils tends to decrease.
- 4) With smaller sizing factors, the hydraulic loading per unit area increases, potentially reducing the average contact time of water in the soil media and diminishing treatment performance.

The MS4 Permit requires that volume and pollutant retention be maximized. Therefore, a minimum sizing factor was determined to be needed. This minimum sizing factor does not replace the need to conduct sizing calculations as described in this manual; rather it establishes a lower limit on required size of biofiltration BMPs as the last step in these calculations. Additionally, it does not apply to alternative biofiltration designs that utilize the checklist in Appendix F (Biofiltration Standard and Checklist). Acceptable alternative designs (such as proprietary systems meeting Appendix F criteria) typically include design features intended to allow acceptable performance with a smaller footprint and have undergone field scale testing to evaluate performance and required O&M frequency.

B.5.1.3 Lines of Evidence to Select Minimum Sizing Factor

Three primary lines of evidence were used to select the minimum sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) in this manual:

1. Typical design calculations.
2. Volume reduction performance.
3. Sediment clogging calculations.

These lines of evidence and associated findings are explained below.

Typical Design Calculations

A range of BMP profiles were evaluated for different design rainfall depths and soil conditions. Worksheet B.5-1 was used for each case to compute the required footprint sizing factor. For these calculations, the amount of water filtered during the storm event was determined based on a media filtration rate of 5 inches per hour and a routing time of 6 hours. These input assumptions are considered to be well-supported and consistent with the intent of the MS4 Permit. These calculations generally yielded footprint factors between 1.5 and 4.9 percent. In the interest of establishing a uniform County-wide minimum sizing factor, a 3 percent sizing factor was selected from this range, consistent with other lines of evidence.

Volume Reduction Performance

Consistent with guidance in Fact Sheet PR-1, the amount of retention storage (in gravel sump below

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underdrain) that would drain in 36 hours was calculated for a range of soil types. This was used to estimate the volume reduction that would be expected to be achieved. For a sizing factor of 3 percent and a soil filtration rate of 0.20 inches per hour, the average annual volume reduction was estimated to be approximately 40 percent (via percent capture method; see Appendix B.4.2).

In describing the basis for equivalency between retention and biofiltration (1.5 multiplier), the MS4 Permit Fact Sheet referred to analysis prepared in the Ventura County Technical Guidance Manual. The Ventura County analysis considered the pollutant treatment as well as the volume reduction provided by biofiltration in considering equivalency to retention. This analysis assumed an average long term volume reduction of 40 percent based on analysis of data from the International Stormwater BMP Database. The calculations of estimated volume reduction at a 3 percent sizing factor is (previous paragraph) consistent with this value. While estimated volume reduction is sensitive to site-specific factors, this analysis suggests that a sizing factor of approximately 3 percent provides levels of volume reduction that are reasonably consistent with the intent of the MS4 Permit.

Sediment Clogging Calculations

As sediment accumulates in a filter, the permeability of the filter tends to decline. The lifespan of the filter bed can be estimated by determining the rate of sediment loading per unit area of the filter bed. To determine the media bed surface area sizing factor needed to provide a target lifespan, simple sediment loading calculations were conducted based on typical urban conditions. The inputs and results of this calculation are summarized in Table B.5-1.

Table B.5-1: Inputs and Results of Clogging Calculation

Parameter	Value	Source
Representative TSS Event Mean Concentration, mg/L	100	Approximate average of San Diego Land Use Event Mean Concentrations from San Diego River and San Luis Rey River WQIP
Runoff Coefficient of Impervious Surface	0.90	Table B.1-1
Runoff Coefficient of Pervious Surface	0.10	Table B.1-1 for landscape areas
Imperviousness	40% to 90%	Planning level assumption, covers typical range of single family to commercial land uses
Average Annual Precipitation, inches	11 to 13	Typical range for much of urbanized San Diego County
Load to Initial Maintenance, kg/m ²	10	Pitt, R. and S. Clark, 2010. Evaluation of Biofiltration Media for Engineered Natural Treatment Systems.
Allowable period to initial clogging, yr	10	Planning-level assumption
Estimated BMP Footprint Needed for 10-Year Design Life	2.8 to 3.3%	Calculated

This analysis suggests that a 3 percent sizing factor, coupled with sediment source controls and careful

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system design, should provide reasonable protection against premature clogging. However, there is substantial uncertainty in sediment loading and the actual load to clog that will be observed under field conditions in the San Diego climate. Additionally this analysis did not account for the effect of plants on maintaining soil permeability. Therefore this line of evidence should be considered provisional, subject to refinement based on field scale experience. As field scale experience is gained about the lifespan of biofiltration BMPs in San Diego and the mitigating effects of plants on long term clogging, it may be possible to justify lower factors of safety and therefore smaller design sizes in some cases. If a longer lifespan is desired and/or greater sediment load is expected, then a larger sizing factor may be justified.

B.5.1.4 Discussion

Generally, the purpose of a minimum sizing factor is to help improve the performance and reliability of standard biofiltration systems and limit the use of sizing methods and assumptions that may lead to designs that are less consistent with the intent of the MS4 Permit.

Ultimately, this factor is a surrogate for a variety of design considerations, including clogging and associated hydraulic capacity, volume reduction potential, and treatment contact time. A prudent design approach should consider each of these factors on a project-specific basis and identify whether site conditions warrant a larger or smaller factor. For example a system treating only rooftop runoff in an area without any allowable infiltration may have negligible clogging risk and negligible volume reduction potential – a smaller sizing factor may not substantially reduce performance in either of these areas. Alternatively, for a site with high sediment load and limited pre-treatment potential, a larger sizing factor may be warranted to help mitigate potential clogging risks. The Port has discretion to accept alternative sizing factor(s) based on project-specific or jurisdiction-specific considerations. Additionally, the recommended minimum sizing factor may change over time as more experience with biofiltration is obtained.

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The worksheet B.5-2 below shall be used to support a request for an alternative minimum footprint sizing factor. Based on a review of the submitted worksheet and supporting documentation, the use of a smaller footprint sizing factor may be approved at the discretion of the Port. If approved, the estimated footprint from the worksheet below can be used in line 26 of worksheet B.5-1 in lieu of the 3 percent minimum footprint value.

This worksheet includes the following general steps to calculate the minimum footprint sizing factor:

- Select a “load to clog” that is representative of the type of BMP proposed
- Select a target life span (i.e., frequency of major maintenance) that is acceptable to the Port. A default value of 10 years is recommended.
- Compile information about the DMA from other parts of the SWQMP development process.
- Determine the event mean concentration (EMC) of TSS that is appropriate for the DMA
- Perform calculations to determine the minimum footprint to provide the target lifespan.

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Worksheet B.5-2: Calculation of Alternative Minimum Footprint Sizing Factor

Alternative Minimum Footprint Sizing Factor		Worksheet B.5-2 (Page 1 of 2)	
1	Area draining to the BMP		sq-ft
2	Adjusted Runoff Factor for drainage area (Refer to Appendix B.1 and B.2)		
3	Load to Clog ¹ (See Table B.5-2 for guidance; L _c)	2.0	lb/sq-ft
4	Allowable Period to Accumulate Clogging Load (T _L)	10	years
Volume Weighted EMC Calculation			
	Land Use	Fraction of Total DCV	TSS EMC (mg/L)
	Single Family Residential		123
	Commercial		128
	Industrial		125
	Education (Municipal)		132
	Transportation		78
	Multi-family Residential		40
	Roof Runoff		14
	Low Traffic Areas		50
	Open Space		216
	Other, specify:		
	Other, specify:		
	Other, specify:		
5	Volume Weighted EMC (sum of all products)		mg/L
BMP Parameters			
6	If pretreatment measures are included in the design, apply an adjustment of 25% ² [Line 5 x (1-0.25)]		mg/L
7	Average Annual Precipitation		inches
8	Calculate the Average Annual Runoff (Line 7 x 43,560/12) x Line 2	1	cu-ft/yr
9	Calculate the Average Annual TSS Load (Line 8 x 62.4 x Line 6)/10 ⁶		lb/yr
10	Calculate the BMP Footprint Needed (Line 9 x Line 4)/Line 3		sq-ft
11	Calculate the Alternative Minimum Footprint Sizing Factor [Line 10/ (Line 1 x Line 2)]		

¹ Load to clog value should be in the range of 2 – 5 lb/sq-ft per Pitt and Clark (2010). If selecting a value other than 2, a justification for the value selected is required. See guidance in Table B.5-2.

² A value of 25 percent is supported by Maniquiz-Redillas et al. (2014) study, which found a pretreatment sediment capture range of 15% - 35%. If using a value outside of this range, documentation of the selected value is required. A value of 50 percent can be claimed for a system with an active Washington State TAPE approval rating for “pre-treatment.”

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Table B.5-1: Typical land use total suspended solids (TSS) event mean concentration (EMC) values.

Land Use	TSS EMC ³ , mg/L
Single Family Residential	123
Commercial	128
Industrial	125
Education (Municipal)	132
Transportation ⁴	78
Multi-family Residential	40
Roof Runoff ⁵	14
Low Traffic Areas ⁶	50
Open Space	216

Table B.5-2: Guidance for Selecting Load to Clog (LC)

BMP Configuration	Load to Clog, L _c , lb/sq-ft
Baseline: Approximately 50 percent vegetative cover; typical fine sand and compost blend	2
Baseline + increase vegetative cover to at least 75 percent	3
Baseline + include coarser sand to increase initial permeability to 20 to 30 in/hr; control flowrate with outlet control	3
Baseline + increase vegetative cover and include more permeable media with outlet control, per above	4

References

- Charters, F.J., Cochrane, T.A., and O'Sullivan, A.D., (2015). Particle Size Distribution Variance in Untreated Urban Runoff and its implication on treatment selection. *Water Research*, 85 (2015), pg. 337-345.
- Davis, A.P. and McCuen, R.H., (2005). *Stormwater Management for Smart Growth*. Springer Science & Business Media, pg. 155.
- Maniquiz-Redillas, M.C., Geronimo, F.K.F, and Kim, L-H. Investigation on the Effectiveness of Pretreatment in Stormwater Management Technologies. *Journal of Environmental Sciences*, 26 (2014), pg. 1824-1830.
- Pitt, R. and Clark, S.E., (2010). *Evaluation of Biofiltration Media for Engineered Natural Treatment Systems*. Geosyntec Consultants and The Boeing Company.

³ EMCs are from SBPAT datasets for SLR and SDR Watersheds – Arithmetic Estimates of the Lognormal Summary Statistics for San Diego, unless otherwise noted.

⁴ EMCs are based on Los Angeles region default SBPAT datasets due to lack of available San Diego data.

⁵ Value represents the average first flush concentration for roof runoff (Charters et al., 2015).

⁶ Davis and McCuen (2005)

B.5.2 Sizing Biofiltration BMPs Downstream of a Storage Unit

B.5.2.1 Introduction

In scenarios, where the BMP footprint is governed based on Option 1 (Line 21 of Worksheet B.5-1) or the required volume reduction of 40% average annual (long term) runoff capture for partial infiltration conditions (Line 31 of Worksheet B.5.1) the footprint of the biofiltration BMP can be optimized using the sizing calculations in this Appendix B.5.2 when there is an upstream storage unit (e.g. cistern) that can be used to regulate the flows through the biofiltration BMP.

This methodology is **not** applicable when the minimum footprint factor is governed based on the alternative minimum footprint sizing factor calculated using Worksheet B.5-2 (Line 11). Biofiltration BMP smaller than the alternative minimum footprint sizing factor is considered compact biofiltration BMP and may be allowed at the discretion of the Port if the BMP meets the requirements in Appendix F **and** Option 1 or Option 2 sizing in Worksheet B.5-1.

B.5.2.2 Sizing Calculations

Sizing calculations for the biofiltration footprint shall demonstrate that one of two equivalent performance standards is met:

1. Use continuous simulation and demonstrate one of the following is met based on the infiltration condition identified in Chapter 5.4.2:
 - a. **No infiltration condition:** The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume. This can be demonstrated through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to the Port. The 92 percent of average annual runoff treatment corresponds to the average capture achieved by implementing a BMP with 1.5 times the DCV and a drawdown time of 36 hours (Appendix B.4.2).
 - b. **Partial infiltration condition:** The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume and achieves a volume reduction of at least 40 percent of average annual (long term) runoff volume. This can be demonstrated through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to the Port.
2. Use the simple sizing method in Worksheet B.5-3. The applicant is also required to complete Worksheet B.5-1 and B.5-2 when the applicant elects to use Worksheet B.5-3 to optimize the biofiltration BMP footprint. Worksheet B.5-3 was developed to satisfy the following two criteria as applicable:
 - a. Greater than 92 percent of the average annual runoff volume from the storage unit is routed to the biofiltration BMP through the low flow orifice and the peak flow from the low flow orifice can instantaneously be filtered through the biofiltration media. If the outlet design includes orifices at different elevations and an overflow structure,

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only flows from the overflow structure should be excluded from the calculation (both for 92 percent capture and for peak flow to the biofiltration BMP that needs to be instantaneously filtered), unless the flows from other orifices also bypass the biofiltration BMP, in which case flows from the orifices that bypass should also be excluded.

- b. The retention losses from the optimized biofiltration BMP is equal to or greater than the retention losses from the conventional biofiltration BMP. This second criterion is only applicable for partial infiltration condition.

Table B.5-3 Storage required for different drawdown times

Drawdown Time (hours)	Storage requirement (below the overflow elevation, or below outlet elevation that bypass the biofiltration BMP)
12	0.85 DCV
24	1.25 DCV
36	1.50 DCV
48	1.80 DCV
72	2.20 DCV
96	2.60 DCV
120	2.80 DCV

For drawdown times that are outside the range of values presented in Table B.5-4 above the storage unit should be designed to discharge greater than 92% average annual capture to the downstream Biofiltration BMP.

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Worksheet B.5-3: Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit

Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit		Worksheet B.5-3	
1	Area draining to the storage unit and biofiltration BMP		sq-ft
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	Effective impervious area draining to the storage unit and biofiltration BMP [Line 1 x Line 2]		sq-ft
4	Remaining DCV after implementing retention BMPs		cubic-feet
5	Infiltration rate from Worksheet D.5-1 if partial infiltration is feasible		ft/hr.
6	Media Thickness [1.5 feet minimum], also add mulch layer thickness to this line for sizing calculations		ft
7	Media filtration rate to be used for sizing (0.42 ft/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate)		ft/hr
8	Media retained pore storage	0.1	ft/ft
Storage Unit Requirement			
9	Drawdown time of the storage unit, minimum(from the elevation that bypasses the biofiltration BMP, overflow elevation)		hours
10	Storage required to achieve greater than 92 percent capture (see Table B.5-4)		fraction
11	Storage required in cubic feet (Line 4 x Line 10)		cubic-feet
12	Storage provided in the design, minimum(from the elevation that bypasses the biofiltration BMP, overflow elevation)		cubic-feet
13	Is Line 12 \geq Line 11. If no increase storage provided until this criteria is met	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Criteria 1: BMP Footprint Biofiltration Capacity			
14	Peak flow from the storage unit to the biofiltration BMP (using the elevation used to evaluate the percent capture)		cfs
15	Required biofiltration footprint [(3,600 x Line 14)/Line 7]		sq-ft
Criteria 2: Alternative Minimum Sizing Factor (Clogging)			
16	Alternative Minimum Footprint Sizing Factor [Line 11 of Worksheet B.5-2]		Fraction
17	Required biofiltration footprint [Line 3 x Line 16]		sq-ft
Criteria 3: Retention requirement [Not applicable for No Infiltration Condition]			
18	Conventional biofiltration footprint Line 28 of Worksheet B.5-1		sq-ft
19	Retention Losses from the conventional footprint (36 x Line 5 + Line 6 x Line 8) x Line 18		cubic-feet
20	Average discharge rate from the storage unit to the biofiltration BMP		cfs
21	Depth retained in the optimized biofiltration BMP {Line 6 x Line 8} + {(Line 4)/(2400 x Line 20)} x Line 5		ft
22	Required optimized biofiltration footprint (Line 19/Line 21)		sq-ft
Optimized Biofiltration Footprint			
23	Optimized biofiltration footprint, maximum(Line 15, Line 17, Line 22)		sq-ft

Note: Biofiltration BMP smaller than the alternative minimum footprint sizing (Line 17) is considered compact biofiltration BMP and may be allowed at the discretion of the Port if the BMP meets the requirements in Appendix F and Option 1 or Option 2 sizing in Worksheet B.5-1.

B.6 Flow-Thru Treatment Control BMPs (for use with Alternative Compliance)

The following methodology shall be used for selecting and sizing onsite flow-thru treatment control BMPs. These BMPs are to be used only when the project is participating in an alternative compliance program. This methodology consists of three steps:

- 1) Determine the PDP most significant pollutants of concern (Appendix B.6.1).
- 2) Select a flow-thru treatment control BMP that treats the PDP most significant pollutants of concern and meets the pollutant control BMP treatment performance standard (Appendix B.6.2).
- 3) Size the selected flow-thru treatment control BMP (Appendix B.6.3).

B.6.1 PDP Most Significant Pollutants of Concern

The following steps shall be followed to identify the PDP most significant pollutants of concern:

- 1) Compile the following information for the PDP and receiving water:
 - a. Receiving water quality (including pollutants for which receiving waters are listed as impaired under the Clean Water Act section 303(d) List; refer to Section 1.9);
 - b. Pollutants, stressors, and/or receiving water conditions that cause or contribute to the highest priority water quality conditions identified in the WQIP (refer to Section 1.9);
 - c. Land use type(s) proposed by the PDP and the storm water pollutants associated with the PDP land use(s) (see Table B.6–1).
- 2) From the list of pollutants identified in Step 1 identify the most significant PDP pollutants of concern. A PDP could have multiple most significant pollutants of concerns and shall include the highest priority water quality condition identified in the watershed WQIP and pollutants anticipated to be present onsite/generated from land use.

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TABLE B.6-1: Anticipated and Potential Pollutants Generated by Land Use Type

Priority Project Categories	General Pollutant Categories								
	Sediment	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development >one acre	P(1)	P(1)	X	P(2)	X	P(5)	X	P(3)	P(5)
Heavy Industry	X		X	X	X	X	X		
Automotive Repair Shops			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	P(1)
Hillside Development >5,000 ft ²	X	X			X	X	X		X
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Retail Gasoline Outlets			X	X	X	X	X		
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X	X	P(1)
<p>X = anticipated P = potential (1) A potential pollutant if landscaping exists onsite. (2) A potential pollutant if the project includes uncovered parking areas. (3) A potential pollutant if land use involves food or animal waste products. (4) Including petroleum hydrocarbons. (5) Including solvents.</p>									

B.6.2 Selection of Flow-Thru Treatment Control BMPs

The following steps shall be followed to select the appropriate flow-thru treatment control BMPs for the PDP:

- 1) For each PDP most significant pollutant of concern identify the grouping using Table B.6-2. Table B.6-2 is adopted from the Model SUSMP.
- 2) Select the flow-thru treatment control BMP based on the grouping of pollutants of concern that are identified to be most significant in Step 1. This section establishes the pollutant control BMP treatment performance standard to be met for each grouping of pollutants in order to meet the standards required by the MS4 permit and how an applicant can select a non-proprietary or a proprietary BMP that meets the established performance standard. The grouping of pollutants of concern are:
 - a. Coarse Sediment and Trash (Appendix B.6.2.1)
 - b. Pollutants that tend to associate with fine particles during treatment (Appendix B.6.2.2)
 - c. Pollutants that tend to be dissolved following treatment (Appendix B.6.2.3)

TABLE B.6-2: Grouping of Potential Pollutants of Concern

Pollutant	Coarse Sediment and Trash	Suspended Sediment and Particulate-bound Pollutants ¹	Soluble-form Dominated Pollutants ²
Sediment	X	X	
Nutrients			X
Heavy Metals		X	
Organic Compounds		X	
Trash & Debris	X		
Oxygen Demanding		X	
Bacteria		X	
Oil & Grease		X	
Pesticides		X	

¹ Pollutants in this category can be addressed to Medium or High effectiveness by effectively removing suspended sediments and associated particulate-bound pollutants. Some soluble forms of these pollutants will exist, however treatment mechanisms to address soluble pollutants are not necessary to remove these pollutants to a Medium or High effectiveness.

² Pollutants in this category are not typically addressed to a Medium or High level of effectiveness with particle and particulate-bound pollutant removal alone.

One flow-thru BMP can be used to satisfy the required pollutant control BMP treatment performance standard for the PDP most significant pollutants of concern. In some situations it might be necessary

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to implement multiple flow-thru BMPs to satisfy the pollutant control BMP treatment performance standards. For example, a PDP has trash, nutrients and bacteria as the most significant pollutants of concern. If a vegetated filter strip is selected as a flow-thru BMP then it is anticipated to meet the performance standard in Appendix B.6.2.2 and B.6.2.3 but would need a trash removal BMP to meet the pollutant control BMP treatment performance standard in Appendix B.6.2.1 upstream of the vegetated filter strip. This could be achieved by fitting the inlets and/or outlets with racks or screens on to address trash.

B.6.2.1 Coarse Sediment and Trash

If coarse sediment and/or trash and debris are identified as a pollutant of concern for the PDP, then BMPs must be selected to capture and remove these pollutants from runoff. The BMPs described below can be effective in removing coarse sediment and/or trash. These devices must be sized to treat the flow rate estimated using Worksheet B.6-1. Applicant can only select BMPs that have High or Medium effectiveness.

Trash Racks and Screens [Coarse Sediment: Low effectiveness; Trash: Medium to High effectiveness] are simple devices that can prevent large debris and trash from entering storm drain infrastructure and/or ensure that trash and debris are retained with downstream BMPs. Trash racks and screens can be installed at inlets to the storm drain system, at the inflow line to a BMP, and/or on the outflow structure from the BMP. Trash racks and screens are commercially available in many sizes and configurations or can be designed and fabricated to meet specific project needs.

Hydrodynamic Separation Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] are devices that remove coarse sediment, trash, and other debris from incoming flows through a combination of screening, settlement, and centrifugal forces. The design of hydrodynamic devices varies widely, more specific information can be found by contacting individual vendors. A list of hydrodynamic separator products approved by the Washington State Technology Acceptance Protocol-Ecology protocol can be found at:

<http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>.

Systems should be rated for “pretreatment” with a General Use Level Designation or provide results of field-scale testing indicating an equivalent level of performance.

Catch Basin Insert Baskets [Coarse Sediment: Low effectiveness; Trash: Medium effectiveness, if appropriately maintained] are manufactured filters, fabrics, or screens that are placed in inlets to remove trash and debris. The shape and configuration of catch basin inserts varies based on inlet type and configuration. Inserts are prone to clogging and bypass if large trash items are accumulated, and therefore require frequent observation and maintenance to remain effective. Systems with screen size small enough to retain coarse sediment will tend to clog rapidly and should be avoided.

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Other Manufactured Particle Filtration Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] include a range of products such as cartridge filters, bag filters, and other configurations that address medium to coarse particles. Systems should be rated for “pretreatment” with a General Use Level Designation under the Technology Acceptance Protocol-Ecology program or provide results of field-scale testing indicating an equivalent level of performance.

Note, any BMP that achieves Medium or High performance for suspended solids (See Section B.6.2.2) is also considered to address coarse sediments. However, some BMPs that address suspended solids do not retain trash (for example, swales and detention basins). These types of BMPs could be fitted with racks or screens on inlets or outlets to address trash.

BMP Selection for Pretreatment:

Devices that address both coarse sediment and trash can be used as pretreatment devices for other BMPs, such as infiltration BMPs. However, it is recommended that BMPs that meet the performance standard in Appendix B.6.2.2 be used. A device with a “pretreatment” rating and General Use Level Designation under Technology Acceptance Protocol-Ecology is required for pretreatment upstream of infiltration basins and underground galleries. Pretreatment may also be provided as presettling basins or forebays as part of a pollutant control BMP instead of implementing a specific pretreatment device for systems where maintenance access to the facility surface is possible (to address clogging), expected sediment load is not high, and appropriate factors of safety are included in design.

B.6.2.2 Suspended Sediment and Particulate-Bound Pollutants

Performance Standard

The pollutant treatment performance standard is shown in Table B.6-3. This performance standard is consistent with the Washington State Technology Acceptance Protocol-Ecology Basic Treatment Level, and is also met by technologies receiving Phosphorus Treatment or Enhanced Treatment certification. This standard is based on pollutant removal performance for total suspended solids. Systems that provide effective TSS treatment also typically address trash, debris, and particulate bound pollutants and can serve as pre-treatment for offsite mitigation projects or for onsite infiltration BMPs.

Table B.6-3: Performance Standard for Flow-Thru Treatment Control

Influent Range	Criteria
20 – 100 mg/L TSS	Effluent goal \leq 20 mg/L TSS
100 – 200 mg/L TSS	\geq 80% TSS removal
>200 mg/L TSS	> 80% TSS removal

Selecting Non-Proprietary BMPs

Table B.6-4 identifies the categories of non-proprietary BMPs that are considered to meet the pollutant treatment performance standard if designed to contemporary design standards⁷. BMP types with a “High” ranking should be considered before those with a “Medium” ranking. Statistical analysis by category from the International Stormwater BMP Database (also presented in Table B.6-4) indicates each of these BMP types (as a categorical group) meets or nearly meets the performance standard. The International Stormwater BMP Database includes historic as well as contemporary BMP studies; contemporary BMP designs in these categories are anticipated to meet or exceed this standard on average.

⁷ Contemporary design standards refers to design standards that are reasonably consistent with the current state of practice and are based on desired outcomes that are reasonably consistent with the context of the MS4 Permit and this manual. For example, a detention basin that is designed solely to mitigate peak flow rates would not be considered a contemporary water quality BMP design because it is not consistent with the goal of water quality improvement. Current state of the practice recognizes that a drawdown time of 24 to 72 hours is typically needed to promote settling. For practical purposes, design standards can be considered “contemporary” if they have been published within the last 10 years, preferably in California or Washington State, and are specifically intended for storm water quality management.

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Table B.6-4: Flow-Thru Treatment Control BMPs Meeting Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs	Statistical Analysis of International Stormwater BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TSS Mean Influent, mg/L	TSS Mean Effluent ¹ , mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc ² , mg/L	Volume-Adjusted Removal Efficiency ²	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	361/282	69	31	38%	19	72%	Medium, effluent < 20 mg/L after volume adjustment
Vegetated Swale	399/346	45	33	48%	17	61%	Medium, effluent < 20 mg/L after volume adjustment
Detention Basin	321/346	125	42	33%	28	77%	Medium, percent removal near 80% after volume adjustment
Sand Filter/Media Bed Filter	381/358	95	19	NA ³	19	80%	High, effluent and % removal meet criteria without adjustment
Lined Porous Pavement ⁴	356/220	229	46	NA ^{3,4}	46	80%	High, % removal meets criteria without adjustment
Wet Pond	923/933	119	31	NA ³	31	74%	Medium, percent removal near 80%

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

1 - A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories.

2 - Estimates were adjusted to account for category-average volume reduction.

3 - Not Applicable as these BMPs are not designed for volume reduction and are anticipated to have very small incidental volume reduction.

4 - The category presented in this table represents a lined system for flow-thru treatment purposes. Porous pavement for retention purposes is an infiltration BMP, not a flow-thru BMP. This table should not be consulted for porous pavement for infiltration.

Selecting Proprietary BMPs

Proprietary BMPs can be used if the BMP meets each of the following conditions:

- (1) The proposed BMP meets the performance standard in Appendix B.6.2.2 as certified through third-party, field scale evaluation.** An active General Use Level Designation for Basic Treatment, Phosphorus Treatment or Enhanced Treatment under the Washington State Technology Acceptance Protocol-Ecology program is the preferred method of demonstrating that the performance standard is met. The list of certified technologies is updated as new technologies are approved (link below). Technologies with Pilot Use Level Designation and Conditional Use Level Designations are not acceptable. Refer to:

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<http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>.

Alternatively, other field scale verification of 80 percent TSS capture, such as through Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing may be acceptable. A list of field-scale verified technologies under Technology Acceptance Reciprocity Partnership Tier II and New Jersey Corporation for Advance Testing can be accessed at: <http://www.njcat.org/verification-process/technology-verification-database.html> (refer to field verified technologies only).

- (2) **The proposed BMP is designed and maintained in a manner consistent with its performance certifications (see explanation below).** The applicant must demonstrate conclusively that the proposed application of the BMP is consistent with the basis of its certification/verification. Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification. It is common for these approvals to specify the specific model of BMP, design capacity for given unit sizes, type of media that is the basis for approval, and/or other parameters.
- (3) **The proposed BMP is acceptable at the discretion of the Port.** The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. In determining the acceptability of a proprietary flow-thru treatment control BMP, the Port should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the Port, a written explanation/reason will be provided to the applicant

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B.6.2.3 Soluble-form dominated Pollutants (Nutrients)

If nutrients are identified as a most significant pollutant of concern for the PDP, then BMPs must be selected to meet the performance standard described in Appendix B.6.2.2 and must be selected to provide medium or high level of effectiveness for nutrient treatment as described in this section. The most common nutrient of concern in the San Diego region is nitrogen, therefore total nitrogen (TN) was used as the primary indicator of nutrient performance in storm water BMPs.

Selection of BMPs to address nutrients consists of two steps:

- 1) Determine if nutrients can be addressed via source control BMPs as described in Appendix E and Chapter 4. After applying source controls, if there are no remaining source areas for soluble nutrients, then this pollutant can be removed from the list of pollutants of concerns for the purpose of selecting flow-thru treatment control BMPs. Particulate nutrients will be addressed by the performance standard in Appendix B.6.2.2.
- 2) If soluble nutrients cannot be fully addressed with source controls, then select a flow-thru treatment control BMPs that meets the performance criteria in Table B.6-5 or select from the nutrient-specific menu of treatment control BMPs in Table B.6-6.
 - a. The performance standard for nitrogen removal (Table B.6-5) has been developed based on evaluation of the relative performance of available categories of non-proprietary BMPs.
 - b. For proprietary BMPs, submit third party performance data indicating that the criteria in Table B.6-5 are met. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. In determining the acceptability of a proprietary flow-thru treatment control BMP, the Port should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the Port, a written explanation/reason will be provided to the applicant

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Table B.6-5: Performance Standard for Flow-Thru Treatment Control BMPs for Nutrient Treatment

Basis	Criteria
Treatment Basis	Comparison of mean influent and effluent indicates significant concentration reduction of TN approximately 40 percent or higher based on studies with representative influent concentrations
Combined Treatment and Volume Reduction Basis	Combination of concentration reduction and volume reduction yields TN mass removal of approximately 40 percent or higher based on studies with representative influent concentrations

Table B.6-6: Flow-Thru Treatment Control BMPs Meeting Nutrient Treatment Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs for Nutrients	Statistical Analysis of International Stormwater BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TN Mean Influent, mg/L	TN Mean Effluent ¹ , mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc ² , mg/L	Volume-Adjusted Removal Efficiency ²	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	138/ 122	1.53	1.37	38%	0.85	44%	Medium, if designed to include volume reduction processes
Detention Basin	90/ 89	2.34	2.01	33%	1.35	42%	Medium, if designed to include volume reduction processes
Wet Pond	397/ 425	2.12	1.33	NA	1.33	37%	Medium, best concentration reduction among BMP categories, but limited volume reduction

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

1 - A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories included.

2 - Estimates were adjusted to account for category-average volume reduction.

B.6.3 Sizing Flow-Thru Treatment Control BMPs:

Flow-thru treatment control BMPs shall be sized to filter or treat the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The required flow-thru treatment rate should be adjusted for the portion of the DCV already retained or biofiltered onsite as described in Worksheet B.6-1. The following hydrologic method shall be used to calculate the flow rate to be filtered or treated:

$$Q = C \times i \times A$$

Where:

Q = Design flow rate in cubic feet per second

C = Runoff factor, area-weighted estimate using Table B.1-1.

i = Rainfall intensity of 0.2 in/hr.

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Section 3.3.3 for additional guidance. Street projects consult Section 1.4.3.

Worksheet B.6-1: Flow-Thru Design Flows

Flow-thru Design Flows		Worksheet B.6-1		
1	DCV	DCV		cubic-feet
2	DCV retained	DCV _{retained}		cubic-feet
3	DCV biofiltered	DCV _{biofiltered}		cubic-feet
4	DCV requiring flow-thru (Line 1 – Line 2 – 0.67*Line 3)	DCV _{flow-thru}		cubic-feet
5	Adjustment factor (Line 4 / Line 1)*	AF=		unitless
6	Design rainfall intensity	i=	0.20	in/hr
7	Area tributary to BMP (s)	A=		acres
8	Area-weighted runoff factor (estimate using Appendix B.2)	C=		unitless
9	Calculate Flow Rate = AF x (C x i x A)	Q=		cfs

- 1) Adjustment factor shall be estimated considering only retention and biofiltration BMPs located upstream of flow-thru BMPs. That is, if the flow-thru BMP is upstream of the project's retention and biofiltration BMPs then the flow-thru BMP shall be sized using an adjustment factor of 1.
- 2) Volume based (e.g., dry extended detention basin) flow-thru treatment control BMPs shall be sized to the volume in Line 4 and flow based (e.g., vegetated swales) shall be sized to flow rate in Line 9. Sand filter and media filter can be designed either by volume in Line 4 or flow rate in Line 9.
- 3) Proprietary BMPs, if used, shall provide certified treatment capacity equal to or greater than the calculated flow rate in Line 9; certified treatment capacity per unit shall be consistent with third party certifications.

BMP DESIGN MANUAL

Geotechnical and Groundwater Investigation Requirements

Appendix C Geotechnical and Groundwater Investigation Requirements

C.1 Purpose and Phasing

Feasibility of storm water infiltration is dependent on the geotechnical and groundwater conditions at the project site.

This appendix provides guidelines for performing and reporting feasibility analysis for infiltration with respect to geotechnical and groundwater conditions. It provides framework for feasibility analysis at two phases of project development:

- **Planning Phase:** Simpler methods for conducting preliminary screening for feasibility/infeasibility, and
- **Design Phase:** When infiltration is considered potentially feasible, more rigorous analysis is needed to confirm feasibility and to develop design considerations and mitigation measures if required

Planning Phase At this stage of the project, information about the site may be limited, the proposed design features may be conceptual, and there may be an opportunity to adjust project plans to incorporate infiltration into the project layout as it is developed. At this phase, project geotechnical engineers are typically responsible for conducting explorations of geologic conditions, performing preliminary analyses, and identifying particular aspects of design that require more detailed investigation at later phases. As part of this process, the role of a planning- level infiltration feasibility assessment is to help planners reach early tentative conclusions regarding where infiltration is likely feasible, possibly feasible if done carefully, or clearly infeasible. This determination can help guide the design process by influencing project layout, selection of infiltration BMPs, and identifying if more detailed studies are necessary. The goal of the planning and feasibility phase is to identify potential geotechnical and groundwater impacts and to determine which impacts may be considered fatal flaws and which impacts may be possible to mitigate with design features. Determination of acceptable risks and/or mitigation measures may involve discussions with adjacent land owners and/or utility operators, as well as coordination with other projects under planning or design in the project vicinity. Early involvement of potentially impacted parties is critical to avoid late-stage design changes and schedule delays and to reduce potential future liabilities.

Design Phase During this phase, potential geotechnical and groundwater impacts must be fully considered and evaluated and mitigation measures should be incorporated in the BMP design, as appropriate. Mitigation measures refer to design features or assumptions intended to reduce risks associated with storm water infiltration. While rules of thumb may be useful, if applied carefully, for

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the planning level phase, the analyses conducted in the detailed design phase require the involvement of a geotechnical professional familiar with the local conditions. One of the first steps in the design phase should be determination if additional field and/or laboratory investigations are required (e.g., borings, test pits, laboratory or field testing) to further assess the geotechnical impacts of storm water infiltration. As the design of infiltration systems are highly dependent on the subsurface conditions, coordination with the storm water design team may be beneficial to limit duplicative efforts and costs.

Worksheet C.4-1 is provided to document infiltration feasibility screening. This worksheet is divided into two parts. Part 1 “Full Infiltration Feasibility Screening Criteria” is used to determine if the full design volume can be infiltrated onsite, whereas Part 2 “Partial Infiltration versus No Infiltration Screening Criteria” is used to determine if any amount of volume can be infiltrated.

Note that it is not necessary to investigate each and every criterion in the worksheet, a single “no” answer in Part 1 and Part 2 controls the feasibility and desirability. If all the answers in Part 1 are “yes” then it is not required to complete Part 2. The same worksheet could be used to document both planning-level categorization and design-level categorization. Note that planning-level categorization, are typically based on initial site assessment results; therefore it is not necessarily conclusive. Categorizations should be confirmed or revised, as necessary, based on more detailed design-level investigation and analysis during BMP design.

C.2 Geotechnical Feasibility Criteria

This section is divided into seven factors that should be considered, as applicable, while assessing the feasibility and desirability of infiltration related to geotechnical conditions. Note that during the planning phase, if one or more of these factors precludes infiltration as an approach, it is not necessary to assess every other factor. However, if proposing infiltration BMPs, then every applicable factor in this section must be addressed.

C.2.1 Soil and Geologic Conditions

Site soils and geologic conditions influence the rate at which water can physically enter the soils. Site assessment approaches for soil and geologic conditions may consist of:

- Review of soil survey maps
- Review of available reports on local geology to identify relevant features, such as depth to bedrock, rock type, lithology, faults, and hydrostratigraphic or confining units
- Review of previous geotechnical investigations of the area
- Site-specific geotechnical and/or geologic investigations (e.g., borings, infiltration tests)

Geologic investigations should also seek to provide an assessment of whether soil infiltration

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properties are likely to be uniform or variable across the project site. Appendix D provides guidance on determining infiltration rates for planning and design phase.

C.2.2 Settlement and Volume Change

Settlement and volume change limits the amount of infiltration that can be allowed without resulting in adverse impacts that cannot be mitigated. Upon considering the impacts of an infiltration design, the designer must identify areas where soil settlement or heave is likely and whether these conditions would be unfavorable to existing or proposed features. Settlement refers to the condition when soils decrease in volume, and heave refers to expansion of soils or increase in volume.

There are several different mechanisms that can induce volume change due to infiltration that the professional must be aware of and consider while completing the feasibility screening including:

- Hydro collapse and calcareous soils;
- Expansive soils;
- Frost heave;
- Consolidation; and
- Liquefaction.

C.2.3 Slope Stability

Infiltration of water has the potential to result in an increased risk of slope failure of nearby slopes. This should be assessed as part of both the feasibility and design stages of a project. There are many factors that impact the stability of slopes, including, but not limited to, slope inclination, soil and unit weight and seepage forces. Increases in moisture content or rising of the water table in the vicinity of a slope, which may result from storm water infiltration, have the potential to change the soil strength and unit weight and to add seepage forces to the slope, which in turn, may reduce the factor of safety of the stability of the slope. When evaluating the effect of infiltration on the design of a slope, the designer must consider all types of potential slope failures.

C.2.4 Utility Considerations

Utilities are either public or private infrastructure components that include underground pipelines and vaults (e.g., potable water, sewer, storm water, gas pipelines), underground wires/conduit (e.g., telephone, cable, electrical) and above ground wiring and associated structures (e.g., electrical distribution and transmission lines). Utility considerations are typically within the purview of a geotechnical site assessment and should be considered in assessing the feasibility of storm water infiltration. Infiltration has the potential to damage subsurface utilities and/or underground utilities may pose geotechnical hazards in themselves when infiltrated water is introduced. Impacts related to storm water infiltration in the vicinity of underground utilities are not likely to cause a fatal flaw in the

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design, but the designer must be aware of the potential cost impacts to the design during the planning stage.

C.2.5 Groundwater Mounding

Storm water infiltration and recharge to the underlying groundwater table may create a groundwater mound beneath the infiltration facility. The height and shape of the mound depends on the infiltration system design, the recharge rate, and the hydrogeologic conditions at the site, especially the horizontal hydraulic conductivity and the saturated thickness. Elevated groundwater levels can lead to a number of problems, including flooding and damage to structures and utilities through buoyancy and moisture intrusion, increase in inflow and infiltration into municipal sanitary sewer systems, and flow of water through existing utility trenches, including sewers, potentially leading to formation of sinkholes (Gobel et al. 2004). Mounding shall be considered by the geotechnical professional while performing the infiltration feasibility screening.

C.2.6 Retaining Walls and Foundations

Development projects may include retaining walls or foundations in close proximity to proposed infiltration BMPs. These structures are designed to withstand the forces of the earth they are retaining and other surface loading conditions such as nearby structures. Foundations include shallow foundations (spread and strip footings, mats) and deep foundations (piles, piers) and are designed to support overburden and design loads. All types of retaining walls and foundations can be impacted by increased water infiltration into the subsurface as a result of potential increases in lateral pressures and potential reductions in soil strength. The geotechnical professional should consider these factors while performing the infiltration feasibility screening.

C.2.7 Other Factors

While completing the feasibility screening, other factors determined by the geotechnical professional to influence the feasibility and desirability of infiltration related to geotechnical conditions shall also be considered.

C.3 Groundwater Quality and Water Balance Feasibility Criteria

This section is divided into eight factors that should be considered, to the extent applicable, while assessing the feasibility and desirability of infiltration related to groundwater quality and water balance. Note that during the planning phase, if one or more of these factors precludes infiltration as an approach, it is not necessary to assess every other factor. However, if proposing infiltration BMPs, then every applicable factor in this section must be addressed.

C.3.1 Soil and Groundwater Contamination

Infiltration shall be avoided in areas with:

- Physical and chemical characteristics (e.g., appropriate cation exchange capacity, organic content, clay content and infiltration rate) which are not adequate for proper infiltration durations and treatment of runoff for the protection of groundwater beneficial uses.
- Groundwater contamination and/or soil pollution, if infiltration could contribute to the movement or dispersion of soil or groundwater contamination or adversely affect ongoing clean-up efforts, either onsite or down-gradient of the project.

If infiltration is under consideration for one of the above conditions, a site-specific analysis should be conducted to determine where infiltration-based BMPs can be used without adverse impacts.

C.3.2 Separation to Seasonal High Groundwater

The depth to seasonally high groundwater tables (normal high depth during the wet season) beneath the base of any infiltration BMP must be greater than 10 feet for infiltration BMPs to be allowed. The depth to groundwater requirement can be reduced from 10 feet at the discretion of the approval agency if the underlying groundwater basin does not support beneficial uses and the groundwater quality is maintained at the proposed depth. Depth to seasonally high groundwater levels can be estimated based on well level measurements or redoximorphic methods. For sites with complex groundwater tables, long term studies may be needed to understand how groundwater levels change in wet and dry years.

C.3.3 Wellhead Protection

Wellheads natural and man-made are water resources that may potentially be adversely impacted by storm water infiltration through the introduction of contaminants or alteration in water supply and levels. It is recommended that the locations of wells and springs be identified early in the design process and site design be developed to avoid infiltration in the vicinity of these resources. Infiltration BMPs must be located a minimum of 100 feet horizontally from any water supply well.

C.3.4 Contamination Risks from Land Use Activities

Concentration of storm water pollutants in runoff is highly dependent on the land uses and activities present in the area tributary to an infiltration BMP. Likewise, the potential for groundwater contamination due to the infiltration BMP is a function of pollutant abundance, concentration of pollutants in soluble forms, and the mobility of the pollutant in the subsurface soils. Hence infiltration

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BMPs must not be used for areas of industrial or light industrial activity unless source control BMPs to prevent exposure of high threat activities are implemented, or runoff from such activities is first treated or filtered to remove pollutants prior to infiltration.

C.3.5 Consultation with Applicable Groundwater Agencies

Infiltration activities should be coordinated with the applicable groundwater management agency, such as groundwater providers and/or resource protection agencies, to ensure groundwater quality is protected. It is recommended that coordination be initiated as early as possible during the planning process to determine whether specific site assessment activities apply or whether these agencies have data available that may support the planning and design process.

C.3.6 Water Balance Impacts on Stream Flow

Use of infiltration systems to reduce surface water discharge volumes may result in additional volume of deeper infiltration compared to natural conditions, which may result in impacts to receiving channels associated with change in dry weather flow regimes. A relatively simple survey of hydrogeologic data (piezometer measurements, boring logs, regional groundwater maps) and downstream receiving water characteristics is generally adequate to determine whether there is potential for impacts and whether a more rigorous assessment is needed.

Where water balance conditions appear to be sensitive to development impacts and there is an elevated risk of impacts, a computational analysis may be warranted to evaluate the feasibility/desirability of infiltration. Such an analysis should account for precipitation, runoff, irrigation inputs, soil moisture retention, evapotranspiration, baseflow, and change in groundwater recharge on a long term basis. Because water balance calculations are sensitive to the timing of precipitation versus evapotranspiration, it is most appropriate to utilize a continuous model simulation rather than basing calculations on average annual or monthly normal conditions.

C.3.7 Downstream Water Rights

While water rights cases are not believed to be common, there may be cases in which infiltration of water from area that was previously allowed to drain freely to downstream water bodies would not be legal from a water rights perspective. Site-specific evaluation of water rights laws should be conducted if this is believed to be a potential issue in the project location.

C.3.8 Other Factors

While completing the feasibility screening, other factors determined by the geotechnical professional to influence the feasibility and desirability of infiltration related to groundwater quality and water

balance shall also be considered.

C.4 Geotechnical and Groundwater Investigation Report Requirements

The geotechnical and groundwater investigation report(s) addressing onsite storm water infiltration shall include the following elements, as applicable. These reports may need to be completed by multiple professional disciplines, depending on the issues that need be addressed for a given site. It may also be necessary to prepare separate report(s) at the planning phase and design phase of a project if the methods and timing of analyses differ.

C.4.1 Site Evaluation

Site evaluation shall identify the following:

- Areas of contaminated soil or contaminated groundwater within the site;
- “Brown fields” adjacent to the site;
- Mapped soil type(s);
- Historic high groundwater level;
- Slopes steeper than 25 percent; and
- Location of water supply wells, septic systems (and expansion area), or underground storage tanks, or permitted gray water systems within 100 feet of a proposed infiltration/ percolation BMP.

C.4.2 Field Investigation

Where the site evaluation indicates potential feasibility for onsite storm water infiltration BMPs, the following field investigations will be necessary to demonstrate suitability and to provide design recommendations.

C.4.2.1 Subsurface Exploration

Subsurface exploration and testing for storm water infiltration BMPs shall include:

- A minimum of two exploratory excavations shall be conducted within 50-feet of each proposed storm water infiltration BMP. The excavations shall extend at least 10 feet below the lowest elevation of the base of the proposed infiltration BMP.
- Soils shall be logged in detail with emphasis on describing the soil profile.
- Identify low permeability or impermeable materials.

Appendix C: Geotechnical and Groundwater Investigation Requirements

- Indicate any evidence of soil contamination.

C.4.2.2 Material Testing and Infiltration/Percolation Testing

Various material testing and in situ infiltration/percolation testing methods and guidance for appropriate factor of safety are discussed in detail in Appendix D. Infiltration testing methods described in Appendix D include surface and shallow excavation methods and deeper subsurface tests.

C.4.2.3 Evaluation of Depth to Groundwater

An evaluation of the depth to groundwater is required to confirm the feasibility of infiltration. Infiltration BMPs may not be feasible in high groundwater conditions (within 10 feet of the base of infiltration/ percolation BMP) unless an exemption is granted by the approval agency.

C.4.3 Reporting Requirements by Geotechnical Engineer

The geotechnical and groundwater investigation report shall address the following key elements, and where appropriate, mitigation recommendations shall be provided.

- Identify areas of the project site where infiltration is likely to be feasible and provide justifications for selection of those areas based on soil types, slopes, proximity to existing features, etc. Include completed and signed Worksheet C.4-1.
- Investigate, evaluate and estimate the vertical infiltration rates and capacities in accordance with the guidance provided in Appendix D which describes infiltration testing and appropriate factor of safety to be applied for infiltration testing results. The site may be broken into sub-basins, each of which has different infiltration rates or capacities.
- Describe the infiltration/ percolation test results and correlation with published infiltration/ percolation rates based on soil parameters or classification. Recommend providing design infiltration/percolation rate(s) at the sub-basins. Use Worksheet D.5-1.
- Investigate the subsurface geological conditions and geotechnical conditions that would affect infiltration or migration of water toward structures, slopes, utilities, or other features. Describe the anticipated flow path of infiltrated water. Indicate if the water will flow into pavement sections, utility trench bedding, wall drains, foundation drains, or other permeable improvements.
- Investigate depth to groundwater and the nature of the groundwater. Include an estimate of the high seasonal groundwater elevations.
- Evaluate proposed use of the site (industrial use, commercial use, etc.), soil and groundwater data and provide a concluding opinion whether proposed storm water infiltration could cause adverse impacts to groundwater quality and if it does cause impacts whether the impacts could be reasonably mitigated or not.

Appendix C: Geotechnical and Groundwater Investigation Requirements

- Estimate the maximum allowable infiltration rates and volumes that could occur at the site that would avoid damage to existing and proposed structures, utilities, slopes, or other features. In addition the report must indicate if the recommended infiltration rate is appropriate based on the conditions exposed during construction.
- Provide a concluding opinion regarding whether or not the proposed onsite storm water infiltration/percolation BMP will result in soil piping, daylight water seepage, slope instability, or ground settlement.
- Recommend measures to substantially mitigate or avoid any potentially detrimental effects of the storm water infiltration BMPs or associated soil response on existing or proposed improvements or structures, utilities, slopes or other features within and adjacent to the site. For example, minimize soil compaction.
- Provide guidance for the selection and location of infiltration BMPs, including the minimum separations between such infiltration BMPs and structures, streets, utilities, manufactured and existing slopes, engineered fills, utilities or other features. Include guidance for measures that could be used to reduce the minimum separations or to mitigate the potential impacts of infiltration BMPs.
- Provide a concluding opinion whether or not proposed infiltration BMPs are in conformance with the following design criteria:
 - Runoff will undergo pretreatment such as sedimentation or filtration prior to infiltration;
 - Pollution prevention and source control BMPs are implemented at a level appropriate to protect groundwater quality for areas draining to infiltration BMPs;
 - The vertical distance from the base of the infiltration BMPs to the seasonal high groundwater mark is greater than 10 feet. This vertical distance may be reduced when the groundwater basin does not support beneficial uses and the groundwater quality is maintained;
 - The soil through which infiltration is to occur has physical and chemical characteristics (e.g., appropriate cation exchange capacity, organic content, clay content, and infiltration rate) which are adequate for proper infiltration durations and treatment of runoff for the protection of groundwater beneficial uses;
 - Infiltration BMPs are not used for areas of industrial or light industrial activity unless source control BMPs to prevent exposure of high threat activities are implemented, or runoff from such activities is first treated or filtered to remove pollutants prior to infiltration; and
 - Infiltration BMPs are located a minimum of 100 feet horizontally from any water supply wells.

C.4.4 Reporting Requirements by the Project Design Engineer

Project design engineer has the following responsibilities:

- Complete criteria 4 and 8 in Worksheet C.4-1; and
- In the SWQMP provide a concluding opinion whether or not proposed infiltration BMPs will affect seasonality of ephemeral streams.

Worksheet C.4-1: Categorization of Infiltration Feasibility Condition

Provide basis:

Summarize findings of studies, provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.

Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
Worksheet C.4-1 Page 2 of 4			
Criteria	Screening Question	Yes	No
3	Can infiltration greater than 0.5 inches per hour be allowed without increasing risk of groundwater contamination (shallow water table, storm water pollutants or other factors) that cannot be mitigated to an acceptable level? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
4	Can infiltration greater than 0.5 inches per hour be allowed without causing potential water balance issues such as change of seasonality of ephemeral streams or increased discharge of contaminated groundwater to surface waters? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		

<p>Provide basis:</p>		
<p>Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.</p>		
<p>Part 1 Result*</p>	<p>If all answers to rows 1 - 4 are “Yes” a full infiltration design is potentially feasible. The feasibility screening category is Full Infiltration</p> <p>If any answer from row 1-4 is “No”, infiltration may be possible to some extent but would not generally be feasible or desirable to achieve a “full infiltration” design. Proceed to Part 2</p>	

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Worksheet C.4-1 Page 3 of 4			
<u>Part 2 – Partial Infiltration vs. No Infiltration Feasibility Screening Criteria</u>			
Would infiltration of water in any appreciable amount be physically feasible without any negative consequences that cannot be reasonably mitigated?			
Criteria	Screening Question	Yes	No
5	Do soil and geologic conditions allow for infiltration in any appreciable rate or volume? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.2 and Appendix D.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.			
6	Can Infiltration in any appreciable quantity be allowed without increasing risk of geotechnical hazards (slope stability, groundwater mounding, utilities, or other factors) that cannot be mitigated to an acceptable level? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.2.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.			

Worksheet C.4-1 Page 4 of 4			
Criteria	Screening Question	Yes	No
7	Can Infiltration in any appreciable quantity be allowed without posing significant risk for groundwater related concerns (shallow water table, storm water pollutants or other factors)? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.			
8	Can infiltration be allowed without violating downstream water rights? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.			
Part 2 Result*	If all answers from row 1-4 are yes then partial infiltration design is potentially feasible. The feasibility screening category is Partial Infiltration . If any answer from row 5-8 is no, then infiltration of any volume is considered to be infeasible within the drainage area. The feasibility screening category is No Infiltration .		

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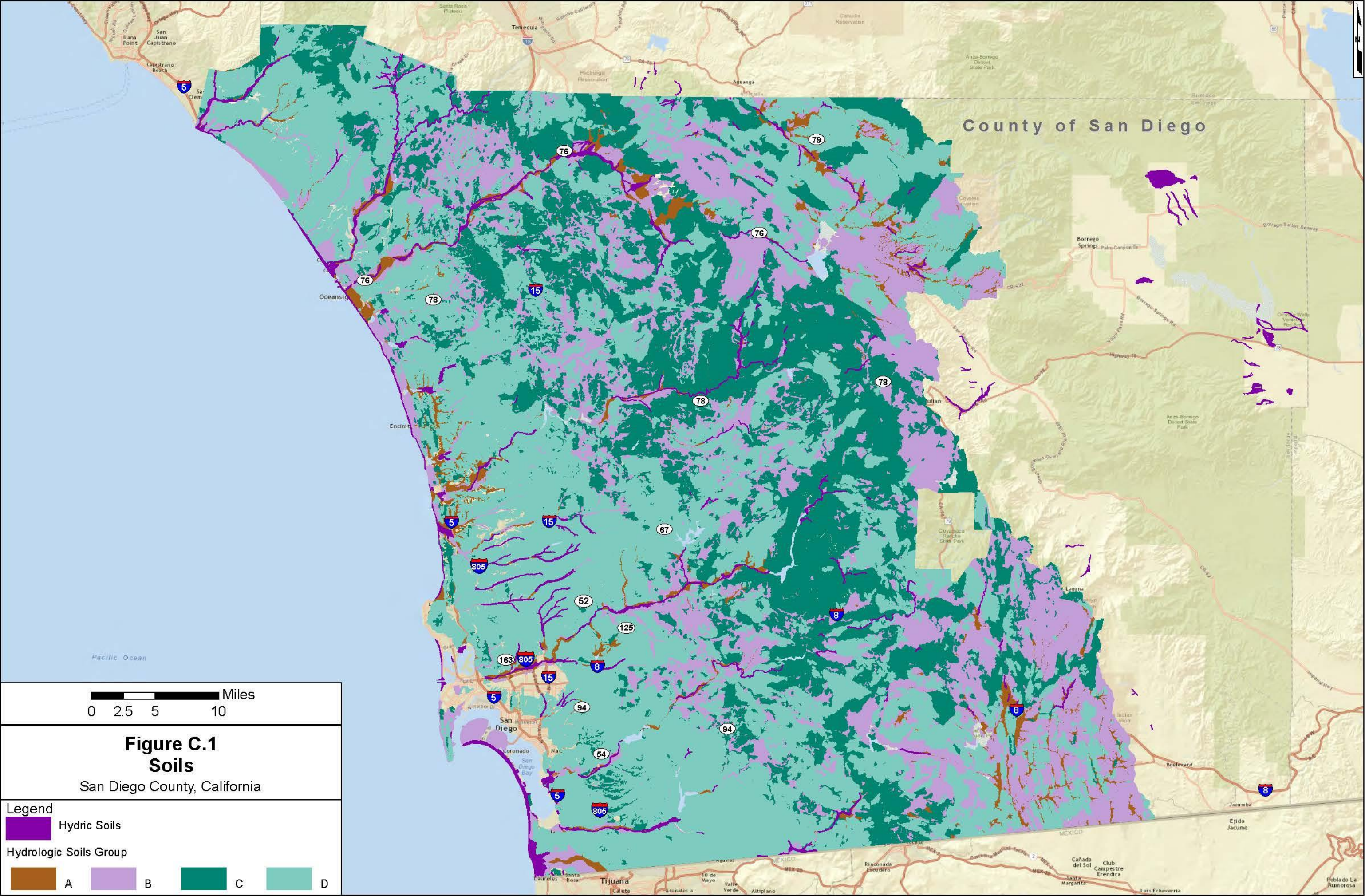
C.5 Feasibility Screening Exhibits

Table C.5-1 lists the feasibility screening exhibits that were generated using readily available GIS data sets to assist the project applicant to screen the project site for feasibility.

Table C.5-1: Feasibility Screening Exhibits

Figures	Layer	Intent/Rationale	Data Sources
C.1 Soils ¹	Hydrologic Soil Group – A, B, C, D	Hydrologic Soil Group will aid in determining areas of potential infiltration	SanGIS http://www.sangis.org/
	Hydric Soils	Hydric soils will indicate layers of intermittent saturation that may function like a D soil and should be avoided for infiltration	USDA Web Soil Survey. Hydric soils, (ratings of 100) were classified as hydric. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
C.2: Slopes and Geologic Hazards	Slopes >25%	BMPs are hard to construct on slopes >25% and can potentially cause slope instability	SanGIS http://www.sangis.org/
	Liquefaction Potential	BMPs (particularly infiltration BMPs) must not be sited in areas with high potential for liquefaction or landslides to minimize earthquake/landslide risks	SanGIS http://www.sangis.org/
	Landslide Potential		SanGIS Geologic Hazards layer. Subset of polygons with hazard codes related to landslides was selected. This data is limited to the City of San Diego Boundary. http://www.sangis.org/
C.3: Groundwater Table Elevations	Groundwater Depths	Infiltration BMPs will need to be sited in areas with adequate distance (>10 ft) from the groundwater table	GeoTracker. Data downloaded for San Diego county from 2014 and 2013. In cases where there were multiple measurements made at the same well, the average was taken over that year. http://geotracker.waterboards.ca.gov/data_download_by_county.asp
C.4: Contaminated Sites	Contaminated soils and/or groundwater sites	Infiltration must be limited in areas of contaminated soil/groundwater	GeoTracker. Data downloaded for San Diego county and limited to active cleanup sites http://geotracker.waterboards.ca.gov/

¹In undefined areas it is the responsibility of the project proponent to verify soils conditions and provide geotechnical findings.



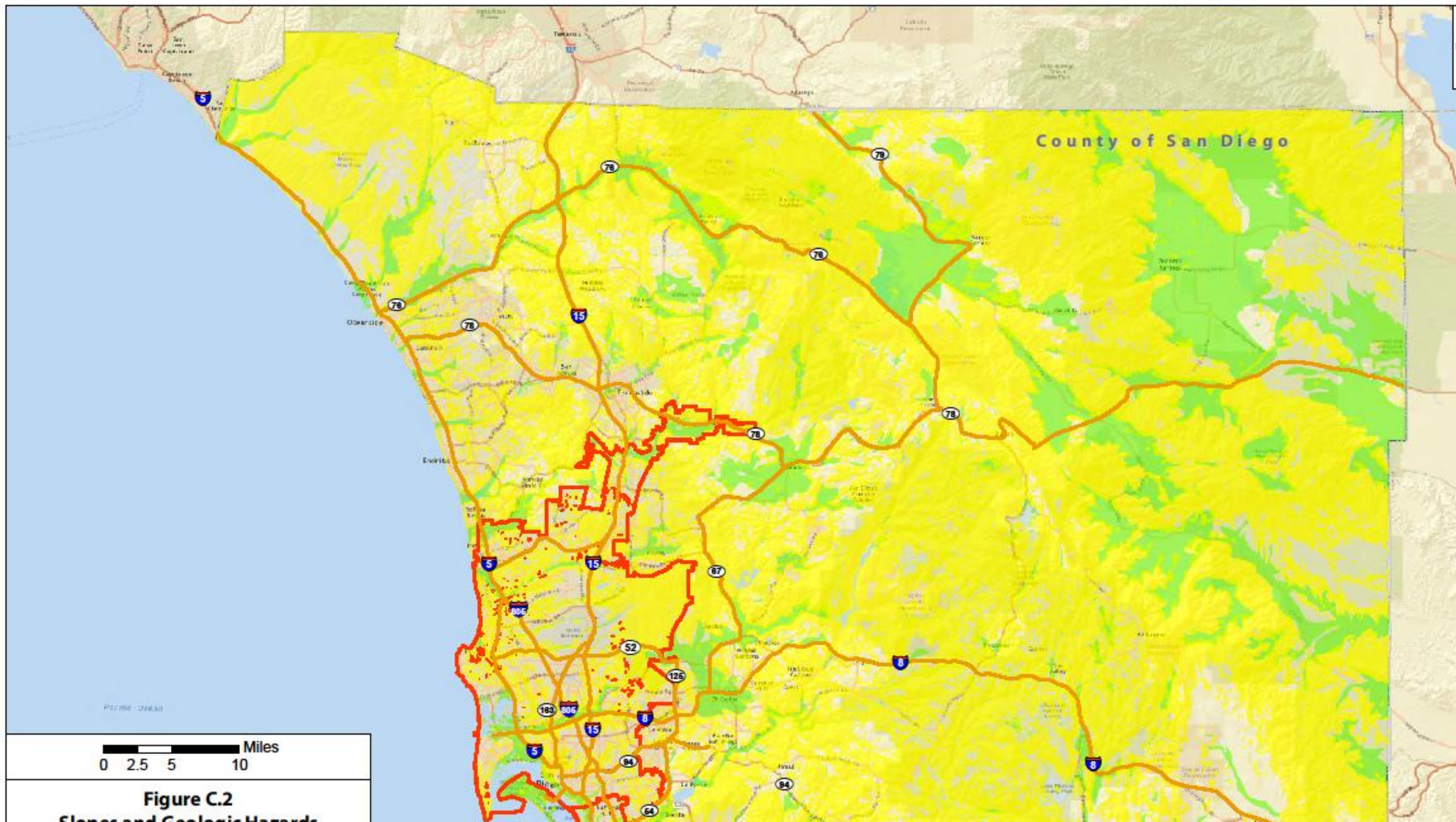
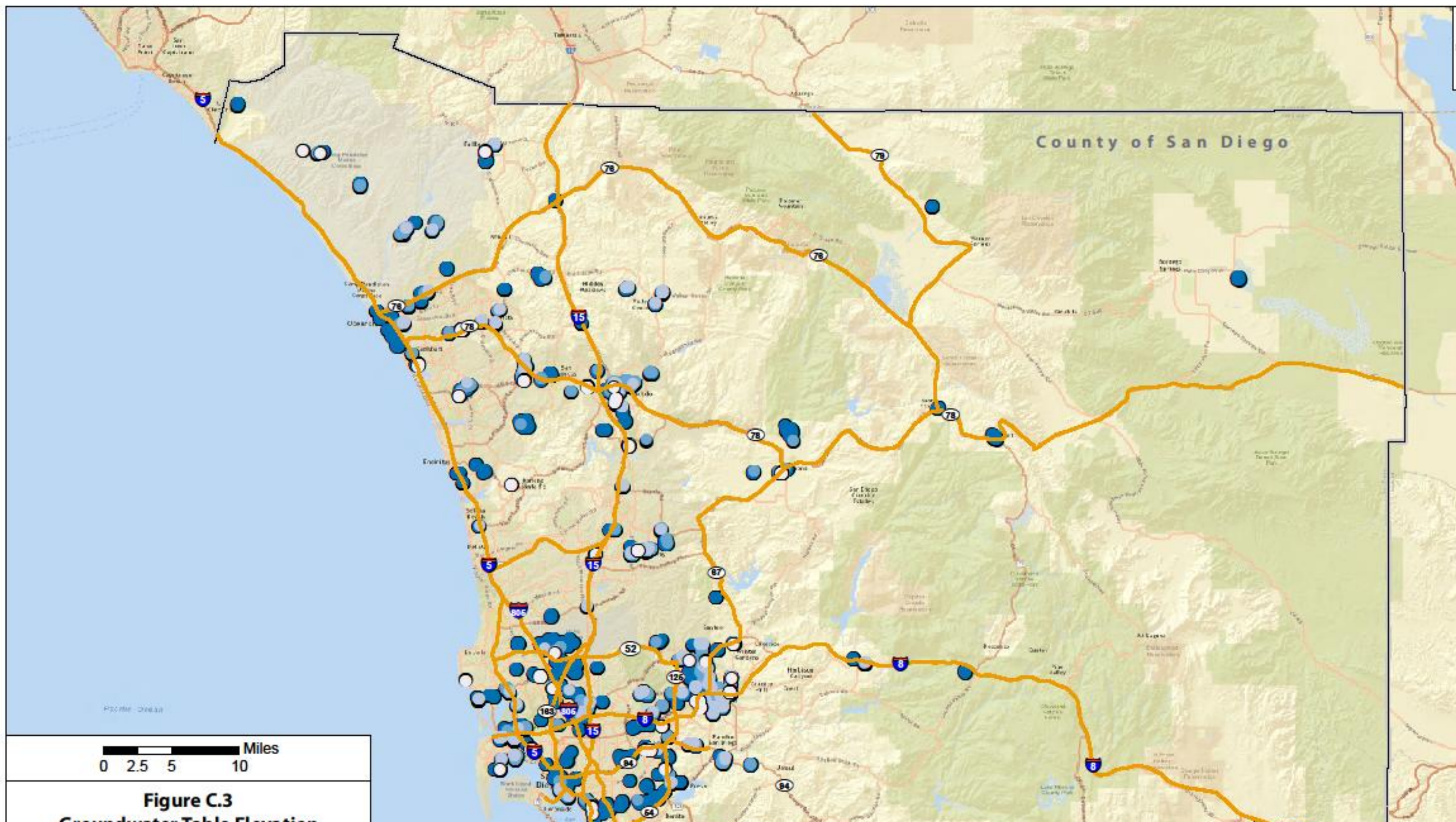


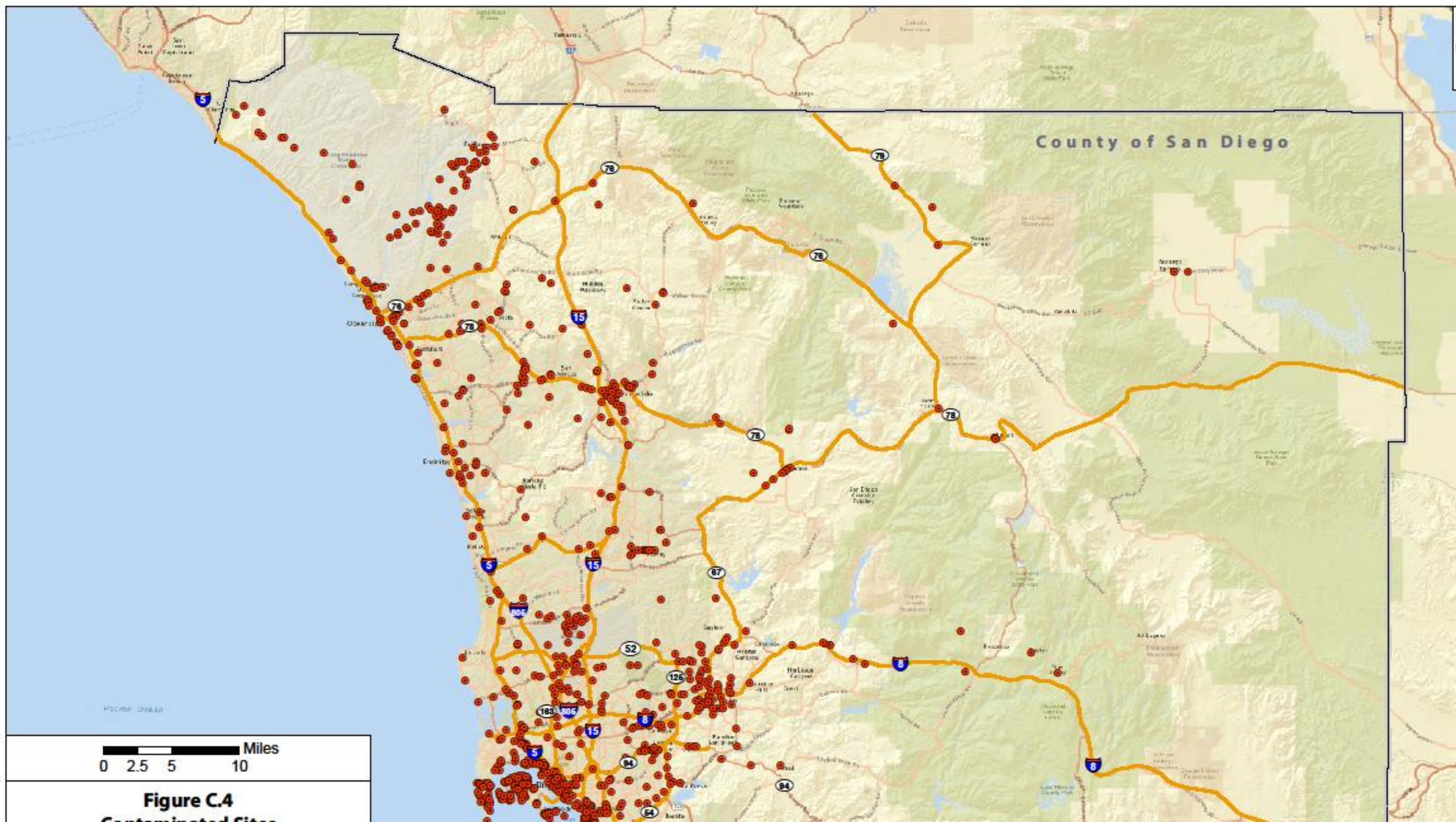
Figure C.2
Slopes and Geologic Hazards



County of San Diego

0 2.5 5 10 Miles

Figure C.3
Groundwater Table Elevation



0 2.5 5 10 Miles

Figure C.4
Contaminated Sites

B M P D E S I G N M A N U A L

**Approved Infiltration Rate
Assessment Methods for
Selection of Storm Water BMPs**

Appendix D Approved Infiltration Rate Assessment Methods for Selection and Design of Storm Water BMPs

D.1 Introduction

Characterization of potential infiltration rates is a critical step in evaluating the degree to which infiltration can be used to reduce storm water runoff volume. This appendix is intended to provide guidance to help answer the following questions:

1. *How and where does infiltration testing fit into the project development process?*

Section D.2 discusses the role of infiltration testing in different stage of project development and how to plan a phased investigation approach.

2. *What infiltration rate assessment methods are acceptable?*

Section D.3 describes the infiltration rate assessment methods that are acceptable.

3. *What factors should be considered in selecting the most appropriate testing method for a project?*

Section D.4 provides guidance on site-specific considerations that influence which assessment methods are most appropriate.

4. *How should factors of safety be selected and applied to, for BMP selection and design?*

Section D.5 provides guidance for selecting a safety factor.

Note, that this appendix does not consider other feasibility criteria that may make infiltration infeasible, such as groundwater contamination and geotechnical considerations (these are covered in Appendix C). In general, infiltration testing should only be conducted after other feasibility criteria specified in this manual have been evaluated and cleared.

D.2 Role of Infiltration Testing in Different Stages of Project Development

In the process of planning and designing infiltration facilities, there are a number of ways that infiltration testing or estimation factors into project development, as summarized in Table D.2-1. As part of selecting infiltration testing methods, the geotechnical engineer shall select methods that are applicable to the phase of the project and the associated burden of proof.

Appendix D: Approved Infiltration Rate Assessment Methods

Table D.2-1: Role of Infiltration Testing

Project Phase	Key Questions/Burden of Proof	General Assessment Strategies
Site Planning Phase	<ul style="list-style-type: none">• Where within the project area is infiltration potentially feasible?• What volume reduction approaches are potentially suitable for my project?	<ul style="list-style-type: none">• Use existing data and maps to the extent possible• Use less expensive methods to allow a broader area to be investigated more rapidly• Reach tentative conclusions that are subject to confirmation/refinement at the design phase
BMP Design Phase	<ul style="list-style-type: none">• What infiltration rates should be used to design infiltration and biofiltration facilities?• What factor of safety should be applied?	<ul style="list-style-type: none">• Use more rigorous testing methods at specific BMP locations• Support or modify preliminary feasibility findings• Estimate design infiltration rates with appropriate factors of safety

D.3 Guidance for Selecting Infiltration Testing Methods

The geotechnical engineer shall select appropriate testing methods for the site conditions, subject to the engineer's discretion and approval of the Port, that are adequate to meet the burden of proof that is applicable at each phase of the project design (See Table D.3-1):

- At the planning phase, testing/evaluation method must be selected to provide a reliable estimate of the locations where infiltration is feasible and allow a reasonably confident determination of infiltration feasibility to support the selection between full infiltration, partial infiltration, and no infiltration BMPs.
- At the design phase, the testing method must be selected to provide a reliable infiltration rate to be used in design. The degree of certainty provided by the selected test should be considered

Table D.3-1 provides a matrix comparison of these methods. Sections D.3.1 to D.3.3 provide a summary of each method. This appendix is not intended to be an exhaustive reference on infiltration testing at this time. It does not attempt to discuss every method for testing, nor is it intended to provide step-by-step procedures for each method. The user is directed to supplemental resources (referenced in this appendix) or other appropriate references for more specific information.

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Alternative testing methods are allowed with appropriate rationales, subject to the discretion of the Port.

In order to select an infiltration testing method, it is important to understand how each test is applied and what specific physical properties the test is designed to measure. Infiltration testing methods vary considerably in these regards. For example, a borehole percolation test is conducted by drilling a borehole, filling a portion of the hole with water, and monitoring the rate of fall of the water. This test directly measures the three dimensional flux of water into the walls and bottom of the borehole. An approximate correction is applied to indirectly estimate the vertical hydraulic conductivity from the results of the borehole test. In contrast, a double-ring infiltrometer test is conducted from the ground surface and is intended to provide a direct estimate of vertical (one-dimensional) infiltration rate at this point. Both of these methods are applicable under different conditions.

Table D.3-1: Comparison of Infiltration Rate Estimation and Testing Methods

Test	Suitability at Planning Level Screening Phase	Suitability at BMP Design Phase
NRCS Soil Survey Maps	Yes, but mapped soil types must be confirmed with site observations. Regional soil maps are known to contain inaccuracies at the scale of typical development sites.	No, unless a strong correlation is developed between soil types and infiltration rates in the direct vicinity of the site and an elevated factor of safety is used.
Grain Size Analysis	Not preferred. Should only be used if a strong correlation has been developed between grain size analysis and measured infiltration rates testing results of site soils.	No
Cone Penetrometer Testing	Not preferred. Should only be used if a strong correlation has been developed between CPT results and measured infiltration rates testing results of site soils.	No
Simple Open Pit Test	Yes	Yes, with appropriate correction for infiltration into side walls and elevated factor of safety.
Open Pit Falling Head Test	Yes	Yes, with appropriate correction for infiltration into side walls and elevated factor of safety.
Double Ring Infiltrometer Test (ASTM 3385)	Yes	Yes
Single Ring Infiltrometer Test	Yes	Yes

Appendix D: Approved Infiltration Rate Assessment Methods

Test	Suitability at Planning Level Screening Phase	Suitability at BMP Design Phase
Large-scale Pilot Infiltration Test	Yes, but generally cost prohibitive and too water-intensive for preliminary screening of a large area.	Yes, but should consider relatively large water demand associated with this test.
Smaller-scale Pilot Infiltration Test	Yes	Yes
Well Permeameter Method (USBR 7300-89)	Yes; reliability of this test can be improved by obtaining a continuous core where tests are conducted.	Yes in areas of proposed cut where other tests are not possible; a continuous boring log should be recorded and used to interpret test; should be confirmed with a more direct measurement following excavation.
Borehole Percolation Tests (various methods)	Yes; reliability of this test can be improved by obtaining a continuous core where tests are conducted.	Yes in areas of proposed cut where other tests are not possible; a continuous boring log should be recorded and used to interpret test; should be confirmed with a more direct measurement following excavation.
Laboratory Permeability Tests (e.g., ASTM D2434)	Yes, only suitable for evaluating potential infiltration rates in proposed fill areas. For sites with proposed cut, it is preferred to do a borehole percolation test at the proposed grade instead of analyzing samples in the lab. A combination of both tests may improve reliability.	No. However, may be part of a line of evidence for estimating the design infiltration of partial infiltration BMPs constructed in future compacted fill.

D.3.1 Desktop Approaches and Data Correlation Methods

This section reviews common methods used to evaluate infiltration characteristics based on desktop-available information, such as GIS data. This section also introduces methods for estimating infiltration properties via correlations with other measurements.

D.3.1.1 NRCS Soil Survey Maps

NRCS Soil Survey maps (<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>) can be used to estimate preliminary feasibility conditions, specifically by mapping hydrologic soil groups, soil texture classes, and presence of hydric soils relative to the site layout. For feasibility determinations, mapped conditions must be supplemented with available data from the site (e.g., soil borings, observed soil textures, biological indicators). The presence of D soils, if confirmed by available data, provides a reasonable basis to determine that full infiltration is not feasible for a given DMA.

D.3.1.2 Grain Size Analysis Testing and Correlations to Infiltration Rate

Hydraulic conductivity can be estimated indirectly from correlations with soil grain-size distributions. While this method is approximate, correlations have been relatively well established for some soil conditions. One of the most commonly used correlations between grain size parameters and hydraulic conductivity is the Hazen (1892, 1911) empirical formula (Philips and Kitch, 2011), but a variety of others have been developed. Correlations must be developed based on testing of site-specific soils.

D.3.1.3 Cone Penetrometer Testing and Correlations to Infiltration Rate

Hydraulic conductivity can also be estimated indirectly from cone penetrometer testing (CPT). A cone penetrometer test involves advancing a small probe into the soil and measuring the relative resistance encountered by the probe as it is advanced. The signal returned from this test can be interpreted to yield estimated soil types and the location of key transitions between soil layers. If this method is used, correlations must be developed based on testing of site-specific soils.

D.3.2 Surface and Shallow Excavation Methods

This section describes tests that are conducted at the ground surface or within shallow excavations close to the ground surface. These tests are generally applicable for cases where the bottom of the infiltration system will be near the existing ground surface. They can also be conducted to confirm the results of borehole methods after excavation/site grading has been completed.

D.3.2.1 Simple Open Pit Test

The Simple Open Pit Test is most appropriate for planning level screening of infiltration feasibility. Although it is similar to Open Pit Falling Head tests used for establishing a design infiltration rate (see below), the Simple Open Pit Test is less rigorous and is generally conducted to a lower standard of care. This test can be conducted by a nonprofessional as part of planning level screening phase.

The Simple Open Pit Test is a falling head test in which a hole at least two feet in diameter is filled with water to a level of 6" above the bottom. Water level is checked and recorded regularly until either an hour has passed or the entire volume has infiltrated. The test is repeated two more times in succession and the rate at which the water level falls in the third test is used as the infiltration rate.

This test has the advantage of being inexpensive to conduct. Yet it is believed to be fairly reliable for screening as the dimensions of the test are similar, proportionally, to the dimensions of a typical BMP. The key limitations of this test are that it measures a relatively small area, does not necessarily result in a precise measurement, and may not be uniformly implemented.

Source: City of Portland, 2008. Storm Water Management Manual

D.3.2.2 Open Pit Falling Head Test

This test is similar to the Simple Open Pit Test, but covers a larger footprint, includes more specific instructions, returns more precise measurements, and generally should be overseen by a geotechnical professional. Nonetheless, it remains a relatively simple test.

To perform this test, a hole is excavated at least 2 feet wide by 4 feet long (larger is preferred) and to a depth of at least 12 inches. The bottom of the hole should be approximately at the depth of the proposed infiltrating surface of the BMP. The hole is pre-soaked by filling it with water at least a foot above the soil to be tested and leaving it at least 4 hours (or overnight if clays are present). After pre-soaking, the hole is refilled to a depth of 12 inches and allow it to drain for one hour (2 hours for slower soils), measuring the rate at which the water level drops. The test is then repeated until successive trials yield a result with less than 10 percent change.

In comparison to a double-ring infiltrometer, this test has the advantage of measuring infiltration over a larger area and better resembles the dimensionality of a typical small scale BMP. Because it includes both vertical and lateral infiltration, it should be adjusted to estimate design rates for larger scale BMPs.

D.3.2.3 Double Ring Infiltrometer Test (ASTM 3385)

The Double Ring Infiltrometer was originally developed to estimate the saturated hydraulic conductivity of low permeability materials, such as clay liners for ponds, but has seen significant use in storm water applications. The most recent revision of this method from 2009 is known as ASTM 3385-09. The testing apparatus is designed with concentric rings that form an inner ring and an annulus between the inner and outer rings. Infiltration from the annulus between the two rings is intended to saturate the soil outside of the inner ring such that infiltration from the inner ring is restricted primarily to the vertical direction.

To conduct this test, both the center ring and annulus between the rings are filled with water. There is no pre-wetting of the soil in this test. However, a constant head of 1 to 6 inches is maintained for 6 hours, or until a constant flow rate is established. Both the inner flow rate and annular flow rate are recorded, but if they are different, the inner flow rate should be used. There are a variety of approaches that are used to maintain a constant head on the system, including use of a Mariotte tube, constant level float valves, or manual observation and filling. This test must be conducted at the elevation of the proposed infiltrating surface; therefore application of this test is limited in cases where the infiltration surface is a significant distance below existing grade at the time of testing.

This test is generally considered to provide a direct estimate of vertical infiltration rate for the specific point tested and is highly replicable. However, given the small diameter of the inner ring (standard diameter is 12 inches, but it can be larger), this test only measures infiltration rate in a small area. Additionally, given the small quantity of water used in this test compared to larger scale tests, this test may be biased high in cases where the long term infiltration rate is governed by groundwater mounding

Appendix D: Approved Infiltration Rate Assessment Methods

and the rate at which mounding dissipates (i.e., the capacity of the infiltration receptor). Finally, the added effort and cost of isolating vertical infiltration rate may not necessarily be warranted considering that BMPs typically have a lateral component of infiltration as well. Therefore, while this method has the advantages of being technical rigorous and well standardized, it should not necessarily be assumed to be the most representative test for estimating full-scale infiltration rates. Source: American Society for Testing and Materials (ASTM) International (2009)

D.3.2.4 Single Ring Infiltrometer Test

The single ring infiltrometer test is not a standardized ASTM test, however it is a relatively well-controlled test and shares many similarities with the ASTM standard double ring infiltrometer test (ASTM 3385-09). This test is a constant head test using a large ring (preferably greater than 40 inches in diameter) usually driven 12 inches into the soil. Water is ponded above the surface. The rate of water addition is recorded and infiltration rate is determined after the flow rate has stabilized. Water can be added either manually or automatically.

The single ring used in this test tends to be larger than the inner ring used in the double ring test. Driving the ring into the ground limits lateral infiltration; however some lateral infiltration is generally considered to occur. Experience in Riverside County (CA) has shown that this test gives results that are close to full-scale infiltration facilities. The primary advantages of this test are that it is relatively simple to conduct and has a larger footprint (compared to the double-ring method) and restricts horizontal infiltration and is more standardized (compared to open pit methods). However, it is still a relatively small scale test and can only be reasonably conducted near the existing ground surface.

D.3.2.5 Large-scale Pilot Infiltration Test

As its name implies, this test is closer in scale to a full-scale infiltration facility. This test was developed by Washington State Department of Ecology specifically for storm water applications.

To perform this test, a test pit is excavated with a horizontal surface area of roughly 100 square feet to a depth that allows 3 to 4 feet of ponding above the expected bottom of the infiltration facility. Water is continually pumped into the system to maintain a constant water level (between 3 and 4 feet about the bottom of the pit, but not more than the estimated water depth in the proposed facility) and the flow rate is recorded. The test is continued until the flow rate stabilizes. Infiltration rate is calculated by dividing the flow rate by the surface area of the pit. Similar to other open pit test, this test is known to result in a slight bias high because infiltration also moves laterally through the walls of the pit during the test. Washington State Department of Ecology requires a correction factor of 0.75 (factor of safety of 1.33) be applied to results.

This test has the advantage of being more resistant to bias from localized soil variability and being more similar to the dimensionality and scale of full scale BMPs. It is also more likely to detect long term decline in infiltration rates associated with groundwater mounding. As such, it remains the

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preferred test for establishing design infiltration rates in Western Washington (Washington State Department of Ecology, 2012). In a comparative evaluation of test methods, this method was found to provide a more reliable estimate of full-scale infiltration rate than double ring infiltrometer and borehole percolation tests (Philips and Kitch 2011).

The difficulty encountered in this method is that it requires a larger area be excavated than the other methods, and this in turn requires larger equipment for excavation and a greater supply of water. However, this method should be strongly considered when less information is known about spatial variability of soils and/or a higher degree of certainty in estimated infiltration rates is desired.

Source: Washington State Department of Ecology, 2012.

D.3.2.6 Smaller-scale Pilot Infiltration Test

The smaller-scale PIT is conducted similarly to the large-scale PIT but involves a smaller excavation, ranging from 20 to 32 square feet instead of 100 square feet for the large-scale PIT, with similar depths. The primary advantage of this test compared to the full-scale PIT is that it requires less excavation volume and less water. It may be more suitable for small-scale distributed infiltration controls where the need to conduct a greater number of tests outweighs the accuracy that must be obtained in each test, and where groundwater mounding is not as likely to be an issue. Washington State Department of Ecology establishes a correction factor of 0.5 (factor of safety of 2.0) for this test in comparison to 0.75 (factor of safety of 1.33) for the large-scale PIT to account for a greater fraction of water infiltrating through the walls of the excavation and lower degree of certainty related to spatial variability of soils.

D.3.3 Deeper Subsurface Tests

D.3.3.1 Well Permeameter Method (USBR 7300-89)

Well permeameter methods were originally developed for purposes of assessing aquifer permeability and associated yield of drinking water wells. This family of tests is most applicable in situations in which infiltration facilities will be placed substantially below existing grade, which limits the use of surface testing methods.

In general, this test involves drilling a 6 inch to 8 inch test well to the depth of interest and maintaining a constant head until a constant flow rate has been achieved. Water level is maintained with down-hole floats. The Porchet method or the nomographs provided in the USBR Drainage Manual (United States Department of the Interior, Bureau of Reclamation, 1993) are used to convert the measured rate of percolation to an estimate of vertical hydraulic conductivity. A smaller diameter boring may be adequate, however this then requires a different correction factor to account for the increased variability expected.

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While these tests have applicability in screening level analysis, considerable uncertainty is introduced in the step of converting direct percolation measurements to estimates of vertical infiltration. Additionally, this testing method is prone to yielding erroneous results cases where the vertical horizon of the test intersects with minor lenses of sandy soils that allow water to dissipate laterally at a much greater rate than would be expected in a full-scale facility. To improve the interpretation of this test method, a continuous bore log should be inspected to determine whether thin lenses of material may be biasing results at the strata where testing is conducted. Consult USBR procedure 7300-89 for more details.

Source: (United States Department of the Interior, Bureau of Reclamation, 1990, 1993)

D.3.3.2 Borehole Percolation Tests (various methods)

Borehole percolation tests were originally developed as empirical tests to estimate the capacity of onsite sewage disposal systems (septic system leach fields), but have more recently been adopted into use for evaluating storm water infiltration. Similar to the well permeameter method, borehole percolation methods primarily measure lateral infiltration into the walls of the boring and are designed for situations in which infiltration facilities will be placed well below current grade. The percolation rate obtained in this test should be converted to an infiltration rate using a technique such as the Porchet method.

This test is generally implemented similarly to the USBR Well Permeameter Method. Per the Riverside County Borehole Percolation method, a hole is bored to a depth at least 5 times the borehole radius. The hole is presoaked for 24 hours (or at least 2 hours if sandy soils with no clay). The hole is filled to approximately the anticipated top of the proposed infiltration basin. Rates of fall are measured for six hours, refilling each half hour (or 10 minutes for sand). Tests are generally repeated until consistent results are obtained.

The same limitations described for the well permeameter method apply to borehole percolation tests, and their applicability is generally limited to initial screening. To improve the interpretation of this test method, a continuous soil core can be extracted from the hole and below the test depth, following testing, to determine whether thin lenses of material may be biasing results at the strata where testing is conducted.

Sources: Riverside County Percolation Test (2011), California Test 750 (Caltrans, 1986), San Bernardino County Percolation Test (1992); USEPA Falling Head Test (USEPA, 1980).

D.4 Specific Considerations for Infiltration Testing

The following subsections are intended to address specific topics that commonly arise in characterizing infiltration rates.

D.4.1 Hydraulic Conductivity versus Infiltration Rate versus Percolation Rate

A common misunderstanding is that the “percolation rate” obtained from a percolation test is equivalent to the “infiltration rate” obtained from tests such as a single or double ring infiltrometer test which is equivalent to the “saturated hydraulic conductivity”. In fact, these terms have different meanings. Saturated hydraulic conductivity is an intrinsic property of a specific soil sample under a given degree of compaction. It is a coefficient in Darcy’s equation (Darcy 1856) that characterizes the flux of water that will occur under a given gradient. The measurement of saturated hydraulic conductivity in a laboratory test is typically referred to as “permeability”, which is a function of the density, structure, stratification, fines, and discontinuities of a given sample under given controlled conditions. In contrast, infiltration rate is an empirical observation of the rate of flux of water into a given soil structure under long term ponding conditions. Similarly to permeability, infiltration rate can be limited by a number of factors including the layering of soil, density, discontinuities, and initial moisture content. These factors control how quickly water can move through a soil. However, infiltration rate can also be influenced by mounding of groundwater, and the rate at which water dissipates horizontally below a BMP – both of which describe the “capacity” of the “infiltration receptor” to accept this water over an extended period. For this reason, an infiltration test should ideally be conducted for a relatively long duration resembling a series of storm events so that the capacity of the infiltration receptor is evaluated as well as the rate at which water can enter the system. Infiltration rates are generally tested with larger diameter holes, pits, or apparatuses intended to enforce a primarily vertical direction of flux.

In contrast, percolation is tested with small diameter holes, and it is mostly a lateral phenomenon. The direct measurement yielded by a percolation test tends to overestimate the infiltration rate, except perhaps in cases in which a BMP has similar dimensionality to the borehole, such as a dry well. Adjustment of percolation rates may be made to an infiltration rate using a technique such as the Porchet Method.

D.4.2 Cut and Fill Conditions

Cut Conditions: Where the proposed infiltration BMP is to be located in a cut condition, the infiltration surface level at the bottom of the BMP might be far below the existing grade. For example, if the infiltration surface of a proposed BMP is to be located at an elevation that is currently beneath 15 feet of planned cut, *how can the proposed infiltration surface be tested to establish a design infiltration rate prior to beginning excavation?* The question can be addressed in two ways: First, one of the deeper subsurface tests described above can be used to provide a planning level screening of potential rates at the elevation of the proposed infiltrating surface. These tests can be conducted at depths exceeding 100 feet, therefore are applicable in most cut conditions. Second, the project can commit to further testing using more reliable methods following bulk excavation to refine or adjust infiltration rates, and/or

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apply higher factors of safety to borehole methods to account for the inherent uncertainty in these measurements and conversions.

Fill Conditions: There are two types of fills – those that are engineered or documented, and those that are undocumented. Undocumented fills are fills placed without engineering controls or construction quality assurance and are subject to great uncertainty. Engineered fills are generally placed using construction quality assurance procedures and may have criteria for grain-size and fines content, and the properties can be very well understood. However, for engineered fills, infiltration rates may still be quite uncertain due to layering and heterogeneities introduced as part of construction that cannot be precisely controlled.

If the bottom of a BMP (infiltration surface) is proposed to be located in a fill location, the infiltration surface may not exist prior to grading. How then can the infiltration rate be determined? For example, if a proposed infiltration BMP is to be located with its bottom elevation in 10 feet of fill, how could one reasonably establish an infiltration rate prior to the fill being placed?

Where possible, infiltration BMPs on fill material should be designed such that their infiltrating surface extends into native soils. Additionally, for shallow fill depths, fill material can be selectively graded (i.e., high permeability granular material placed below proposed BMPs) to provide reliable infiltration properties until the infiltrating water reaches native soils. In some cases, due to considerable fill depth, the extension of the BMP down to natural soil and/or selective grading of fill material may prove infeasible. In addition, fill material will result in some compaction of now buried native soils potentially reducing their ability to infiltrate. In these cases, because of the uncertainty of fill parameters as described above as well as potential compaction of the native soils, an infiltration BMP may not be feasible.

If the source of fill material is defined and this material is known to be of a granular nature and that the native soils below is permeable and will not be highly compacted, infiltration through compacted fill materials may still be feasible. In this case, a project phasing approach could be used including the following general steps, (1) collect samples from areas expected to be used as borrow sites for fill activities, (2) remold samples to approximately the proposed degree of compaction and measure the saturated hydraulic conductivity of remolded samples using laboratory methods, (3) if infiltration rates appear adequate for infiltration, then apply an appropriate factor of safety and use the initial rates for preliminary design, (4) following placement of fill, conduct in-situ testing to refine design infiltration rates and adjust the design as needed; the infiltration rate of native soil below the fill should also be tested at this time to determine if compaction as a result of fill placement has significantly reduced its infiltration rate. The project geotechnical engineer should be involved in decision making whenever infiltration is proposed in the vicinity of engineered fill structures so that potential impacts of infiltration on the strength and stability of fills and pavement structures can be evaluated.

D.4.3 Effects of Direct and Incidental Compaction

It is widely recognized that compaction of soil has a major influence on infiltration rates (Pitt et al. 2008). However, direct (intentional) compaction is an essential aspect of project construction and indirect compaction (such as by movement of machinery, placement of fill, stockpiling of materials, and foot traffic) can be difficult to avoid in some parts of the project site. Infiltration testing strategies should attempt to measure soils at a degree of compaction that resembles anticipated post-construction conditions.

Ideally, infiltration systems should be located outside of areas where direct compaction will be required and should be staked off to minimize incidental compaction from vehicles and stockpiling. For these conditions, no adjustment of test results is needed.

However, in some cases, infiltration BMPs will be constructed in areas to be compacted. For these areas, it may be appropriate to include field compaction tests or prepare laboratory samples and conducting infiltration testing to approximate the degree of compaction that will occur in post-construction conditions. Alternatively, testing could be conducted on undisturbed soil, and an additional factor of safety could be applied to account for anticipated infiltration after compaction. To develop a factor of safety associated with incidental compaction, samples could be compacted to various degrees of compaction, their hydraulic conductivity measured, and a “response curve” developed to relate the degree of compaction to the hydraulic conductivity of the material.

D.4.4 Temperature Effects on Infiltration Rate

The rate of infiltration through soil is affected by the viscosity of water, which in turn is affected by the temperature of water. As such, infiltration rate is strongly dependent on the temperature of the infiltrating water (Cedergren, 1997). For example, Emerson (2008) found that wintertime infiltration rates below a BMP in Pennsylvania were approximately half their peak summertime rates. As such, it is important to consider the effects of temperature when planning tests and interpreting results.

If possible, testing should be conducted at a temperature that approximates the typical runoff temperatures for the site during the times when rainfall occurs. If this is not possible, then the results of infiltration tests should be adjusted to account for the difference between the temperature at the time of testing and the typical temperature of runoff when rainfall occurs. The measured infiltration can be adjusted by the ratio of the viscosity at the test temperature versus the typical temperature when rainfall occurs (Cedergren, 1997), per the following formula:

$$K_{Typical} = K_{Test} \times \left(\frac{\mu_{Test}}{\mu_{Typical}} \right)$$

Where:

$K_{Typical}$ = the typical infiltration rate expected at typical temperatures when rainfall occurs

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K_{Test} = the infiltration rate measured or estimated under the conditions of the test

μ_{Typical} = the viscosity of water at the typical temperature expected when rainfall occurs

μ_{Test} = the viscosity of water at the temperature at which the test was conducted

D.4.5 Number of Infiltration Tests Needed

The heterogeneity inherent in soils implies that all but the smallest proposed infiltration facilities would benefit from infiltration tests in multiple locations. The following requirements apply for in situ infiltration/percolation testing:

- In situ infiltration/ percolation testing shall be conducted at a minimum of two locations within 50-feet of each proposed storm water infiltration/ percolation BMP.
- In situ infiltration/percolation testing shall be conducted using an approved method listed in Table D.3-1
- Testing shall be conducted at approximately the same depth and in the same material as the base of the proposed storm water BMP.

D.5 Selecting a Safety Factor

Monitoring of actual facility performance has shown that the full-scale infiltration rate can be much lower than the rate measured by small-scale testing (King County Department of Natural Resources and Parks, 2009). Factors such as soil variability and groundwater mounding may be responsible for much of this difference. Additionally, the infiltration rate of BMPs naturally declines between maintenance cycles as the BMP surface becomes occluded and particulates accumulate in the infiltrative layer.

In the past, infiltration structures have been shown to have a relatively short lifespan. Over 50 percent of infiltration systems either partially or completely failed within the first 5 years of operation (United States EPA, 1999). In a Maryland study on infiltration trenches (Lindsey et al. 1991), 53 percent were not operating as designed, 36 percent were clogged, and 22 percent showed reduced filtration. In a study of 12 infiltration basins (Galli 1992), none of which had built-in pretreatment systems, all had failed within the first two years of operation.

Given the known potential for infiltration BMPs to degrade or fail over time, an appropriate factor of safety applied to infiltration testing results is strongly recommended. This section presents a recommended thought process for selecting a safety factor. This method considers factor of safety to be a function of:

- Site suitability considerations, and
- Design-related considerations.

These factors and the method for using them to compute a safety factor are discussed below.

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Importantly, this method encourages rigorous site investigation, good pretreatment, and commitments to routine maintenance to provide technically-sound justification for using a lower factor of safety.

D.5.1 Determining Factor of Safety

Worksheet D.5-1, at the end of this section can be used in conjunction with Tables D.5-1 and D.5-2 to determine an appropriate safety factor. Tables D.5-1 and D.5-2 assign point values to design considerations; the values are entered into Worksheet D.5-1, which assign a weighting factor for each design consideration.

The following procedure can be used to estimate an appropriate factor of safety to be applied to the infiltration testing results. When assigning a factor of safety, care should be taken to understand what other factors of safety are implicit in other aspects of the design to avoid incorporating compounding factors of safety that may result in significant over-design.

1. For each consideration shown above, determine whether the consideration is a high, medium, or low concern.
2. For all high concerns in Table D.5-1, assign a factor value of 3, for medium concerns, assign a factor value of 2, and for low concerns assign a factor value of 1.
3. Multiply each of the factors in Table D.5-1 by 0.25 and then add them together. This should yield a number between 1 and 3.
4. For all high concerns in Table D.5-2, assign a factor value of 3, for medium concerns, assign a factor value of 2, and for low concerns assign a factor value of 1.
5. Multiply each of the factors in Table D.5-2 by 0.5 and then add them together. This should yield a number between 1 and 3.
6. Multiply the two safety factors together to get the final combined safety factor. If the combined safety factor is less than 2, then 2 should be used as the safety factor.
7. Divide the tested infiltration rate by the combined safety factor to obtain the adjusted design infiltration rate for use in sizing the infiltration facility.

Note: The minimum combined adjustment factor should not be less than 2.0 and the maximum combined adjustment factor should not exceed 9.0.

D.5.2 Site Suitability Considerations for Selection of an Infiltration Factor of Safety

Considerations related to site suitability include:

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- Soil assessment methods – the site assessment extent (e.g., number of borings, test pits, etc.) and the measurement method used to estimate the short-term infiltration rate.
- Predominant soil texture/percent fines – soil texture and the percent of fines can influence the potential for clogging. Finer grained soils may be more susceptible to clogging.
- Site soil variability – site with spatially heterogeneous soils (vertically or horizontally) as determined from site investigations are more difficult to estimate average properties for resulting in a higher level of uncertainty associated with initial estimates.
- Depth to seasonal high groundwater/impervious layer – groundwater mounding may become an issue during excessively wet conditions where shallow aquifers or shallow clay lenses are present.

These considerations are summarized in Table D.5-1 below, in addition to presenting classification of concern.

Table D.5-1: Suitability Assessment Related Considerations for Infiltration Facility Safety Factors

Consideration	High Concern – 3 points	Medium Concern – 2 points	Low Concern – 1 point
Assessment methods (see explanation below)	Use of soil survey maps or simple texture analysis to estimate short-term infiltration rates Use of well permeameter or borehole methods without accompanying continuous boring log Relatively sparse testing with direct infiltration methods	Use of well permeameter or borehole methods with accompanying continuous boring log Direct measurement of infiltration area with localized infiltration measurement methods (e.g., infiltrometer) Moderate spatial resolution	Direct measurement with localized (i.e., small-scale) infiltration testing methods at relatively high resolution ¹ or Use of extensive test pit infiltration measurement methods ²
Texture Class	Silty and clayey soils with significant fines	Loamy soils	Granular to slightly loamy soils
Site soil variability	Highly variable soils indicated from site assessment, or Unknown variability	Soil borings/test pits indicate moderately homogeneous soils	Soil borings/test pits indicate relatively homogeneous soils
Depth to groundwater/ impervious layer	<5 ft below facility bottom	5-15 ft below facility bottom	>15 below facility bottom

1 - Localized (i.e., small scale) testing refers to methods such as the double-ring infiltrometer and borehole tests)

2 - Extensive infiltration testing refers to methods that include excavating a significant portion of the proposed infiltration area, filling the excavation with water, and monitoring drawdown. The excavation should be to the depth of the proposed infiltration surface and ideally be at least 30 to 100 square feet.

D.5.3 Design Related Considerations for Selection of an Infiltration Factor of Safety

Design related considerations include:

- Level of pretreatment and expected influent sediment loads – credit should be given for good pretreatment to account for the reduced probability of clogging from high sediment loading. Appendix B.6 describes performance criteria for “flow-thru treatment” based 80 percent capture of total suspended solids, which provides excellent levels of pretreatment. Additionally, the Washington State Technology Acceptance Protocol-Ecology provides a certification for “pre-treatment” based on 50 percent removal of TSS, which provides moderate levels of treatment. Current approved technologies are listed at: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>. Use of certified technologies can allow a lower factor of safety. Also, facilities designed to capture runoff from relatively clean surfaces such as rooftops are likely to see low sediment loads and therefore may be designed with lower safety factors. Finally, the amount of landscaped area and its vegetation coverage characteristics should be considered. For example in arid areas with more soils exposed, open areas draining to infiltration systems may contribute excessive sediments.
- Compaction during construction – proper construction oversight is needed during construction to ensure that the bottoms of infiltration facility are not impacted by significant incidental compaction. Facilities that use proper construction practices and oversight need less restrictive safety factors.

Table D.5-2: Design Related Considerations for Infiltration Facility Safety Factors

Consideration	High Concern – 3 points	Medium Concern – 2 points	Low Concern – 1 point
Level of pretreatment/ expected influent sediment loads	Limited pretreatment using gross solids removal devices only, such as hydrodynamic separators, racks and screens AND tributary area includes landscaped areas, steep slopes, high traffic areas, road sanding, or any other areas expected to produce high sediment, trash, or debris loads.	Good pretreatment with BMPs that mitigate coarse sediments such as vegetated swales AND influent sediment loads from the tributary area are expected to be moderate (e.g., low traffic, mild slopes, stabilized pervious areas, etc.). Performance of pretreatment consistent with “pretreatment BMP performance criteria” (50% TSS removal) in Appendix B.6	Excellent pretreatment with BMPs that mitigate fine sediments such as bioretention or media filtration OR sedimentation or facility only treats runoff from relatively clean surfaces, such as rooftops/non-sanded road surfaces. Performance of pretreatment consistent with “flow-thru treatment control BMP performance criteria” (i.e., 80% TSS removal) in Appendix B.6

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Consideration	High Concern – 3 points	Medium Concern – 2 points	Low Concern – 1 point
Redundancy/ resiliency	No “backup” system is provided; the system design does not allow infiltration rates to be restored relatively easily with maintenance	The system has a backup pathway for treated water to discharge if clogging occurs <u>or</u> infiltration rates can be restored via maintenance.	The system has a backup pathway for treated water to discharge if clogging occurs <u>and</u> infiltration rates can be relatively easily restored via maintenance.
Compaction during construction	Construction of facility on a compacted site or increased probability of unintended/ indirect compaction.	Medium probability of unintended/ indirect compaction.	Equipment traffic is effectively restricted from infiltration areas during construction and there is low probability of unintended/ indirect compaction.

D.5.4 Implications of a Factor of Safety in BMP Feasibility and Design

The above method will provide safety factors in the range of 2 to 9. From a simplified practical perspective, this means that the size of the facility will need to increase in area from 2 to 9 times relative to that which might be used without a safety factor. Clearly, numbers toward the upper end of this range will make all but the best locations prohibitive in land area and cost.

In order to make BMPs more feasible and cost effective, steps should be taken to plan and execute the implementation of infiltration BMPs in a way that will reduce the safety factors needed for those projects. A commitment to effective site design and source control thorough site investigation, use of effective pretreatment controls, good construction practices, and restoration of the infiltration rates of soils that are damaged by prior compaction should lower the safety factor that should be applied, to help improve the long term reliability of the system and reduce BMP construction cost. While these practices decrease the recommended safety factor, they do not totally mitigate the need to apply a factor of safety. The minimum recommended safety factor of 2.0 is intended to account for the remaining uncertainty and long-term deterioration that cannot be technically mitigated.

Because there is potential for an applicant to “exaggerate” factor of safety to artificially prove infeasibility, an upper cap on the factor of safety is proposed for feasibility screening. A maximum factor of safety of 2.0 is recommended for infiltration feasibility screening such that an artificially high factor of safety cannot be used to inappropriately rule out infiltration, unless justified. If the site passes the feasibility analysis at a factor of safety of 2.0, then infiltration must be investigated, but a higher factor of safety may be selected at the discretion of the design engineer.

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Worksheet D.5-1: Factor of Safety and Design Infiltration Rate Worksheet

Factor of Safety and Design Infiltration Rate Worksheet			Worksheet D.5-1		
Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) $p = w \times v$
A	Suitability Assessment	Soil assessment methods	0.25		
		Predominant soil texture	0.25		
		Site soil variability	0.25		
		Depth to groundwater / impervious layer	0.25		
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			
B	Design	Level of pretreatment/ expected sediment loads	0.5		
		Redundancy/resiliency	0.25		
		Compaction during construction	0.25		
		Design Safety Factor, $S_B = \Sigma p$			
Combined Safety Factor, $S_{total} = S_A \times S_B$					
Observed Infiltration Rate, inch/hr, $K_{observed}$ (corrected for test-specific bias)					
Design Infiltration Rate, in/hr, $K_{design} = K_{observed} / S_{total}$					
Supporting Data					
Briefly describe infiltration test and provide reference to test forms:					



BMP DESIGN MANUAL

BMP Design Fact Sheets

Appendix E BMP Design Fact Sheets

This appendix presents BMPs for consideration for development and redevelopment projects. All projects must include Site Design and Source Control BMPs to reduce pollutants in runoff to San Diego Bay. The following priority pollutants have been identified in the Water Quality Improvement Plan for San Diego Bay (2015): trash, bacteria, and metals. Therefore, BMPs will be required on a project-specific basis that specifically address controlling those pollutants either through source control or site design features. It is the responsibility of the project applicant to propose BMPs to control these pollutants in addition to any project specific pollutants identified in accordance with the methods required by this design manual. During Port review of the SWQMP, the adequacy of BMPs proposed that target trash, bacteria, and metals will be considered and additional BMPs may be required by the Port if adequate BMPs are not selected by the project.

The following fact sheets were developed to assist the project applicants with designing BMPs to meet the storm water obligations:

MS4 Category	Manual Category	Design Fact Sheet
Source Control	Source Control	SC: Source Control BMP Requirements
Site Design	Site Design	SD-1: Street Trees SD-5: Impervious Area Dispersion SD-6A: Green Roofs SD-6B: Permeable Pavement (Site Design BMP) SD-8: Rain Barrels
Retention	Harvest and Use	HU-1: Cistern
	Infiltration	INF-1: Infiltration Basins INF-2: Bioretention INF-3: Permeable Pavement (Pollutant Control)
	Partial Retention	PR-1: Biofiltration with Partial Retention
Biofiltration	Biofiltration	BF-1: Biofiltration BF-2: Nutrient Sensitive Media Design BF-3: Proprietary Biofiltration
Flow-thru Treatment Control	Flow-thru Treatment Control with Alternative Compliance	FT-1: Vegetated Swales FT-2: Media Filters FT-3: Sand Filters FT-4: Dry Extended Detention Basin FT-5: Proprietary Flow-thru Treatment Control
		PL: Plant List

E.1 Source Control BMP Requirements

Worksheet E.1-1: Source Control BMP Requirements

How to comply: Projects shall comply with this requirement by implementing all source control BMPs listed in this section that are applicable to their project. Applicability shall be determined through consideration of the development project's features and anticipated pollutant sources. Appendix E.1 provides guidance for identifying source control BMPs applicable to a project. Checklist I.4 in Appendix I shall be used to document compliance with source control BMP requirements.

How to use this worksheet:

1. Review Column 1 and identify which of these potential sources of storm water pollutants apply to your site. Check each box that applies.
2. Review Column 2 and incorporate all of the corresponding applicable BMPs in your project site plan.
3. Review Columns 3 and 4 and incorporate all of the corresponding applicable permanent controls and operational BMPs in a table in your project-specific storm water management report. Describe your specific BMPs in an accompanying narrative, and explain any special conditions or situations that required omitting BMPs or substituting alternatives.

If These Sources Will Be on the Project Site ...	... Then Your SWQMP Shall Consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> A. Onsite storm drain inlets <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Locations of inlets.	<input type="checkbox"/> Mark all inlets with placards provided by the Port,	<input type="checkbox"/> Maintain and periodically repaint or replace inlet markings. <input type="checkbox"/> Provide storm water pollution prevention information to new site tenants or operators. <input type="checkbox"/> See applicable operational BMPs in Fact Sheet SC-44, “Drainage System Maintenance,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> B. Interior floor drains and elevator shaft sump pumps <input type="checkbox"/> Not Applicable		<input type="checkbox"/> State that interior floor drains and elevator shaft sump pumps will be plumbed to sanitary sewer.	<input type="checkbox"/> Inspect and maintain drains to prevent blockages and overflow.
<input type="checkbox"/> C. Interior parking garages <input type="checkbox"/> Not Applicable		<input type="checkbox"/> State that parking garage floor drains will be plumbed to the sanitary sewer.	<input type="checkbox"/> Inspect and maintain drains to prevent blockages and overflow.
<input type="checkbox"/> D1. Need for future indoor & structural pest control <input type="checkbox"/> Not Applicable		<input type="checkbox"/> Note building design features that discourage entry of pests.	<input type="checkbox"/> Provide Integrated Pest Management information to tenants and operators.

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> D2. Landscape/Outdoor Pesticide Use <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show locations of existing trees or areas of shrubs and ground cover to be undisturbed and retained. <input type="checkbox"/> Show self-retaining landscape areas, if any. <input type="checkbox"/> Show storm water treatment facilities.	<p>State that final landscape plans will accomplish all of the following.</p> <input type="checkbox"/> Preserve existing drought tolerant trees, shrubs, and ground cover to the maximum extent possible. <input type="checkbox"/> Design landscaping to minimize irrigation and runoff, to promote surface infiltration where appropriate, and to minimize the use of fertilizers and pesticides that can contribute to storm water pollution. <input type="checkbox"/> Where landscaped areas are used to retain or detain storm water, specify plants that are tolerant of periodic saturated soil conditions. <input type="checkbox"/> Consider using pest-resistant plants, especially adjacent to hardscape. <input type="checkbox"/> To ensure successful establishment, select plants appropriate to site soils, slopes, climate, sun, wind, rain, land use, air movement, ecological consistency, and plant interactions.	<input type="checkbox"/> Maintain landscaping using minimum or no pesticides. <input type="checkbox"/> See applicable operational BMPs in Fact Sheet SC-41, “Building and Grounds Maintenance,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com . <input type="checkbox"/> Provide IPM information to new tenants and operators.

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> E. Pools, spas, ponds, decorative fountains, and other water features. <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show location of water feature and a sanitary sewer cleanout in an accessible area within 10 feet.	<input type="checkbox"/> If the local municipality requires pools to be plumbed to the sanitary sewer, place a note on the plans and state in the narrative that this connection will be made according to local requirements.	<input type="checkbox"/> See applicable operational BMPs in Fact Sheet SC-72, “Fountain and Pool Maintenance,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .
<input type="checkbox"/> F. Food service <input type="checkbox"/> Not Applicable	<input type="checkbox"/> For restaurants, grocery stores, and other food service operations, show location (indoors or in a covered area outdoors) of a floor sink or other area for cleaning floor mats, containers, and equipment. <input type="checkbox"/> On the drawing, show a note that this drain will be connected to a grease interceptor before discharging to the sanitary sewer.	<input type="checkbox"/> Describe the location and features of the designated cleaning area. <input type="checkbox"/> Describe the items to be cleaned in this facility and how it has been sized to ensure that the largest items can be accommodated.	

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> G. Refuse areas <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show where site refuse and recycled materials will be handled and stored for pickup. See local municipal requirements for sizes and other details of refuse areas. <input type="checkbox"/> If dumpsters or other receptacles are outdoors, show how the designated area will be covered, graded, and paved to prevent run-on and show locations of berms to prevent runoff from the area. Also show how the designated area will be protected from wind dispersal. <input type="checkbox"/> Any drains from dumpsters, compactors, and tallow bin areas shall be connected to a grease removal device before discharge to sanitary sewer.	<input type="checkbox"/> State how site refuse will be handled and provide supporting detail to what is shown on plans. <input type="checkbox"/> State that signs will be posted on or near dumpsters with the words “Do not dump hazardous materials here” or similar.	<input type="checkbox"/> State how the following will be implemented: Provide adequate number of receptacles. Inspect receptacles regularly; repair or replace leaky receptacles. Keep receptacles covered. Prohibit/prevent dumping of liquid or hazardous wastes. Post “no hazardous materials” signs. Inspect and pick up litter daily and clean up spills immediately. Keep spill control materials available on-site. See Fact Sheet SC-34, “Waste Handling and Disposal” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative Table and Narrative
<input type="checkbox"/> H. Industrial processes. <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show process area.	<input type="checkbox"/> If industrial processes are to be located onsite, state: “All process activities to be performed indoors. No processes to drain to exterior or to storm drain system.”	<input type="checkbox"/> See Fact Sheet SC-10, “Non-Stormwater Discharges” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .
<input type="checkbox"/> I. Outdoor storage of equipment or materials. (See rows J and K for source control measures for vehicle cleaning, repair, and maintenance.) <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show any outdoor storage areas, including how materials will be covered. Show how areas will be graded and bermed to prevent run-on or runoff from area and protected from wind dispersal. <input type="checkbox"/> Storage of non-hazardous liquids shall be covered by a roof and/or drain to the sanitary sewer system, and be contained by berms, dikes, liners, or vaults. <input type="checkbox"/> Storage of hazardous materials and wastes must be in compliance with the local hazardous materials ordinance and a Hazardous Materials Management Plan for the site.	<input type="checkbox"/> Include a detailed description of materials to be stored, storage areas, and structural features to prevent pollutants from entering storm drains. Where appropriate, reference documentation of compliance with the requirements of local Hazardous Materials Programs for: <ul style="list-style-type: none"> ▪ Hazardous Waste Generation ▪ Hazardous Materials Release Response and Inventory ▪ California Accidental Release Prevention Program ▪ Aboveground Storage Tank ▪ Uniform Fire Code Article 80 Section 103(b) & (c) 1991 ▪ Underground Storage Tank 	<input type="checkbox"/> See the Fact Sheets SC-31, “Outdoor Liquid Container Storage” and SC-33, “Outdoor Storage of Raw Materials” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> J. Vehicle and Equipment Cleaning <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show on drawings as appropriate: <p>(1) Commercial/industrial facilities having vehicle /equipment cleaning needs shall either provide a covered, bermed area for washing activities or discourage vehicle/equipment washing by removing hose bibs and installing signs prohibiting such uses.</p> <p>(2) Multi-dwelling complexes shall have a paved, bermed, and covered car wash area (unless car washing is prohibited onsite and hoses are provided with an automatic shut-off to discourage such use).</p> <p>(3) Washing areas for cars, vehicles, and equipment shall be paved, designed to prevent run-on to or runoff from the area, and plumbed to drain to the sanitary sewer.</p> <p>(4) Commercial car wash facilities shall be designed such that no runoff from the facility is discharged to the storm drain system. Wastewater from the facility shall discharge to the sanitary sewer, or a wastewater reclamation system shall be installed.</p>	<input type="checkbox"/> If a car wash area is not provided, describe measures taken to discourage onsite car washing and explain how these will be enforced.	<p>Describe operational measures to implement the following (if applicable):</p> <ul style="list-style-type: none"> <input type="checkbox"/> Washwater from vehicle and equipment washing operations shall not be discharged to the storm drain system. <input type="checkbox"/> Car dealerships and similar may rinse cars with water only. <input type="checkbox"/> See Fact Sheet SC-21, “Vehicle and Equipment Cleaning,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> K. Vehicle/Equipment Repair and Maintenance <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Accommodate all vehicle equipment repair and maintenance indoors. Or designate an outdoor work area and design the area to protect from rainfall, run-on runoff, and wind dispersal. <input type="checkbox"/> Show secondary containment for exterior work areas where motor oil, brake fluid, gasoline, diesel fuel, radiator fluid, acid-containing batteries or other hazardous materials or hazardous wastes are used or stored. Drains shall not be installed within the secondary containment areas. <input type="checkbox"/> Add a note on the plans that states either (1) there are no floor drains, or (2) floor drains are connected to wastewater pretreatment systems prior to discharge to the sanitary sewer and an industrial waste discharge permit will be obtained.	<input type="checkbox"/> State that no vehicle repair or maintenance will be done outdoors, or else describe the required features of the outdoor work area. <input type="checkbox"/> State that there are no floor drains or if there are floor drains, note the agency from which an industrial waste discharge permit will be obtained and that the design meets that agency's requirements. <input type="checkbox"/> State that there are no tanks, containers or sinks to be used for parts cleaning or rinsing or, if there are, note the agency from which an industrial waste discharge permit will be obtained and that the design meets that agency's requirements.	<p>In the report, note that all of the following restrictions apply to use the site:</p> <input type="checkbox"/> No person shall dispose of, nor permit the disposal, directly or indirectly of vehicle fluids, hazardous materials, or rinsewater from parts cleaning into storm drains. <input type="checkbox"/> No vehicle fluid removal shall be performed outside a building, nor on asphalt or ground surfaces, whether inside or outside a building, except in such a manner as to ensure that any spilled fluid will be in an area of secondary containment. Leaking vehicle fluids shall be contained or drained from the vehicle immediately. <input type="checkbox"/> No person shall leave unattended drip parts or other open containers containing vehicle fluid, unless such containers are in use or in an area of secondary containment.

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> L. Fuel Dispensing Areas <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Fueling areas ¹ shall have impermeable floors (i.e., portland cement concrete or equivalent smooth impervious surface) that are (1) graded at the minimum slope necessary to prevent ponding; and (2) separated from the rest of the site by a grade break that prevents run-on of storm water to the MEP. <input type="checkbox"/> Fueling areas shall be covered by a canopy that extends a minimum of ten feet in each direction from each pump. [Alternative: The fueling area must be covered and the cover's minimum dimensions must be equal to or greater than the area within the grade break or fuel dispensing area ¹ .] The canopy [or cover] shall not drain onto the fueling area.		<input type="checkbox"/> The tenant or property manager shall dry sweep the fueling area routinely. <input type="checkbox"/> See the Business Guide Sheet, "Automotive Service—Service Stations" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .

1. The fueling area shall be defined as the area extending a minimum of 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus a minimum of one foot, whichever is greater.

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
M. Loading Docks <input type="checkbox"/> Not Applicable	<input type="checkbox"/> Show a preliminary design for the loading dock area, including roofing and drainage. Loading docks shall be covered and/or graded to minimize run-on to and runoff from the loading area. Roof downspouts shall be positioned to direct storm water away from the loading area. Water from loading dock areas should be drained to the sanitary sewer where feasible. Direct connections to storm drains from depressed loading docks are prohibited. <input type="checkbox"/> Loading dock areas draining directly to the sanitary sewer shall be equipped with a spill control valve or equivalent device, which shall be kept closed during periods of operation. <input type="checkbox"/> Provide a roof overhang over the loading area or install door skirts (cowling) at each bay that enclose the end of the trailer.		<input type="checkbox"/> Move loaded and unloaded items indoors as soon as possible. <input type="checkbox"/> See Fact Sheet SC-30, “Outdoor Loading and Unloading,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> N. Fire Sprinkler Test Water <input type="checkbox"/> Not Applicable		<input type="checkbox"/> Provide a means to drain fire sprinkler test water to the sanitary sewer.	<input type="checkbox"/> See the note in Fact Sheet SC-41, “Building and Grounds Maintenance,” in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com .
<input type="checkbox"/> O. Miscellaneous Drain or Wash Water <input type="checkbox"/> Boiler drain lines <input type="checkbox"/> Condensate drain lines <input type="checkbox"/> Rooftop equipment <input type="checkbox"/> Drainage sumps <input type="checkbox"/> Roofing, gutters, and trim <input type="checkbox"/> Not Applicable		<input type="checkbox"/> Boiler drain lines shall be directly or indirectly connected to the sanitary sewer system and may not discharge to the storm drain system. <input type="checkbox"/> Condensate drain lines may discharge to landscaped areas if the flow is small enough that runoff will not occur. Condensate drain lines may not discharge to the storm drain system. <input type="checkbox"/> Rooftop mounted equipment with potential to produce pollutants shall be roofed and/or have secondary containment. <input type="checkbox"/> Any drainage sumps onsite shall feature a sediment sump to reduce the quantity of sediment in pumped water. <input type="checkbox"/> Avoid roofing, gutters, and trim made of copper or other unprotected metals that may leach into runoff.	

If These Sources Will Be on the Project Site ...	... Then Your SWQMP shall consider These Source Control BMPs		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on Drawings	3 Permanent Controls—List in Table and Narrative	4 Operational BMPs—Include in Table and Narrative
<input type="checkbox"/> P. Plazas, sidewalks, and parking lots. <input type="checkbox"/> Not Applicable			<input type="checkbox"/> Plazas, sidewalks, and parking lots shall be swept regularly to prevent the accumulation of litter and debris. Debris from pressure washing shall be collected to prevent entry into the storm drain system. Washwater containing any cleaning agent or degreaser shall be collected and discharged to the sanitary sewer and not discharged to a storm drain.

E.2 SD-1 Street Trees



MS4 Permit Category

Site Design

Manual Category

Site Design

Applicable Performance Standard

Site Design

Primary Benefits

Volume Reduction

Street Trees (Source: County of San Diego LID Manual – EOA, Inc.)

Description

Trees planted to intercept rainfall and runoff can be used as storm water management measures that provide additional benefits beyond those typically associated with trees, including energy conservation, air quality improvement, and aesthetic enhancement. Typical storm water management benefits associated with trees include:

- **Interception of rainfall** – tree surfaces (roots, foliage, bark, and branches) intercept, evaporate, store, or convey precipitation to the soil before it reaches surrounding impervious surfaces
- **Reduced erosion** – trees protect denuded area by intercepting or reducing the velocity of rain drops as they fall through the tree canopy
- **Increased infiltration** – soil conditions created by roots and fallen leaves promote infiltration
- **Treatment of storm water** – trees provide treatment through uptake of nutrients and other storm water pollutants (phytoremediation) and support of other biological processes that break down pollutants

Typical street tree system components include:

- Trees of the appropriate species for site conditions and constraints
- Available growing space based on tree species, soil type, water availability, surrounding land uses, and project goals
- Optional suspended pavement design to provide structural support for adjacent pavement

without requiring compaction of underlying layers

- Optional root barrier devices as needed; a root barrier is a device installed in the ground, between a tree and the sidewalk, intended to guide roots down and away from the sidewalk in order to prevent sidewalk lifting from tree roots.
- Optional tree grates; to be considered to maximize available space for pedestrian circulation and to protect tree roots from compaction related to pedestrian circulation; tree grates are typically made up of porous material that will allow the runoff to soak through.
- Optional shallow surface depression for ponding of excess runoff
- Optional planter box drain

Design Adaptations for Project Goals

Site design BMP to provide incidental treatment. Street trees primarily functions as site design BMPs for incidental treatment. Benefits from street trees are accounted for by adjustment factors presented in Appendix B.2. This credit can apply to non-street trees as well (that meet the same criteria). Trees as a site design BMP are only credited up to 0.25 times the DCV from the project footprint (with a maximum single tree credit volume of 400 ft³).

Storm water pollutant control BMP to provide treatment. Applicants are allowed to design trees as a pollutant control BMP and obtain credit greater than 0.25 times the DCV from the project footprint (or a credit greater than 400 ft³ from a single tree). For this option to be approved by the Port, applicant is required to do infiltration feasibility screening (Appendix C and D) and provide calculations supporting the amount of credit claimed from implementing trees within the project footprint. The Port has the discretion to request additional analysis before approving credits greater than 0.25 times the DCV from the project footprint (or a credit greater than 400 ft³ from a single tree).

Design Criteria and Considerations

Street Trees must meet the following design criteria and considerations. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Tree species is appropriately chosen for the development (tenant or capital). For public rights-of-ways, local planning guidelines and zoning provisions for the permissible species and placement of trees are consulted. A list of trees appropriate for site design that can be	Proper tree placement and species selection minimizes problems such as pavement damage by surface roots and poor growth.

<i>Siting and Design</i>	<i>Intent/Rationale</i>														
<p>used by all county municipalities are provided in Appendix E.20</p>															
<p>Location of trees planted along public streets follows local requirements and guidelines. Vehicle and pedestrian line of sight are considered in tree selection and placement.</p> <p>Unless exemption is granted by the Port the following minimum tree separation distance is followed</p>															
<div data-bbox="203 800 237 831" style="display: inline-block; width: 15px; height: 15px; border: 1px solid black; margin-right: 10px;"></div> <table border="1" data-bbox="300 663 865 1272"> <thead> <tr> <th>Improvement</th><th>Minimum distance to Street Tree</th></tr> </thead> <tbody> <tr> <td>Traffic Signal, Stop sign</td><td>20 feet</td></tr> <tr> <td>Underground Utility lines (except sewer)</td><td>5 feet</td></tr> <tr> <td>Sewer Lines</td><td>10 feet</td></tr> <tr> <td>Above ground utility structures (Transformers, Hydrants, Utility poles, etc.)</td><td>10 feet</td></tr> <tr> <td>Driveways</td><td>10 feet</td></tr> <tr> <td>Intersections (intersecting curb lines of two streets)</td><td>25 feet</td></tr> </tbody> </table>	Improvement	Minimum distance to Street Tree	Traffic Signal, Stop sign	20 feet	Underground Utility lines (except sewer)	5 feet	Sewer Lines	10 feet	Above ground utility structures (Transformers, Hydrants, Utility poles, etc.)	10 feet	Driveways	10 feet	Intersections (intersecting curb lines of two streets)	25 feet	<p>Roadway safety for both vehicular and pedestrian traffic is a key consideration for placement along public streets.</p>
Improvement	Minimum distance to Street Tree														
Traffic Signal, Stop sign	20 feet														
Underground Utility lines (except sewer)	5 feet														
Sewer Lines	10 feet														
Above ground utility structures (Transformers, Hydrants, Utility poles, etc.)	10 feet														
Driveways	10 feet														
Intersections (intersecting curb lines of two streets)	25 feet														
<div data-bbox="203 1419 237 1451" style="display: inline-block; width: 15px; height: 15px; border: 1px solid black; margin-right: 10px;"></div> <p>Underground utilities and overhead wires are considered in the design and avoided or circumvented. Underground utilities are routed around or through the planter in suspended pavement applications. All underground utilities are protected from water and root penetration.</p>	<p>Tree growth can damage utilities and overhead wires resulting in service interruptions. Protecting utilities routed through the planter prevents damage and service interruptions.</p>														

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<p><input type="checkbox"/> Suspended pavement design was developed where appropriate to minimize soil compaction and improve infiltration and filtration capabilities.</p> <p>Suspended pavement was constructed with an approved structural cell.</p>	<p>Suspended pavement designs provide structural support without compaction of the underlying layers, thereby promoting tree growth.</p> <p>Recommended structural cells include poured in place concrete columns, Silva Cells manufactured by Deeproot Green Infrastructures and Stratacell and Stratavault systems manufactured by Citygreen Systems.</p>
<p><input type="checkbox"/> A minimum soil volume of 2 cubic feet per square foot of canopy projection volume is provided for each tree. Canopy projection area is the ground area beneath the tree, measured at the drip line.</p>	<p>The minimum soil volume ensures that there is adequate storage volume to allow for unrestricted evapotranspiration.</p> <p>A lower amount of soil volume may be allowed at the discretion of the Port if certified by a landscape architect or agronomist. The retention credit from the tree is directly proportional to the soil volume provided for the tree.</p>
<p><input type="checkbox"/> DCV from the tributary area draining to the tree is equal to or greater than the tree credit volume</p>	<p>The minimum tributary area ensures that the tree receives enough runoff to fully utilize the infiltration and evapotranspiration potential provided. In cases where the minimum tributary area is not provided, the tree credit volume must be reduced proportionately to the actual tributary area.</p>
<p><input type="checkbox"/> Inlet opening to the tree that is at least 18 inches wide.</p> <p>A minimum 2 inch drop in grade from the inlet to the finish grade of the tree.</p> <p>Grated inlets are allowed for pedestrian circulation. Grates need to be ADA compliant and have sufficient slip resistance.</p>	<p>Design requirement to ensure that the runoff from the tributary area is not bypassed.</p> <p>Different inlet openings and drops in grade may be allowed at the discretion of the Port if calculations are shown that the diversion flow rate (Appendix B.1.2) from the tributary area can be conveyed to the tree. In cases where the inlet capacity is limiting the amount of runoff draining to the tree, the tree credit</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
	volume must be reduced proportionately.

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where street trees can be used in the site design to achieve incidental treatment. Street trees reduce runoff volumes from the site. Refer to Appendix B. Document the proposed tree locations in the SWQMP.
2. When trees are proposed as a storm water pollutant control BMP, applicant must complete feasibility analysis in Appendix C and D and submit detailed calculations for the DCV treated by trees. Document the proposed tree locations, feasibility analysis and sizing calculations in the SWQMP. The following calculations should be performed and the smallest of the three should be used as the volume treated by trees:
 - a. Delineate the DMA (tributary area) to the tree and calculate the associated DCV.
 - b. Calculate the required diversion flow rate using Appendix B.1.2 and size the inlet required to convey this flow rate to the tree. If the proposed inlet cannot convey the diversion flow rate for the entire tributary area, then the DCV that enters the tree should be proportionally reduced.
 - i. For example, 0.5 acre drains to the tree and the associated DCV is 820 ft³. The required diversion flow rate is 0.10 ft³/s, but only an inlet that can divert 0.05 ft³/s could be installed.
 - ii. Then the effective DCV draining to the tree = $820 \text{ ft}^3 * (0.05/0.10) = 420 \text{ ft}^3$
 - c. Estimate the amount of storm water treated by the tree by summing the following:
 - i. Evapotranspiration credit of 0.1 * amount of soil volume installed; and
 - ii. Infiltration credit calculated using sizing procedures in Appendix B.4.

E.3 SD-5 Impervious Area Dispersion



Photo Credit: Orange County Technical Guidance Document

MS4 Permit Category

Site Design

Manual Category

Site Design

Applicable Performance Criteria

Site Design

Primary Benefits

Volume Reduction

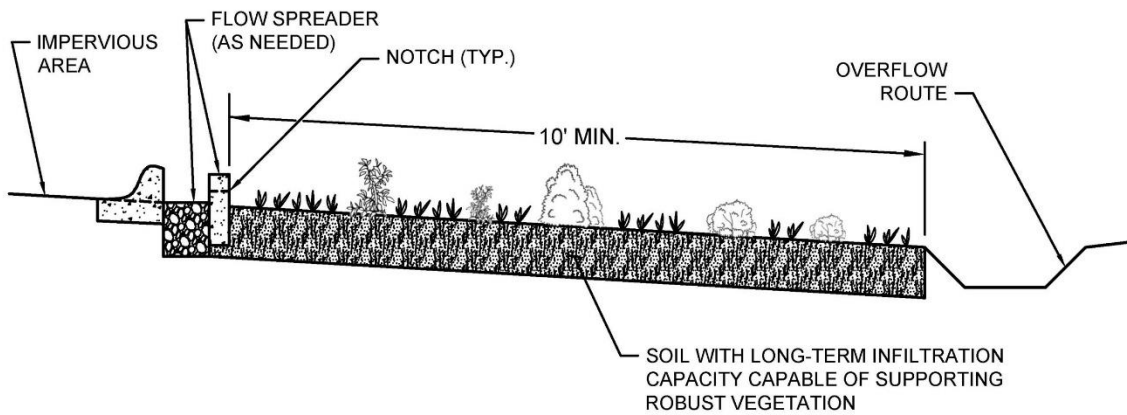
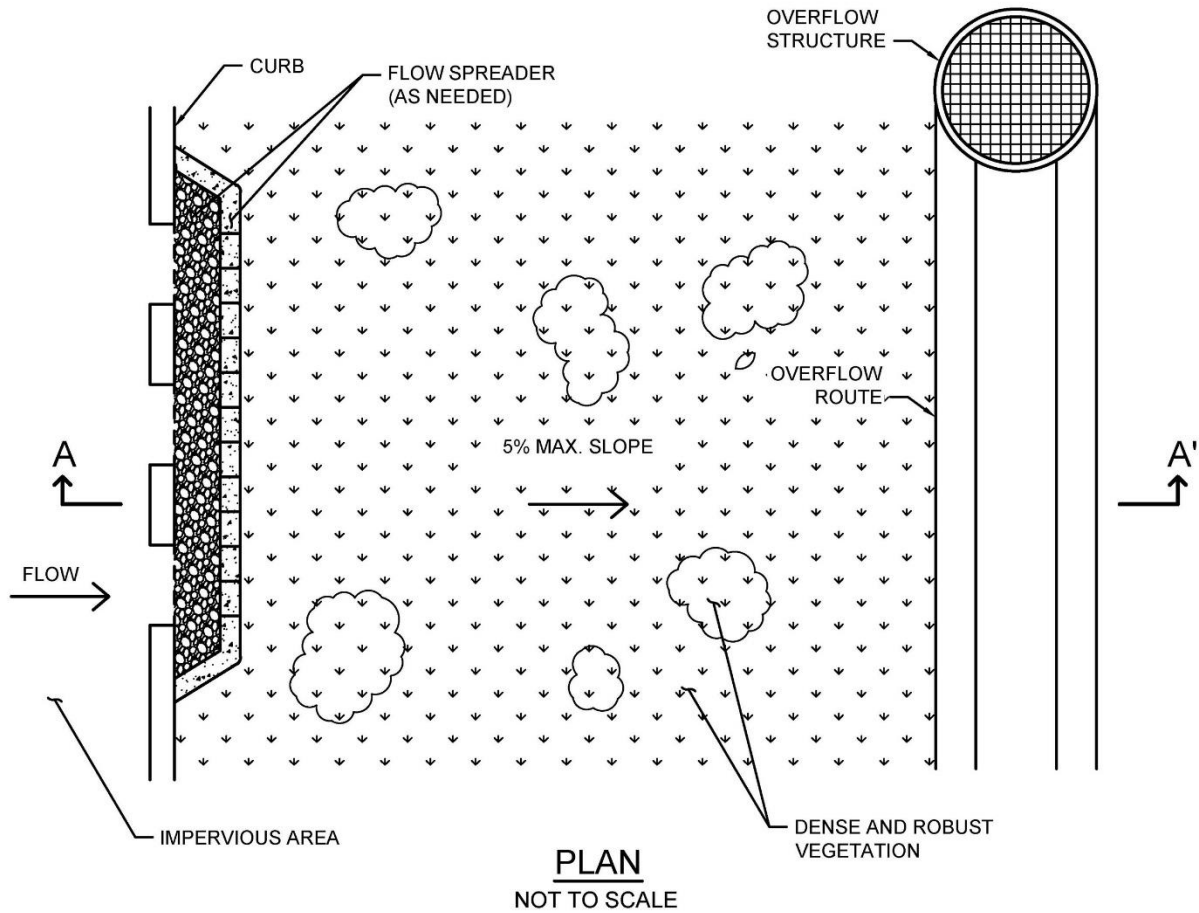
Peak Flow Attenuation

Description

Impervious area dispersion (dispersion) refers to the practice of effectively disconnecting impervious areas from directly draining to the storm drain system by routing runoff from impervious areas such as rooftops (through downspout disconnection), walkways, and driveways onto the surface of adjacent pervious areas. The intent is to slow runoff discharges, and reduce volumes. Dispersion with partial or full infiltration results in significant volume reduction by means of infiltration and evapotranspiration.

Typical dispersion components include:

- An impervious surface from which runoff flows will be routed with minimal piping to limit concentrated inflows
- Splash blocks, flow spreaders, or other means of dispersing concentrated flows and providing energy dissipation as needed
- Dedicated pervious area, typically vegetated, with in-situ soil infiltration capacity for partial or full infiltration
- Optional soil amendments to improve vegetation support, maintain infiltration rates and enhance treatment of routed flows
- Overflow route for excess flows to be conveyed from dispersion area to the storm drain system or discharge point



Typical plan and section view of an Impervious Area Dispersion BMP

Design Adaptations for Project Goals

Site design BMP to reduce impervious area and DCV. Impervious area dispersion primarily functions as a site design BMP for reducing the effective imperviousness of a site by providing partial or full infiltration of the flows that are routed to pervious dispersion areas and otherwise slowing down excess flows that eventually reach the storm drain system. This can significantly reduce the DCV for the site.

Design Criteria and Considerations

Dispersion must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Dispersion is over areas with soil types capable of supporting or being amended (e.g., with sand or compost) to support vegetation. Media amendments must be tested to verify that they are not a source of pollutants.	Soil must have long-term infiltration capacity for partial or full infiltration and be able to support vegetation to provide runoff treatment. Amendments to improve plant growth must not have negative impact on water quality.
<input type="checkbox"/> Dispersion has vegetated sheet flow over a relatively large distance (minimum 10 feet) from inflow to overflow route.	Full or partial infiltration requires relatively large areas to be effective depending on the permeability of the underlying soils.
<input type="checkbox"/> Pervious areas should be flat (with less than 5% slopes) and vegetated.	Flat slopes facilitate sheet flows and minimize velocities, thereby improving treatment and reducing the likelihood of erosion.
<i>Inflow velocities</i>	
<input type="checkbox"/> Inflow velocities are limited to 3 ft/s or less or use energy dissipation methods (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
<i>Dedication</i>	
<input type="checkbox"/> Dispersion areas must be dedicated for the purposes of dispersion to the exclusion of other future uses that might reduce the effectiveness of the dispersion area.	Dedicated dispersion areas prevent future conversion to alternate uses and facilitate continued full and partial infiltration benefits.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<i>Vegetation</i>	
<input type="checkbox"/> Dispersion typically requires dense and robust vegetation for proper function. Drought tolerant species should be selected to minimize irrigation needs. A plant list to aid in selection can be found in Appendix E.20.	Vegetation improves resistance to erosion and aids in runoff treatment.

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where dispersion can be used in the site design to reduce the DCV for pollutant control sizing.
2. Calculate the DCV for storm water pollutant control per Appendix B.2, taking into account reduced runoff from dispersion.
3. Determine if a DMA is considered “Self-retaining” if the impervious to pervious ratio is:
 - a. 2:1 when the pervious area is composed of Hydrologic Soil Group A
 - b. 1:1 when the pervious area is composed of Hydrologic Soil Group B

E.4 SD-6A: Green Roofs

MS4 Permit Category

Site Design

Manual Category

Site Design

Applicable Performance Standard

Site Design

Primary Benefits

Volume Reduction

Peak Flow Attenuation



Location: County of San Diego Operations Center, San Diego, California

Description

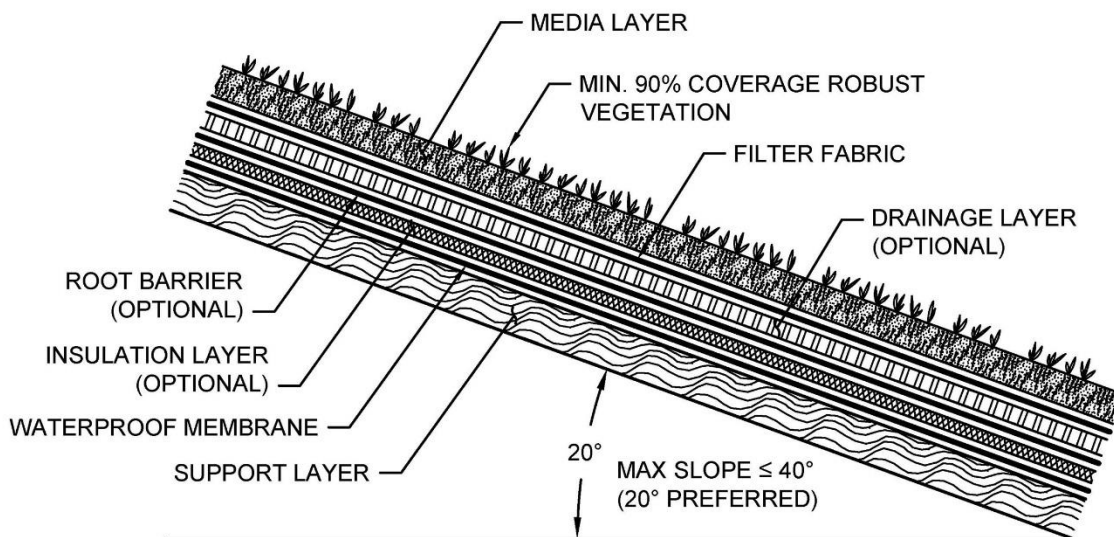
Green roofs are vegetated rooftop systems that reduce runoff volumes and rates, treat storm water pollutants through filtration and plant uptake, provide additional landscape amenity, and create wildlife habitat. Additionally, green roofs reduce the heat island effect and provide acoustical control, air filtration and oxygen production. In terms of building design, they can protect against ultraviolet rays and extend the roof lifetime, as well as increase the building insulation, thereby decreasing heating

and cooling costs. There are two primary types of green roofs:

- **Extensive** – lightweight, low maintenance system with low-profile, drought tolerant type groundcover in shallow growing medium (6 inches or less)
- **Intensive** – heavyweight, high maintenance system with a more garden-like configuration and diverse plantings that may include shrubs or trees in a thicker growing medium (greater than 6 inches)

Typical green roof components include, from top to bottom:

- Vegetation that is appropriate to the type of green roof system, climate, and watering conditions
- Media layer (planting mix or engineered media) capable of supporting vegetation growth
- Filter fabric to prevent migration of fines (soils) into the drainage layer
- Optional drainage layer to convey excess runoff
- Optional root barrier
- Optional insulation layer
- Waterproof membrane
- Structural roof support capable of withstanding the additional weight of a green roof



PROFILE
NOT TO SCALE

Typical profile of a Green Roof BMP

Design Adaptations for Project Goals

Site design BMP to provide incidental treatment. Green roofs can be used as a site design feature to reduce the impervious area of the site through replacing conventional roofing. This can reduce the DCV and flow control requirements for the site.

Design Criteria and Considerations

Green roofs must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Roof slope is $\leq 40\%$ (Roofs that are $\leq 20\%$ are preferred).	Steep roof slopes increases project complexity and requires supplemental anchoring.
<input type="checkbox"/> Structural roof capacity design supports the calculated additional load (lbs/sq. ft) of the vegetation growing medium and additional drainage and barrier layers.	Inadequate structural capacity increases the risk for roof failure and harm to the building and occupants.
<input type="checkbox"/> Design and construction is planned to be completed by an experienced green roof specialist.	A green roof specialist will minimize complications in implementation and potential structural issues that are critical to green roof success.
<input type="checkbox"/> Green roof location and extent must meet fire safety provisions.	Green roof design must not negatively impact fire safety.
<input type="checkbox"/> Maintenance access is included in the green roof design.	Maintenance will facilitate proper functioning of drainage and irrigation components and allow for removal of undesirable vegetation and soil testing, as needed.
<i>Vegetation</i>	
<input type="checkbox"/> Vegetation is suitable for the green roof type, climate and expected watering conditions. Perennial, self-sowing plants that are drought-tolerant (e.g., sedums, succulents) and require little to no fertilizer, pesticides or herbicides are recommended. Vegetation pre-grown at grade may allow plants to establish prior to facing harsh roof conditions.	Plants suited to the design and expected growing environment are more likely to survive.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Vegetation is capable of covering $\geq 90\%$ the roof surface.	Benefits of green roofs are greater with more surface vegetation.
<input type="checkbox"/> Vegetation is robust and erosion-resistant in order to withstand the anticipated rooftop environment (e.g., heat, cold, high winds).	Weak plants will not survive in extreme rooftop environments.
<input type="checkbox"/> Vegetation is fire resistant.	Vegetation that will not burn easily decreases the chance for fire and harm to the building and occupants.
<input type="checkbox"/> Vegetation considers roof sun exposure and shaded areas based on roof slope and location.	The amount of sunlight the vegetation receives can inhibit growth therefore the beneficial effects of a vegetated roof.
<input type="checkbox"/> An irrigation system (e.g., drip irrigation system) is included as necessary to maintain vegetation.	Proper watering will increase plant survival, especially for new plantings.
<input type="checkbox"/> Media is well-drained and is the appropriate depth required for the green roof type and vegetation supported.	Unnecessary water retention increases structural loading. An adequate media depth increases plant survival.
<input type="checkbox"/> A filter fabric is used to prevent migration of media fines through the system.	Migration of media can cause clogging of the drainage layer.
<input type="checkbox"/> A drainage layer is provided if needed to convey runoff safely from the roof. The drainage layer can be comprised of gravel, perforated sheeting, or other drainage materials.	Inadequate drainage increases structural loading and the risk of harm to the building and occupants.
<input type="checkbox"/> A root barrier comprised of dense material to inhibit root penetration is used if the waterproof membrane will not provide root penetration protection.	Root penetration can decrease the integrity of the underlying structural roof components and increase the risk of harm to the building and occupants.
<input type="checkbox"/> An insulation layer is included as needed to protect against the water in the drainage layer from extracting building heat in the winter and cool air in the summer.	Regulating thermal impacts of green roofs will aid in controlling building heating and cooling costs.
<input type="checkbox"/> A waterproof membrane is used to prevent the roof runoff from vertically	Water-damaged roof materials increase the risk of harm to the building and occupants.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
migrating and damaging the roofing material. A root barrier may be required to prevent roots from compromising the integrity of the membrane.	
Conceptual Design and Sizing Approach for Site Design	
<ol style="list-style-type: none"> 1. Determine the areas where green roofs can be used in the site design to replace conventional roofing to reduce the DCV. These green roof areas can be credited toward reducing runoff generated through representation in storm water calculations as pervious, not impervious, areas but are not credited for storm water pollutant control. 2. Calculate the DCV per Appendix B.2. 	

E.5 SD-6B Permeable Pavement (Site Design BMP)



Photo Credit: San Diego Low Impact Development Design Manual

Description

Permeable pavement is pavement that allows for percolation through void spaces in the pavement surface into subsurface layers. Permeable pavements reduce runoff volumes and rates and can provide pollutant control via infiltration, filtration, sorption, sedimentation, and biodegradation processes. When used as a site design BMP, the subsurface layers are designed to provide storage of storm water runoff so that outflow rates can be controlled via infiltration into subgrade soils. Varying levels of storm water treatment and

flow control can be provided depending on the size of the permeable pavement system relative to its drainage area and the underlying infiltration rates. As a site design BMP permeable pavement areas are designed to be self-retaining and are designed primarily for direct rainfall. Self-retaining permeable pavement areas have a ratio of total drainage area (including permeable pavement) to area of permeable pavement of 1.5:1 or less. Permeable pavement surfaces can be constructed from modular paver units or paver blocks, pervious concrete, porous asphalt, and turf pavers. Sites designed with permeable pavements can significantly reduce the impervious area of the project. Reduction in impervious surfaces decreases the DCV and can reduce the footprint of treatment control and flow control BMPs.

Design Adaptations for Project Goals

Site design BMP to reduce impervious area and DCV.

Permeable pavement without an underdrain can be used as a site design feature to reduce the impervious area of the site by replacing traditional pavements, including roadways, parking lots, emergency access lanes, sidewalks, trails and driveways.

Typical Permeable Pavement Components (Top to Bottom)

Permeable surface layer
Bedding layer for permeable surface
Aggregate storage layer with optional underdrain(s)
Optional final filter course layer over uncompacted existing subgrade

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where permeable pavements can be used in the site design to replace conventional pavements to reduce the DCV. These areas can be credited toward reducing runoff generated through representation in storm water calculations as pervious, not impervious, areas but are not credited for storm water pollutant control.
2. Calculate the DCV per Appendix B.2, taking into account reduced runoff from permeable pavement areas.

E.6 SD-8 Rain Barrels



Photo Credit: San Diego Low Impact Development Design Manual

Description

Rain barrels are containers that can capture rooftop runoff and store it for future use. With controlled timing and volume release, the captured rainwater can be used for irrigation or alternative grey water between storm events, thereby reducing runoff volumes and associated pollutants to downstream waterbodies. Rain barrels tend to be smaller systems, less than 100 gallons. Treatment can be achieved when rain barrels are used as part of a treatment train along with other BMPs that use captured flows in applications that do not result in discharges into the storm drain system. Rooftops are the ideal tributary areas for rain barrels.

Design Adaptations for Project Goals

Site design BMP to reduce effective impervious area and DCV. Barrels can be used as a site design feature to reduce the effective impervious area of the site by removing roof runoff from the site discharge. This can reduce the DCV and flow control requirements for the site.

Important Considerations

Maintenance: Rain barrels require regular monitoring and cleaning to ensure that they do not become clogged with leaves or other debris.

Economics: Rain barrels have low installation costs.

Limitations: Due to San Diego's arid climate, some rain barrels may fill only a few times each year.

Typical Rain Barrel Components

Storage container, barrel or tank for holding captured flows
Inlet and associated valves and piping
Outlet and associated valves and piping
Overflow outlet
Optional pump
Optional first flush diverters
Optional roof, supports, foundation, level indicator, and other accessories

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where rain barrels can be used in the site design to capture roof runoff to reduce the DCV. Rain barrels reduce the effective impervious area of the site by removing roof runoff from the site discharge.
2. Calculate the DCV per Appendix B.2, taking into account reduced runoff from permeable pavement areas.

E.7 HU-1 Cistern

MS4 Permit Category

Retention

Manual Category

Harvest and Use

Applicable Performance Standards

Pollutant Control

Flow Control

Primary Benefits

Volume Reduction

Peak Flow Attenuation



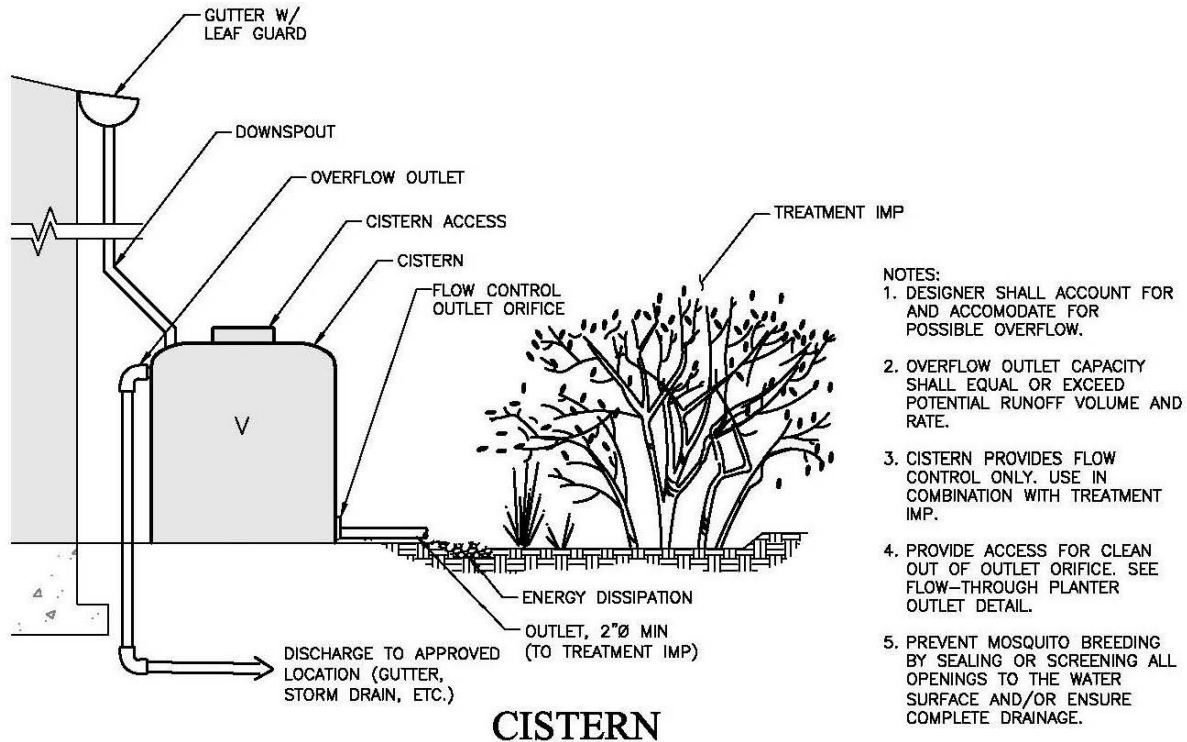
Photo Credit: Water Environment Research Foundation: WERF.org

Description

Cisterns are containers that can capture rooftop runoff and store it for future use. With controlled timing and volume release, the captured rainwater can be used for irrigation or alternative grey water between storm events, thereby reducing runoff volumes and associated pollutants to downstream water bodies. Cisterns are larger systems (generally >100 gallons) that can be self-contained aboveground or below ground systems. Treatment can be achieved when cisterns are used as part of a treatment train along with other BMPs that use captured flows in applications that do not result in discharges into the storm drain system. Rooftops are the ideal tributary areas for cisterns.

Typical cistern components include:

- Storage container, barrel or tank for holding captured flows
- Inlet and associated valves and piping
- Outlet and associated valves and piping
- Overflow outlet
- Optional pump
- Optional first flush diverters
- Optional roof, supports, foundation, level indicator, and other accessories



Source: City of San Diego Storm Water Standards

Design Adaptations for Project Goals

Site design BMP to reduce effective impervious area and DCV. Cisterns can be used as a site design feature to reduce the effective impervious area of the site by removing roof runoff from the site discharge. This can reduce the DCV and flow control requirements for the site.

Harvest and use for storm water pollutant control. Typical uses for captured flows include irrigation, toilet flushing, cooling system makeup, and vehicle and equipment washing.

Integrated storm water flow control and pollutant control configuration. Cisterns provide flow control in the form of volume reduction and/or peak flow attenuation and storm water treatment through elimination of discharges of pollutants. Additional flow control can be achieved by sizing the cistern to include additional detention storage and/or real-time automated flow release controls.

Design Criteria and Considerations

Cisterns must meet the following design criteria. Deviations from the below criteria may be approved

at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Cisterns are sized to detain the full DCV of contributing area and empty within 36 hours.	<p>Draining the cistern makes the storage volume available to capture the next storm.</p> <p>The applicant has an option to use a different drawdown time up to 96 hours if the volume of the facility is adjusted using the percent capture method in Appendix B.4.2.</p>
<input type="checkbox"/> Cisterns are fitted with a flow control device such as an orifice or a valve to limit outflow in accordance with drawdown time requirements.	<p>Flow control provides flow attenuation benefits and limits cistern discharge to downstream facilities during storm events.</p>
<input type="checkbox"/> Cisterns are designed to drain completely, leaving no standing water, and all entry points are fitted with traps or screens, or sealed.	<p>Complete drainage and restricted entry prevents mosquito habitat.</p>
<input type="checkbox"/> Leaf guards and/or screens are provided to prevent debris from accumulating in the cistern.	<p>Leaves and organic debris can clog the outlet of the cistern.</p>
<input type="checkbox"/> Access is provided for maintenance and the cistern outlets are accessible and designed to allow easy cleaning.	<p>Properly functioning outlets are needed to maintain proper flow control in accordance with drawdown time requirements.</p>
<input type="checkbox"/> Cisterns must be designed and sited such that overflow will be conveyed safely overland to the storm drain system or discharge point.	<p>Safe overflow conveyance prevents flooding and damage of property.</p>

Conceptual Design and Sizing Approach for Site Design and Storm Water Pollutant Control

1. Calculate the DCV for site design per Appendix B.
2. Determine the locations on the site where cisterns can be located to capture and detain the DCV from roof areas without subsequent discharge to the storm drain system. Cisterns are best located in close proximity to building and other roofed structures to minimize piping. Cisterns can also be used as part of a treatment train upstream by increasing pollutant control through delayed runoff to infiltration BMPs such as bioretention without underdrain facilities.
3. Use the sizing worksheet in Appendix B.3 to determine if full or partial capture of the DCV is achievable.

4. The remaining DCV to be treated should be calculated for use in sizing downstream BMP(s).

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or duration will typically require significant cistern volumes, and therefore the following steps should be taken prior to determination of site design and storm water pollutant control. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that cistern siting and design criteria have been met. Design for flow control can be achieved using various design configurations, shapes, and quantities of cisterns.
2. Iteratively determine the cistern storage volume required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control valve operation.
3. Verify that the cistern is drawdown within 36 hours. The drawdown time can be estimated by dividing the storage volume by the rate of use of harvested water.
4. If the cistern cannot fully provide the flow rate and duration control required by this manual, a downstream structure with additional storage volume or infiltration capacity such as a biofiltration can be used to provide remaining flow control.

E.8 INF-1 Infiltration Basin

MS4 Permit Category

Retention

Manual Category

Infiltration

Applicable Performance Standard

Pollutant Control
Flow Control

Primary Benefits

Volume Reduction
Peak Flow Attenuation



Photo Credit: <http://www.stormwaterpartners.com/facilities/basin.html>

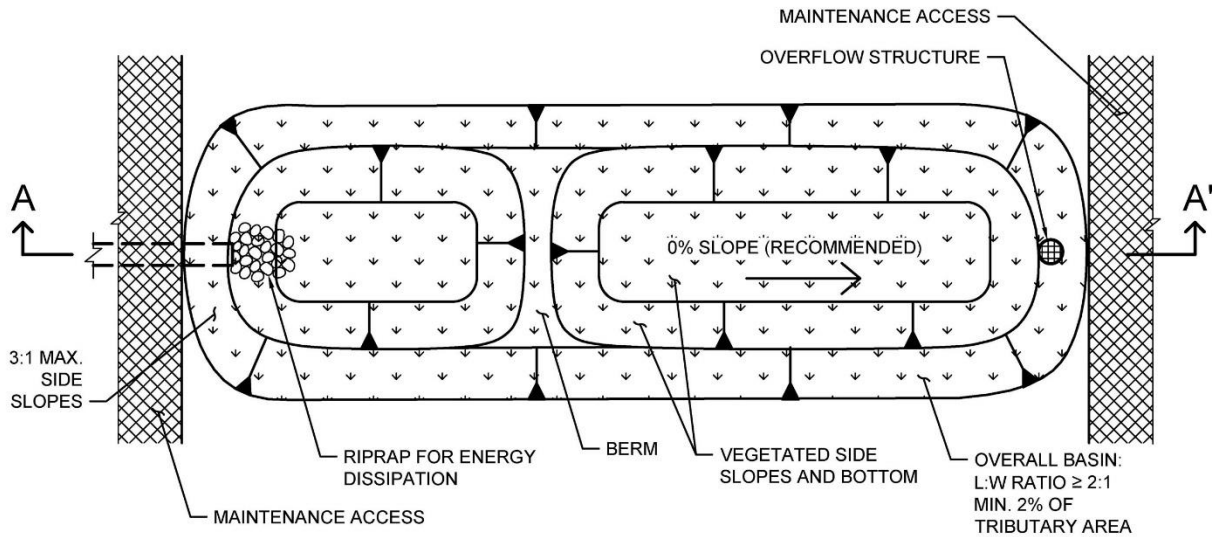
Description

An infiltration basin typically consists of an earthen basin with a flat bottom constructed in naturally pervious soils. An infiltration basin retains storm water and allows it to evaporate and/or percolate into the underlying soils. The bottom of an infiltration basin is typically vegetated with native grasses or turf grass; however other types of vegetation can be used if they can survive periodic inundation

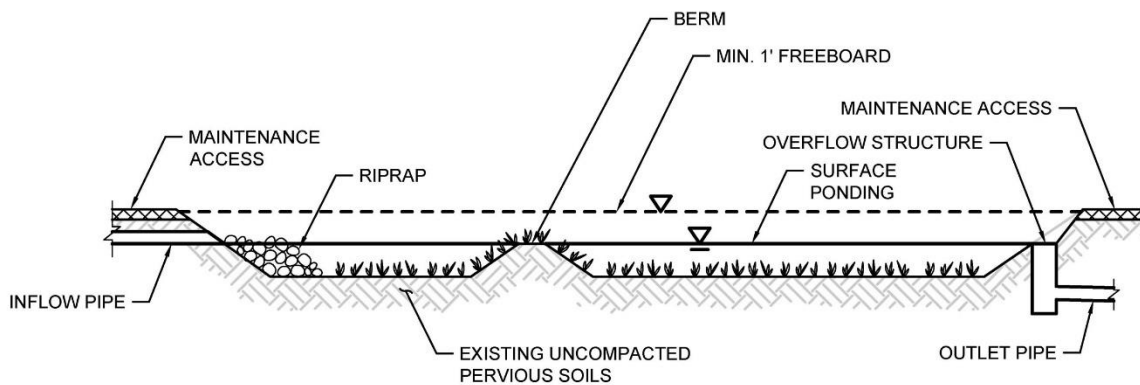
and long inter-event dry periods. Treatment is achieved primarily through infiltration, filtration, sedimentation, biochemical processes and plant uptake. Infiltration basins can be constructed as linear **trenches** or as **underground infiltration galleries**.

Typical infiltration basin components include:

- Inflow distribution mechanisms (e.g., perimeter flow spreader or filter strips)
- Energy dissipation mechanism for concentrated inflows (e.g., splash blocks or riprap)
- Forebay to provide pretreatment surface ponding for captured flows
- Vegetation selected based on basin use, climate, and ponding depth
- Uncompacted native soils at the bottom of the facility
- Overflow structure



PLAN
NOT TO SCALE



SECTION A-A'
NOT TO SCALE

Typical plan and section view of an Infiltration BMP

Design Adaptations for Project Goals

Full infiltration BMP for storm water pollutant control. Infiltration basins can be used as a pollutant control BMP, designed to infiltrate runoff from direct rainfall as well as runoff from adjacent areas that are tributary to the BMP. Infiltration basins must be designed with an infiltration storage volume (a function of the surface ponding volume) equal to the full DCV and able to meet drawdown time limitations.

Integrated storm water flow control and pollutant control configuration. Infiltration basins can

also be designed for flow rate and duration control by providing additional infiltration storage through increasing the surface ponding volume.

Design Criteria and Considerations

Infiltration basins must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> Selection and design of basin is based on infiltration feasibility criteria and appropriate design infiltration rate (See Appendix C and D).	Must operate as a full infiltration design and must be supported by drainage area and in-situ infiltration rate feasibility findings.
<input type="checkbox"/> Finish grade of the facility is $\leq 2\%$ (0% recommended).	Flatter surfaces reduce erosion and channelization with the facility.
<input type="checkbox"/> Settling forebay has a volume $\geq 25\%$ of facility volume below the forebay overflow.	A forebay to trap sediment can decrease frequency of required maintenance.
<input type="checkbox"/> Infiltration of surface ponding is limited to a 36-hour drawdown time.	Prolonged surface ponding reduce volume available to capture subsequent storms. The applicant has an option to use a different drawdown time up to 96 hours if the volume of the facility is adjusted using the percent capture method in Appendix B.4.2.
<input type="checkbox"/> Minimum freeboard provided is ≥ 1 foot.	Freeboard minimizes risk of uncontrolled surface discharge.
<input type="checkbox"/> Side slopes are $= 3H:1V$ or shallower.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<i>Inflow and Overflow Structures</i>		
<input type="checkbox"/>	Inflow and outflow structures are accessible by required equipment (e.g., vactor truck) for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/>	Inflow velocities are limited to 3 ft/s or less or use energy dissipation methods (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
<input type="checkbox"/>	Overflow is safely conveyed to a downstream storm drain system or discharge point. Size overflow structure to pass 100-year peak flow for on-line basins and water quality peak flow for off-line basins.	Planning for overflow lessens the risk of property damage due to flooding.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control

To design infiltration basins for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement and basin area requirements, forebay volume, and maximum slopes for basin sides and bottom.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.
3. Use the sizing worksheet (Appendix B.4) to determine if full infiltration of the DCV is achievable based on the infiltration storage volume calculated from the surface ponding area and depth for a maximum 36-hour drawdown time. The drawdown time can be estimated by dividing the average depth of the basin by the design infiltration rate. Appendix D provides guidance on evaluating a site's infiltration rate.

Conceptual Design and Sizing Approach for Storm Water Pollutant Treatment and Flow Control

Control of flow rates and/or durations will typically require significant surface ponding volume, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and design criteria have been met, including placement and basin area

requirements, forebay volume, and maximum slopes for basin sides and bottom.

2. Iteratively determine the surface ponding required to provide infiltration storage to reduce flow rates and durations to allowable limits while adhering to the maximum 36-hour drawdown time. Flow rates and durations can be controlled using flow splitters that route the appropriate inflow amounts to the infiltration basin and bypass excess flows to the downstream storm drain system or discharge point.
3. If an infiltration basin cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with appropriate storage volume such as an underground vault can be used to provide additional control.
4. After the infiltration basin has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.9 INF-2 Bioretention

MS4 Permit Category

Retention

Manual Category

Infiltration

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Volume Reduction

Treatment

Peak Flow Attenuation



Photo Credit: Ventura County Technical Guidance Document

Description

Bioretention (bioretention without underdrain) facilities are vegetated surface water systems that filter water through vegetation and soil, or engineered media prior to infiltrating into native soils. These facilities are designed to infiltrate the full DCV. Bioretention facilities are commonly incorporated into

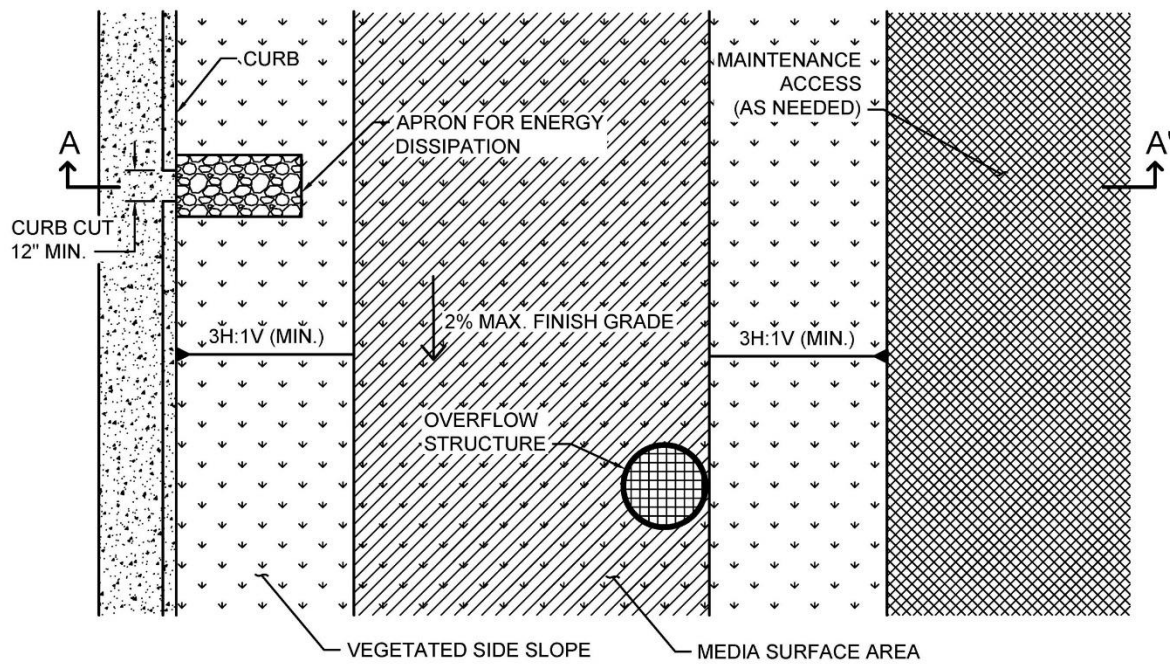
the site within parking lot landscaping, along roadsides, and in open spaces. They can be constructed inground or partially aboveground, such as planter boxes with open bottoms (no impermeable liner at the bottom) to allow infiltration. Treatment is achieved through filtration, sedimentation, sorption, infiltration, biochemical processes and plant uptake.

Typical bioretention without underdrain components include:

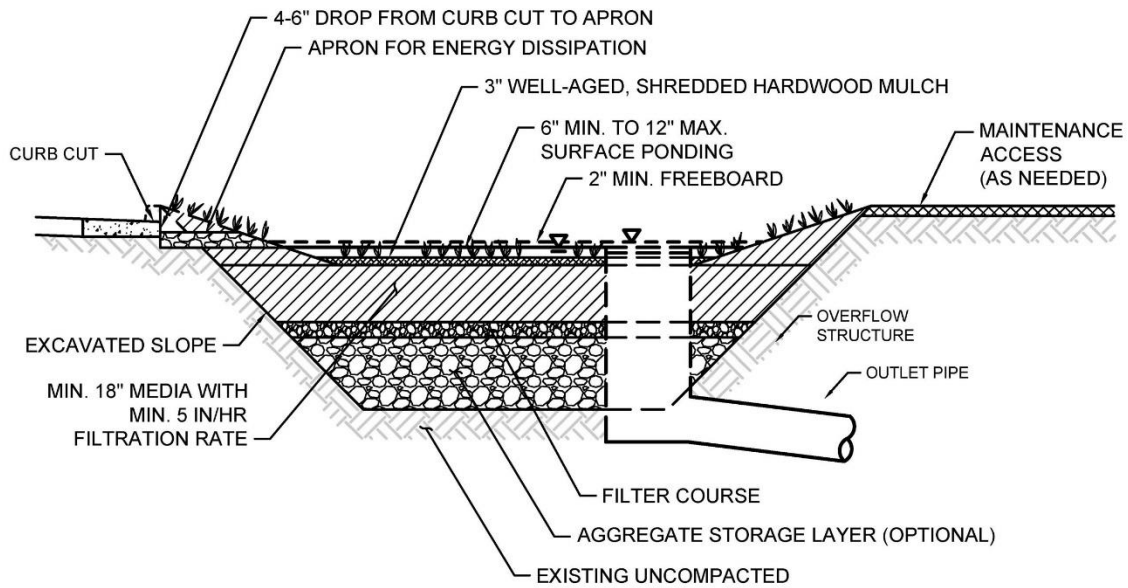
- Inflow distribution mechanisms (e.g, perimeter flow spreader or filter strips)
- Energy dissipation mechanism for concentrated inflows (e.g., splash blocks or riprap)
- Shallow surface ponding for captured flows
- Side slope and basin bottom vegetation selected based on expected climate and ponding depth
- Non-floating mulch layer
- Media layer (planting mix or engineered media) capable of supporting vegetation growth
- Filter course layer consisting of aggregate to prevent the migration of fines into uncompacted native soils or the optional aggregate storage layer
- Optional aggregate storage layer for additional infiltration storage
- Uncompacted native soils at the bottom of the facility
- Overflow structure

Design Adaptations for Project Goals

- **Full infiltration BMP for storm water pollutant control.** Bioretention can be used as a pollutant control BMP designed to infiltrate runoff from direct rainfall as well as runoff from adjacent tributary areas. Bioretention facilities must be designed with an infiltration storage volume (a function of the ponding, media and aggregate storage volumes) equal to the full DCV and able to meet drawdown time limitations.
- **Integrated storm water flow control and pollutant control configuration.** Bioretention facilities can be designed to provide flow rate and duration control. This may be accomplished by providing greater infiltration storage with increased surface ponding and/or aggregate storage volume for storm water flow control.



PLAN
NOT TO SCALE



SECTION A-A'
NOT TO SCALE

Typical plan and section view of a Bioretention BMP

Design Criteria and Considerations

Bioretention must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> Selection and design of BMP is based on infiltration feasibility criteria and appropriate design infiltration rate presented in Appendix C and D.	Must operate as a full infiltration design and must be supported by drainage area and in-situ infiltration rate feasibility findings.
<input type="checkbox"/> Contributing tributary area is ≤ 5 acres (≤ 1 acre preferred).	<p>Bigger BMPs require additional design features for proper performance.</p> <p>Contributing tributary area greater than 5 acres may be allowed at the discretion of the Port if the following conditions are met: 1) incorporate design features (e.g. flow spreaders) to minimizing short circuiting of flows in the BMP and 2) incorporate additional design features requested by the Port for proper performance of the BMP.</p>
<input type="checkbox"/> Finish grade of the facility is $\leq 2\%$. In long bioretention facilities where the potential for internal erosion and channelization exists, the use of check dams is required.	<p>Flatter surfaces reduce erosion and channelization within the facility.</p> <p>Internal check dams reduce velocity and dissipate energy.</p>
<i>Surface Ponding</i>	
<input type="checkbox"/> Surface ponding is limited to a 24-hour drawdown time.	<p>24-hour drawdown time is recommended for plant health.</p> <p>Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the Port if certified by a landscape architect or agronomist.</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Surface ponding depth is ≥ 6 and ≤ 12 inches.	<p>Surface ponding capacity lowers subsurface storage requirements. Deep surface ponding raises safety concerns.</p> <p>Surface ponding depth greater than 12 inches (for additional pollutant control or surface outlet structures or flow-control orifices) may be allowed at the discretion of the Port if the following conditions are met: 1) surface ponding depth drawdown time is less than 24 hours; and 2) safety issues and fencing requirements are considered (typically ponding greater than 18" will require a fence and/or flatter side slopes) and 3) potential for elevated clogging risk is considered.</p>
<input type="checkbox"/> A minimum of 12 inches of freeboard is provided.	<p>Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.</p>
<input type="checkbox"/> Side slopes are stabilized with vegetation and are $\geq 3H: 1V$.	<p>Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.</p>
<i>Vegetation</i>	
<input type="checkbox"/> Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.20.	<p>Plants suited to the climate and ponding depth are more likely to survive.</p>
<input type="checkbox"/> An irrigation system with a connection to water supply is provided as needed.	<p>Seasonal irrigation might be needed to keep plants healthy.</p>
<i>Mulch</i>	
<input type="checkbox"/> A minimum of 3 inches of well-aged, shredded hardwood mulch that has been stockpiled or stored for at least 12 months is provided. Mulch must be non-floating to avoid clogging of overflow structure.	<p>Mulch will suppress weeds and maintain moisture for plant growth. Aging mulch kills pathogens and weed seeds and allows beneficial microbes to multiply.</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
Media Layer	
<input type="checkbox"/> Media maintains a minimum filtration rate of 5 in/hr over lifetime of facility. A minimum initial filtration rate of 10 in/hr is recommended.	<p>A high filtration rate through the soil mix minimizes clogging potential and allows flows to quickly enter the aggregate storage layer, thereby minimizing bypass.</p>
<input type="checkbox"/> Media is a minimum 18 inches deep, meeting either of these two media specifications: City of San Diego Storm Water Standards, Appendix F (February 2016, unless superseded by more recent edition) or County of San Diego Low Impact Development Handbook: Appendix G -Bioretention Soil Specification (June 2014, unless superseded by more recent edition).	<p>A deep media layer provides additional filtration and supports plants with deeper roots.</p> <p>Standard specifications shall be followed.</p>
<input type="checkbox"/> Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in the 2016 City Storm Water Standards or County LID Manual, the media meets the pollutant treatment performance criteria in Section F.1.	<p>For proprietary and approved equivalent designs, compliance with F.1 ensures that adequate treatment performance will be provided.</p>
<input type="checkbox"/> Media surface area is 3% of contributing area times adjusted runoff factor or greater. Unless demonstrated that the BMP surface area can be smaller than 3%.	<p>Greater surface area to tributary area ratios decrease loading rates per square foot and therefore increase longevity.</p> <p>Adjusted runoff factor is to account for site design BMPs implemented upstream of the BMP (such as rain barrels, impervious area dispersion, etc.). Refer to Appendix B.2 guidance.</p> <p>Use Worksheet B.5-1 Line 26 to estimate the minimum surface area required per this criteria.</p>
Filter Course Layer (Optional)	
<input type="checkbox"/> A filter course is used to prevent migration of fines through layers of the facility. Filter fabric is not used.	<p>Migration of media can cause clogging of the aggregate storage layer void spaces or subgrade. Filter fabric is more likely to clog.</p>

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<input type="checkbox"/>	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
<input type="checkbox"/>	Filter course calculations assessing suitability for particle migration prevention have been completed.	Gradation relationship between layers can evaluate factors (e.g., bridging, permeability, and uniformity) to determine if particle sizing is appropriate or if an intermediate layer is needed.
<i>Aggregate Storage Layer (Optional)</i>		
<input type="checkbox"/>	Class 2 Permeable per Caltrans specification 68-1.025 is recommended for the storage layer. Washed, open-graded crushed rock may be used, however a 4-6 inch washed pea gravel filter course layer at the top of the crushed rock is required.	Washing aggregate will help eliminate fines that could clog the aggregate storage layer void spaces or subgrade.
<input type="checkbox"/>	Maximum aggregate storage layer depth is determined based on the infiltration storage volume that will infiltrate within a 36-hour drawdown time.	A maximum drawdown time to facilitate provision of adequate storm water storage for the next storm event.
<i>Inflow and Overflow Structures</i>		
<input type="checkbox"/>	Inflow and overflow structures are accessible for inspection and maintenance. Overflow structures must be connected to downstream storm drain system or appropriate discharge point.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/>	Inflow velocities are limited to 3 ft/s or less or use energy dissipation methods (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
<input type="checkbox"/>	Curb cut inlets are at least 12 inches wide, have a 4-6 inch reveal (drop) and an apron and energy dissipation as needed.	Inlets must not restrict flow and apron prevents blockage from vegetation as it grows in. Energy dissipation prevents erosion.
<input type="checkbox"/>	Overflow is safely conveyed to a downstream storm drain system or discharge point. Size overflow structure to pass 100-year peak flow for on-line basins and water quality peak flow for off-line basins.	Planning for overflow lessens the risk of property damage due to flooding.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design bioretention for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement and basin area requirements, maximum side and finish grade slope, and the recommended media surface area tributary ratio.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.
3. Use the sizing worksheet to determine if full infiltration of the DCV is achievable based on the available infiltration storage volume calculated from the bioretention without underdrain footprint area, effective depths for surface ponding, media and aggregate storage layers, and in-situ soil design infiltration rate for a maximum 36-hour drawdown time for the aggregate storage layer, with surface ponding no greater than a maximum 24-hour drawdown. The drawdown time can be estimated by dividing the average depth of the basin by the design infiltration rate of the underlying soil. Appendix D provides guidance on evaluating a site's infiltration rate. A generic sizing worksheet is provided in Appendix B.4.
4. Where the DCV cannot be fully infiltrated based on the site or bioretention constraints, an underdrain can be added to the design (use biofiltration with partial retention factsheet).

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding and/or aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations shall be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and design criteria have been met, including placement requirements, maximum side and finish grade slopes, and the recommended media surface area tributary area ratio. Design for flow control can be achieved using various design configurations.
2. Iteratively determine the facility footprint area, surface ponding and/or aggregate storage layer depth required to provide infiltration storage to reduce flow rates and durations to allowable limits while adhering to the maximum drawdown times for surface ponding and aggregate storage. Flow rates and durations can be controlled using flow splitters that route the appropriate inflow amounts to the bioretention facility and bypass excess flows to the downstream storm drain system or discharge point.
3. If bioretention without underdrain facility cannot fully provide the flow rate and duration control required by the MS4 permit, an upstream or downstream structure with appropriate storage volume such as an underground vault can be used to provide additional control.
4. After bioretention without underdrain BMPs have been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.10 INF-3 Permeable Pavement (Pollutant Control)

MS4 Permit Category

Retention
Flow-thru Treatment
Control

Manual Category

Infiltration
Flow-thru Treatment
Control

Applicable Performance Standard

Pollutant Control
Flow Control

Primary Benefits

Volume Reduction
Peak Flow Attenuation



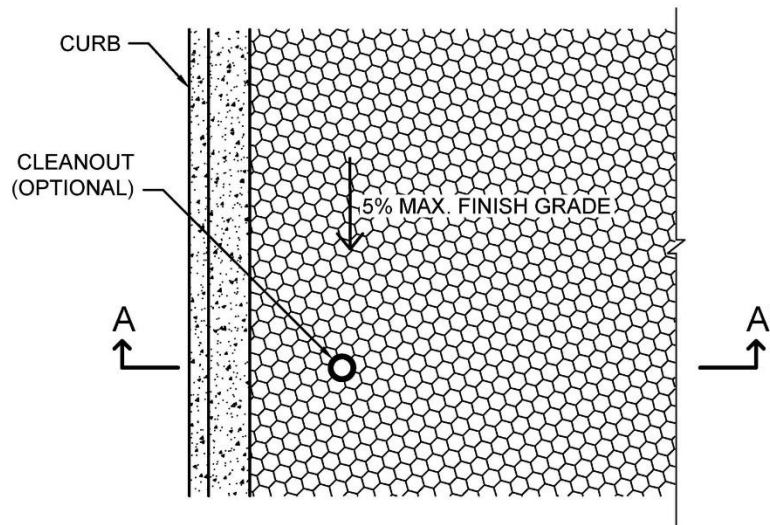
Location: Kellogg Park, San Diego, California

Description

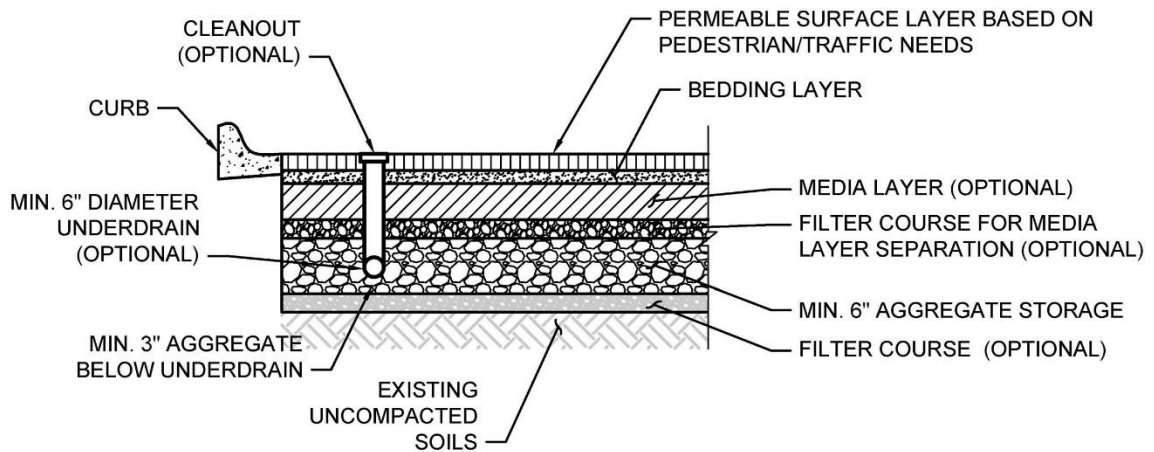
Permeable pavement is pavement that allows for percolation through void spaces in the pavement surface into subsurface layers. The subsurface layers are designed to provide storage of storm water runoff so that outflows, primarily via infiltration into subgrade soils or release to the downstream conveyance system, can be at controlled rates. Varying levels of storm water treatment and flow control can be provided depending on the size of the permeable pavement system relative to its drainage area, the underlying infiltration rates, and the configuration of outflow controls. Pollutant control permeable pavement is designed to receive runoff from a larger tributary area than site design permeable pavement (see SD-6B). Pollutant control is provided via infiltration, filtration, sorption, sedimentation, and biodegradation processes.

Typical permeable pavement components include, from top to bottom:

- Permeable surface layer
- Bedding layer for permeable surface
- Aggregate storage layer with optional underdrain(s)
- Optional final filter course layer over uncompacted existing subgrade



PLAN
NOT TO SCALE



SECTION A-A'
NOT TO SCALE

Typical plan and Section view of a Permeable Pavement BMP

Subcategories of permeable pavement include modular paver units or paver blocks, pervious concrete,

porous asphalt, and turf pavers. These subcategory variations differ in the material used for the permeable surface layer but have similar functions and characteristics below this layer.

Design Adaptations for Project Goals

Site design BMP to reduce impervious area and DCV. See site design option SD-6B.

Full infiltration BMP for storm water pollutant control. Permeable pavement without an underdrain and without impermeable liners can be used as a pollutant control BMP, designed to infiltrate runoff from direct rainfall as well as runoff from adjacent areas that are tributary to the pavement. The system must be designed with an infiltration storage volume (a function of the aggregate storage volume) equal to the full DCV and able to meet drawdown time limitations.

Partial infiltration BMP with flow-thru treatment for storm water pollutant control. Permeable pavement can be designed so that a portion of the DCV is infiltrated by providing an underdrain with infiltration storage below the underdrain invert. The infiltration storage depth should be determined by the volume that can be reliably infiltrated within drawdown time limitations. Water discharged through the underdrain is considered flow-thru treatment and is not considered biofiltration treatment. Storage provided above the underdrain invert is included in the flow-thru treatment volume.

Flow-thru treatment BMP for storm water pollutant control. The system may be lined and/or installed over impermeable native soils with an underdrain provided at the bottom to carry away filtered runoff. Water quality treatment is provided via unit treatment processes other than infiltration. This configuration is considered to provide flow-thru treatment, not biofiltration treatment. Significant aggregate storage provided above the underdrain invert can provide detention storage, which can be controlled via inclusion of an orifice in an outlet structure at the downstream end of the underdrain. **PDPs have the option to add saturated storage to the flow-thru configuration in order to reduce the DCV that the BMP is required to treat.** Saturated storage can be added to this design by including an upturned elbow installed at the downstream end of the underdrain or via an internal weir structure designed to maintain a specific water level elevation. The DCV can be reduced by the amount of saturated storage provided.

Integrated storm water flow control and pollutant control configuration. With any of the above configurations, the system can be designed to provide flow rate and duration control. This may include having a deeper aggregate storage layer that allows for significant detention storage above the underdrain, which can be further controlled via inclusion of an outlet structure at the downstream end of the underdrain.

Design Criteria and Considerations

Permeable pavements must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> Selection must be based on infiltration feasibility criteria.	Full or partial infiltration designs must be supported by drainage area feasibility findings.
<input type="checkbox"/> An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.
<input type="checkbox"/> Permeable pavement is not placed in an area with significant overhanging trees or other vegetation.	Leaves and organic debris can clog the pavement surface.
<input type="checkbox"/> For pollutant control permeable pavement, the ratio of the total drainage area (including the permeable pavement) to the permeable pavement should not exceed 4:1.	Higher ratios increase the potential for clogging but may be acceptable for relatively clean tributary areas.
<input type="checkbox"/> Finish grade of the permeable pavement has a slope $\leq 5\%$.	Flatter surfaces facilitate increased runoff capture.
<input type="checkbox"/> Minimum depth to groundwater and bedrock ≥ 10 ft.	A minimum separation facilitates infiltration and lessens the risk of negative groundwater impacts.
<input type="checkbox"/> Contributing tributary area includes effective sediment source control and/or pretreatment measures such as raised curbed or grass filter strips.	Sediment can clog the pavement surface.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Direct discharges to permeable pavement are only from downspouts carrying “clean” roof runoff that are equipped with filters to remove gross solids.	Roof runoff typically carries less sediment than runoff from other impervious surfaces and is less likely to clog the pavement surface.
<i>Permeable Surface Layer</i>	
<input type="checkbox"/> Permeable surface layer type is appropriately chosen based on pavement use and expected vehicular loading.	Pavement may wear more quickly if not durable for expected loads or frequencies.
<input type="checkbox"/> Permeable surface layer type is appropriate for expected pedestrian traffic.	Expected demographic and accessibility needs (e.g., adults, children, seniors, runners, high-heeled shoes, wheelchairs, strollers, bikes) requires selection of appropriate surface layer type that will not impede pedestrian needs.
<i>Bedding Layer for Permeable Surface</i>	
<input type="checkbox"/> Bedding thickness and material is appropriate for the chosen permeable surface layer type.	<p>Porous asphalt requires a 2- to 4-inch layer of asphalt and a 1- to 2-inch layer of choker course (single-sized crushed aggregate, one-half inch) to stabilize the surface.</p> <p>Pervious concrete also requires an aggregate course of clean gravel or crushed stone with a minimum amount of fines.</p> <p>Permeable Interlocking Concrete Paver requires 1 or 2 inches of sand or No. 8 aggregate to allow for leveling of the paver blocks.</p> <p>Similar to Permeable Interlocking Concrete Paver, plastic grid systems also require a 1- to 2-inch bedding course of either gravel or sand.</p> <p>For Permeable Interlocking Concrete Paver and plastic grid systems, if sand is used, a geotextile should be used between the sand course and the reservoir media to prevent the sand from migrating into the stone media.</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Aggregate used for bedding layer is washed prior to placement.	Washing aggregate will help eliminate fines that could clog the permeable pavement system aggregate storage layer void spaces or underdrain.
<i>Media Layer (Optional) –used between bedding layer and aggregate storage layer to provide pollutant treatment control</i>	
<input type="checkbox"/> The pollutant removal performance of the media layer is documented by the applicant.	Media used for BMP design should be shown via research or testing to be appropriate for expected pollutants of concern and flow rates.
<input type="checkbox"/> A filter course is provided to separate the media layer from the aggregate storage layer.	Migration of media can cause clogging of the aggregate storage layer void spaces or underdrain.
<input type="checkbox"/> If a filter course is used, calculations assessing suitability for particle migration prevention have been completed.	Gradation relationship between layers can evaluate factors (e.g., bridging, permeability, and uniformity) to determine if particle sizing is appropriate or if an intermediate layer is needed.
<input type="checkbox"/> Consult permeable pavement manufacturer to verify that media layer provides required structural support.	Media must not compromise the structural integrity or intended uses of the permeable pavement surface.
<i>Aggregate Storage Layer</i>	
<input type="checkbox"/> Aggregate used for the aggregate storage layer is washed and free of fines.	Washing aggregate will help eliminate fines that could clog aggregate storage layer void spaces or underdrain.
<input type="checkbox"/> Minimum layer depth is 6 inches and for infiltration designs, the maximum depth is determined based on the infiltration storage volume that will infiltrate within a 36-hour drawdown time.	A minimum depth of aggregate provides structural stability for expected pavement loads.
<i>Underdrain and Outflow Structures</i>	
<input type="checkbox"/> Underdrains and outflow structures, if used, are accessible for inspection and maintenance.	Maintenance will improve the performance and extend the life of the permeable pavement system.

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<input type="checkbox"/>	Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve hydraulic performance by allowing perforations to remain unblocked.
<input type="checkbox"/>	Minimum underdrain diameter is 6 inches.	Smaller diameter underdrains are prone to clogging.
<input type="checkbox"/>	Underdrains are made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
<i>Filter Course (Optional)</i>		
<input type="checkbox"/>	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog subgrade and impede infiltration.

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where permeable pavement can be used in the site design to replace traditional pavement to reduce the impervious area and DCV. These permeable pavement areas can be credited toward reducing runoff generated through representation in storm water calculations as pervious, not impervious, areas but are not credited for storm water pollutant control. These permeable pavement areas should be designed as self-retaining with the appropriate tributary area ratio identified in the design criteria.
2. Calculate the DCV per Appendix B, taking into account reduced runoff from self-retaining permeable pavement areas.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design permeable pavement for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement requirements, maximum finish grade slope, and the recommended tributary area ratio for non-self-retaining permeable pavement. If infiltration is infeasible, the permeable pavement can be designed as flow-thru treatment per the sizing worksheet. If infiltration is feasible, calculations should follow the remaining design steps.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.

3. Use the sizing worksheet to determine if full or partial infiltration of the DCV is achievable based on the available infiltration storage volume calculated from the permeable pavement footprint, aggregate storage layer depth, and in-situ soil design infiltration rate for a maximum 36-hour drawdown time. The applicant has an option to use a different drawdown time up to 96 hours if the volume of the facility is adjusted using the percent capture method in Appendix B.4.2.
4. Where the DCV cannot be fully infiltrated based on the site or permeable pavement constraints, an underdrain must be incorporated above the infiltration storage to carry away runoff that exceeds the infiltration storage capacity.
5. The remaining DCV to be treated should be calculated for use in sizing downstream BMP(s).

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and design criteria have been met, including placement requirements, maximum finish grade slope, and the recommended tributary area ratio for non-self-retaining permeable pavement. Design for flow control can be achieved using various design configurations, but a flow-thru treatment design will typically require a greater aggregate storage layer volume than designs which allow for full or partial infiltration of the DCV.
2. Iteratively determine the area and aggregate storage layer depth required to provide infiltration and/or detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If the permeable pavement system cannot fully provide the flow rate and duration control required by this manual, a downstream structure with sufficient storage volume such as an underground vault can be used to provide remaining controls.
4. After permeable pavement has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.11 PR-1 Biofiltration with Partial Retention



Location: 805 and Bonita Road, Chula vista, C.A.

MS4 Permit Category

NA

Manual Category

Partial Retention

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Volume Reduction

Treatment

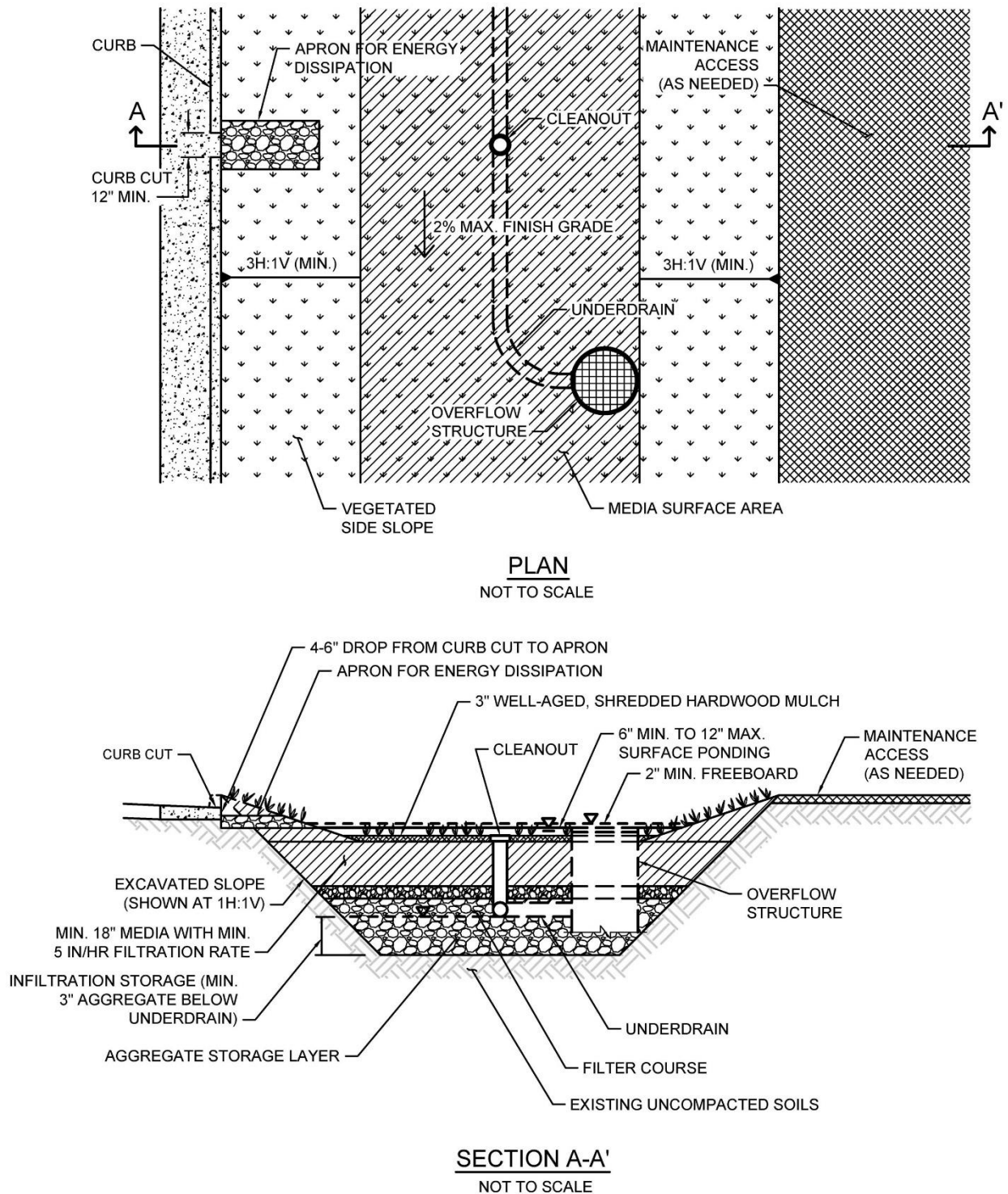
Peak Flow Attenuation

Description

Biofiltration with partial retention (partial infiltration and biofiltration) facilities are vegetated surface water systems that filter water through vegetation, and soil or engineered media prior to infiltrating into native soils, discharge via underdrain, or overflow to the downstream conveyance system. Where feasible, these BMPs have an elevated underdrain discharge point that creates storage capacity in the aggregate storage layer. Biofiltration with partial retention facilities are commonly incorporated into the site within parking lot landscaping, along roadsides, and in open spaces. They can be constructed in ground or partially aboveground, such as planter boxes with open bottoms to allow infiltration. Treatment is achieved through filtration, sedimentation, sorption, infiltration, biochemical processes and plant uptake.

Typical biofiltration with partial retention components include:

- Inflow distribution mechanisms (e.g, perimeter flow spreader or filter strips)
- Energy dissipation mechanism for concentrated inflows (e.g., splash blocks or riprap)
- Shallow surface ponding for captured flows
- Side Slope and basin bottom vegetation selected based on climate and ponding depth
- Non-floating mulch layer
- Media layer (planting mix or engineered media) capable of supporting vegetation growth
- Filter course layer consisting of aggregate to prevent the migration of fines into uncompacted native soils or the optional aggregate storage layer
- Aggregate storage layer with underdrain(s)
- Uncompacted native soils at the bottom of the facility
- Overflow structure



Typical plan and Section view of a Biofiltration with Partial Retention BMP

Design Adaptations for Project Goals

Partial infiltration BMP with biofiltration treatment for storm water pollutant control. Biofiltration with partial retention can be designed so that a portion of the DCV is infiltrated by providing infiltration storage below the underdrain invert. The infiltration storage depth should be determined by the volume that can be reliably infiltrated within drawdown time limitations. Water discharged through the underdrain is considered biofiltration treatment. Storage provided above the underdrain within surface ponding, media, and aggregate storage is included in the biofiltration treatment volume.

Integrated storm water flow control and pollutant control configuration. The system can be designed to provide flow rate and duration control by primarily providing increased surface ponding and/or having a deeper aggregate storage layer. This will allow for significant detention storage, which can be controlled via inclusion of an orifice in an outlet structure at the downstream end of the underdrain.

Design Criteria and Considerations

Biofiltration with partial retention must meet the following design criteria and considerations. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> Selection and design of basin is based on infiltration feasibility criteria and appropriate design infiltration rate (See Appendix C and D).	Must operate as a partial infiltration design and must be supported by drainage area and in-situ infiltration rate feasibility findings.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Contributing tributary area shall be ≤ 5 acres (≤ 1 acre preferred).	<p>Bigger BMPs require additional design features for proper performance.</p> <p>Contributing tributary area greater than 5 acres may be allowed at the discretion of the Port if the following conditions are met: 1) incorporate design features (e.g. flow spreaders) to minimizing short circuiting of flows in the BMP and 2) incorporate additional design features requested by the Port for proper performance of the BMP.</p>
<input type="checkbox"/> Finish grade of the facility is $\leq 2\%$.	<p>Flatter surfaces reduce erosion and channelization within the facility.</p>
<i>Surface Ponding</i>	
<input type="checkbox"/> Surface ponding is limited to a 24-hour drawdown time.	<p>Surface ponding limited to 24 hours for plant health. Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the Port if certified by a landscape architect or agronomist.</p>
<input type="checkbox"/> Surface ponding depth is ≥ 6 and ≤ 12 inches.	<p>Surface ponding capacity lowers subsurface storage requirements. Deep surface ponding raises safety concerns.</p> <p>Surface ponding depth greater than 12 inches (for additional pollutant control or surface outlet structures or flow-control orifices) may be allowed at the discretion of the Port if the following conditions are met: 1) surface ponding depth drawdown time is less than 24 hours; and 2) safety issues and fencing requirements are considered (typically ponding greater than 18" will require a fence and/or flatter side slopes) and 3) potential for elevated clogging risk is considered.</p>

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<input type="checkbox"/>	A minimum of 12 inches of freeboard is provided.	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
<input type="checkbox"/>	Side slopes are stabilized with vegetation and are = 3H:1V or shallower.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
<i>Vegetation</i>		
<input type="checkbox"/>	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.20	Plants suited to the climate and ponding depth are more likely to survive.
<input type="checkbox"/>	An irrigation system with a connection to water supply should be provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
<i>Mulch</i>		
<input type="checkbox"/>	A minimum of 3 inches of well-aged, shredded hardwood mulch that has been stockpiled or stored for at least 12 months is provided. Mulch must be non-floating to avoid clogging of overflow structure.	Mulch will suppress weeds and maintain moisture for plant growth. Aging mulch kills pathogens and weed seeds and allows the beneficial microbes to multiply.
<i>Media Layer</i>		
<input type="checkbox"/>	Media maintains a minimum filtration rate of 5 in/hr over lifetime of facility. An initial filtration rate of 8 to 12 in/hr is recommended to allow for clogging over time; the initial filtration rate should not exceed 12 inches per hour.	A filtration rate of at least 5 inches per hour allows soil to drain between events, and allows flows to relatively quickly enter the aggregate storage layer, thereby minimizing bypass. The initial rate should be higher than long term target rate to account for clogging over time. However an excessively high initial rate can have a negative impact on treatment performance, therefore an upper limit is needed.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<p>Media is a minimum 18 inches deep, meeting either of these two media specifications:</p> <p>City of San Diego Storm Water Standards Appendix F (February 2016, unless superseded by more recent edition) or County of San Diego Low Impact Development Handbook: Appendix G -Bioretention Soil Specification (June 2014, unless superseded by more recent edition).</p> <p><input type="checkbox"/></p>	<p>A deep media layer provides additional filtration and supports plants with deeper roots.</p> <p>Standard specifications shall be followed.</p>
<p>Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in the 2016 City Storm Water Standards or County LID Manual, the media meets the pollutant treatment performance criteria in Section F.1.</p>	<p>For non-standard or proprietary approved equivalent designs, compliance with Appendix F.1 ensures that adequate treatment performance will be provided.</p>
<p>Media surface area is 3% of contributing area times adjusted runoff factor or greater. Unless demonstrated that the BMP surface area can be smaller than 3%.</p> <p><input type="checkbox"/></p>	<p>Greater surface area to tributary area ratios: a) maximizes volume retention as required by the MS4 Permit and b) decrease loading rates per square foot and therefore increase longevity.</p> <p>Adjusted runoff factor is to account for site design BMPs implemented upstream of the BMP (such as rain barrels, impervious area dispersion, etc.). Refer to Appendix B.2 guidance.</p> <p>Use Worksheet B.5-1 Line 26 to estimate the minimum surface area required per this criteria.</p>
<p>Where receiving waters are impaired or have a TMDL for nutrients, the system is designed with nutrient sensitive media design (see fact sheet BF-2).</p> <p><input type="checkbox"/></p>	<p>Potential for pollutant export is partly a function of media composition; media design must minimize potential for export of nutrients, particularly where receiving waters are impaired for nutrients.</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<i>Filter Course Layer</i>	
<input type="checkbox"/> A filter course is used to prevent migration of fines through layers of the facility. Filter fabric is not used.	Migration of media can cause clogging of the aggregate storage layer void spaces or subgrade. Filter fabric is more likely to clog.
<input type="checkbox"/> Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility
<input type="checkbox"/> Filter course calculations assessing suitability for particle migration prevention have been completed.	Gradation relationship between layers can evaluate factors (e.g., bridging, permeability, and uniformity) to determine if particle sizing is appropriate or if an intermediate layer is needed.
<i>Aggregate Storage Layer</i>	
<input type="checkbox"/> Class 2 Permeable per Caltrans specification 68-1.025 is recommended for the storage layer. Washed, open-graded crushed rock may be used, however a 4-6 inch washed pea gravel filter course layer at the top of the crushed rock is required.	Washing aggregate will help eliminate fines that could clog the aggregate storage layer void spaces or subgrade.
<input type="checkbox"/> Maximum aggregate storage layer depth below the underdrain invert is determined based on the infiltration storage volume that will infiltrate within a 36-hour drawdown time.	A maximum drawdown time is needed for vector control and to facilitate providing storm water storage for the next storm event.
<i>Inflow, Underdrain, and Outflow Structures</i>	
<input type="checkbox"/> Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/> Inflow velocities are limited to 3 ft/s or less or use energy dissipation methods. (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
<input type="checkbox"/> Curb cut inlets are at least 12 inches wide, have a 4-6 inch reveal (drop) and an apron and energy dissipation as needed.	Inlets must not restrict flow and apron prevents blockage from vegetation as it

<i>Siting and Design</i>		<i>Intent/Rationale</i>
		grows in. Energy dissipation prevents erosion.
<input type="checkbox"/>	Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve hydraulic performance by allowing perforations to remain unblocked.
<input type="checkbox"/>	Minimum underdrain diameter is 6 inches.	Smaller diameter underdrains are prone to clogging.
<input type="checkbox"/>	Underdrains are made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
<input type="checkbox"/>	An underdrain cleanout with a minimum 6-inch diameter and lockable cap is placed every 250 to 300 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance.
<input type="checkbox"/>	Overflow is safely conveyed to a downstream storm drain system or discharge point. Size overflow structure to pass 100-year peak flow for on-line infiltration basins and water quality peak flow for off-line basins.	Planning for overflow lessens the risk of property damage due to flooding.

Nutrient Sensitive Media Design

To design biofiltration with partial retention with underdrain for storm water pollutant control only (no flow control required), the following steps should be taken:

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design biofiltration with partial retention and an underdrain for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended media surface area tributary ratio.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.
3. Generalized sizing procedure is presented in Appendix B.5. The surface ponding should be verified to have a maximum 24-hour drawdown time.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding and/or aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended media surface area tributary ratio.
2. Iteratively determine the facility footprint area, surface ponding and/or aggregate storage layer depth required to provide detention and/or infiltration storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If biofiltration with partial retention cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with significant storage volume such as an underground vault can be used to provide remaining controls.
4. After biofiltration with partial retention has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.12 BF-1 Biofiltration

MS4 Permit Category

Biofiltration

Manual Category

Biofiltration

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Treatment

Volume Reduction (Incidental)

Peak Flow Attenuation (Optional)



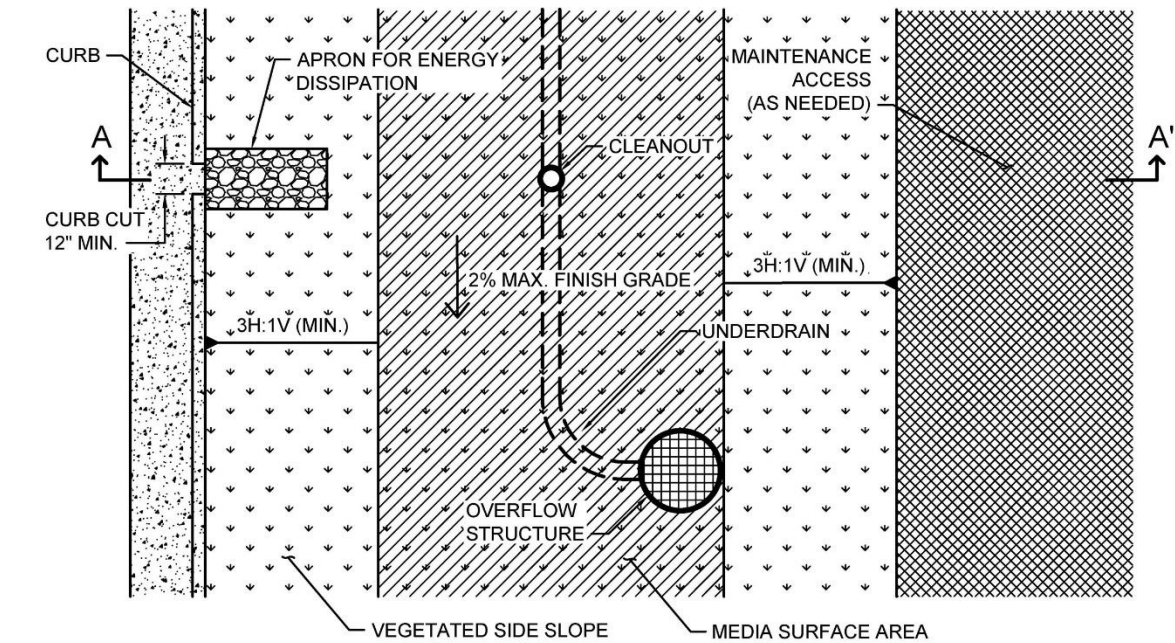
Location: 43rd Street and Logan Avenue, San Diego, California

Description

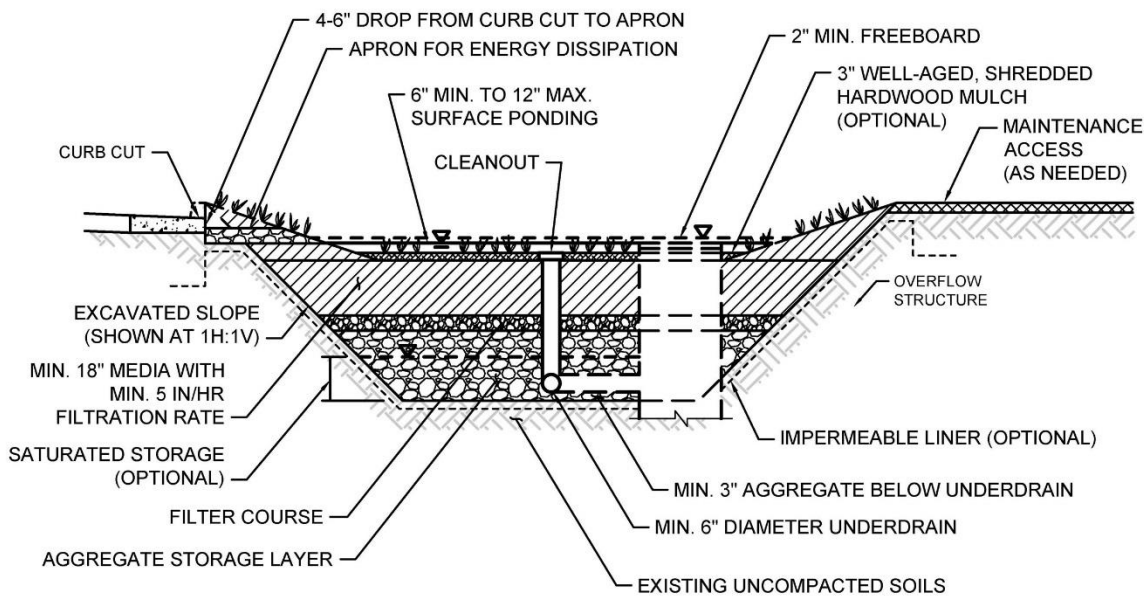
Biofiltration (Bioretention with underdrain) facilities are vegetated surface water systems that filter water through vegetation, and soil or engineered media prior to discharge via underdrain or overflow to the downstream conveyance system. Bioretention with underdrain facilities are commonly incorporated into the site within parking lot landscaping, along roadsides, and in open spaces. Because these types of facilities have limited or no infiltration, they are typically designed to provide enough hydraulic head to move flows through the underdrain connection to the storm drain system. Treatment is achieved through filtration, sedimentation, sorption, biochemical processes and plant uptake.

Typical bioretention with underdrain components include:

- Inflow distribution mechanisms (e.g, perimeter flow spreader or filter strips)
- Energy dissipation mechanism for concentrated inflows (e.g., splash blocks or riprap)
- Shallow surface ponding for captured flows
- Side slope and basin bottom vegetation selected based on expected climate and ponding depth
- Non-floating mulch layer
- Media layer (planting mix or engineered media) capable of supporting vegetation growth
- Filter course layer consisting of aggregate to prevent the migration of fines into uncompacted native soils or the aggregate storage layer
- Aggregate storage layer with underdrain(s)
- Impermeable liner or uncompacted native soils at the bottom of the facility
- Overflow structure



PLAN
NOT TO SCALE



SECTION A-A'
NOT TO SCALE

Typical plan and Section view of a Biofiltration BMP

Design Adaptations for Project Goals

Biofiltration Treatment BMP for storm water pollutant control. The system is lined or un-lined to provide incidental infiltration, and an underdrain is provided at the bottom to carry away filtered runoff. This configuration is considered to provide biofiltration treatment via flow through the media layer. Storage provided above the underdrain within surface ponding, media, and aggregate storage is considered included in the biofiltration treatment volume. Saturated storage within the aggregate storage layer can be added to this design by raising the underdrain above the bottom of the aggregate storage layer or via an internal weir structure designed to maintain a specific water level elevation.

Integrated storm water flow control and pollutant control configuration. The system can be designed to provide flow rate and duration control by primarily providing increased surface ponding and/or having a deeper aggregate storage layer above the underdrain. This will allow for significant detention storage, which can be controlled via inclusion of an outlet structure at the downstream end of the underdrain.

Design Criteria and Considerations

Bioretention with underdrain must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration or lateral flows should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Contributing tributary area shall be ≤ 5 acres (≤ 1 acre preferred).	<p>Bigger BMPs require additional design features for proper performance.</p> <p>Contributing tributary area greater than 5 acres may be allowed at the discretion of the Port if the following conditions are met: 1) incorporate design features (e.g. flow spreaders) to minimizing short circuiting of flows in the BMP and 2) incorporate additional design features requested by the Port for proper performance of the BMP.</p>
<input type="checkbox"/> Finish grade of the facility is $\leq 2\%$.	<p>Flatter surfaces reduce erosion and channelization within the facility.</p>
<i>Surface Ponding</i>	
<input type="checkbox"/> Surface ponding is limited to a 24-hour drawdown time.	<p>Surface ponding limited to 24 hours for plant health. Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the Port if certified by a landscape architect or agronomist.</p>
<input type="checkbox"/> Surface ponding depth is ≥ 6 and ≤ 12 inches.	<p>Surface ponding capacity lowers subsurface storage requirements. Deep surface ponding raises safety concerns.</p> <p>Surface ponding depth greater than 12 inches (for additional pollutant control or surface outlet structures or flow-control orifices) may be allowed at the discretion of the Port if the following conditions are met: 1) surface ponding depth drawdown time is less than 24 hours; and 2) safety issues and fencing requirements are considered (typically ponding greater than 18" will require a fence and/or flatter side slopes) and 3) potential for elevated clogging risk is considered.</p>

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<input type="checkbox"/>	A minimum of 12 inches of freeboard is provided.	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
<input type="checkbox"/>	Side slopes are stabilized with vegetation and are = 3H:1V or shallower.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
<i>Vegetation</i>		
<input type="checkbox"/>	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.20.	Plants suited to the climate and ponding depth are more likely to survive.
<input type="checkbox"/>	An irrigation system with a connection to water supply should be provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
<i>Mulch</i>		
<input type="checkbox"/>	A minimum of 3 inches of well-aged, shredded hardwood mulch that has been stockpiled or stored for at least 12 months is provided.	Mulch will suppress weeds and maintain moisture for plant growth. Aging mulch kills pathogens and weed seeds and allows the beneficial microbes to multiply.
<i>Media Layer</i>		
<input type="checkbox"/>	Media maintains a minimum filtration rate of 5 in/hr over lifetime of facility. An initial filtration rate of 8 to 12 in/hr is recommended to allow for clogging over time; the initial filtration rate should not exceed 12 inches per hour.	A filtration rate of at least 5 inches per hour allows soil to drain between events. The initial rate should be higher than long term target rate to account for clogging over time. However an excessively high initial rate can have a negative impact on treatment performance, therefore an upper limit is needed.
<input type="checkbox"/>	Media is a minimum 18 inches deep, meeting either of these two media specifications: City of San Diego Storm Water Standards Appendix F (February 2016, unless superseded by more recent edition) or County of San Diego Low Impact Development Handbook: Appendix G -Bioretention Soil Specification	A deep media layer provides additional filtration and supports plants with deeper roots. Standard specifications shall be followed.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<p>(June 2014, unless superseded by more recent edition).</p> <p>Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in the 2016 City Storm Water Standards or County LID Manual, the media meets the pollutant treatment performance criteria in Section F.1.</p>	<p>For non-standard or proprietary approved equivalent designs, compliance with F.1 ensures that adequate treatment performance will be provided.</p>
<p><input type="checkbox"/> Media surface area is 3% of contributing area times adjusted runoff factor or greater. Unless demonstrated that the BMP surface area can be smaller than 3%.</p>	<p>Greater surface area to tributary area ratios: a) maximizes volume retention as required by the MS4 Permit and b) decrease loading rates per square foot and therefore increase longevity.</p> <p>Adjusted runoff factor is to account for site design BMPs implemented upstream of the BMP (such as rain barrels, impervious area dispersion, etc.). Refer to Appendix B.2 guidance.</p> <p>Use Worksheet B.5-1 Line 26 to estimate the minimum surface area required per this criteria.</p>
<p><input type="checkbox"/> Where receiving waters are impaired or have a TMDL for nutrients, the system is designed with nutrient sensitive media design (see fact sheet BF-2).</p>	<p>Potential for pollutant export is partly a function of media composition; media design must minimize potential for export of nutrients, particularly where receiving waters are impaired for nutrients.</p>
<i>Filter Course Layer</i>	
<p><input type="checkbox"/> A filter course is used to prevent migration of fines through layers of the facility. Filter fabric is not used.</p>	<p>Migration of media can cause clogging of the aggregate storage layer void spaces or subgrade. Filter fabric is more likely to clog.</p>
<p><input type="checkbox"/> Filter course is washed and free of fines.</p>	<p>Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.</p>

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Filter course calculations assessing suitability for particle migration prevention have been completed.	Gradation relationship between layers can evaluate factors (e.g., bridging, permeability, and uniformity) to determine if particle sizing is appropriate or if an intermediate layer is needed.
<i>Aggregate Storage Layer</i>	
<input type="checkbox"/> Class 2 Permeable per Caltrans specification 68-1.025 is recommended for the storage layer. Washed, open-graded crushed rock may be used, however a 4-6 inch washed pea gravel filter course layer at the top of the crushed rock is required.	Washing aggregate will help eliminate fines that could clog the aggregate storage layer void spaces or subgrade.
<input type="checkbox"/> The depth of aggregate provided (12-inch typical) and storage layer configuration is adequate for providing conveyance for underdrain flows to the outlet structure.	Proper storage layer configuration and underdrain placement will minimize facility drawdown time.
<i>Inflow, Underdrain, and Outflow Structures</i>	
<input type="checkbox"/> Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/> Inflow velocities are limited to 3 ft/s or less or use energy dissipation methods. (e.g., riprap, level spreader) for concentrated inflows.	High inflow velocities can cause erosion, scour and/or channeling.
<input type="checkbox"/> Curb cut inlets are at least 12 inches wide, have a 4-6 inch reveal (drop) and an apron and energy dissipation as needed.	Inlets must not restrict flow and apron prevents blockage from vegetation as it grows in. Energy dissipation prevents erosion.
<input type="checkbox"/> Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve

<i>Siting and Design</i>	<i>Intent/Rationale</i>
	hydraulic performance by allowing perforations to remain unblocked.
<input type="checkbox"/> Minimum underdrain diameter is 6 inches.	Smaller diameter underdrains are prone to clogging.
<input type="checkbox"/> Underdrains are made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
<input type="checkbox"/> An underdrain cleanout with a minimum 6-inch diameter and lockable cap is placed every 250 to 300 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance.
<input type="checkbox"/> Overflow is safely conveyed to a downstream storm drain system or discharge point. Size overflow structure to pass 100-year peak flow for on-line infiltration basins and water quality peak flow for off-line basins.	Planning for overflow lessens the risk of property damage due to flooding.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design bioretention with underdrain for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended media surface area tributary ratio.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.
3. Use the sizing worksheet presented in Appendix B.5 to size biofiltration BMPs.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding and/or aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, maximum side and finish grade slopes, and the recommended

media surface area tributary ratio.

2. Iteratively determine the facility footprint area, surface ponding and/or aggregate storage layer depth required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If bioretention with underdrain cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with significant storage volume such as an underground vault can be used to provide remaining controls.
4. After bioretention with underdrain has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.13 BF-2 Nutrient Sensitive Media Design

Some studies of bioretention with underdrains have observed export of nutrients, particularly inorganic nitrogen (nitrate and nitrite) and dissolved phosphorus. This has been observed to be a short-lived phenomenon in some studies or a long term issue in some studies. The composition of the soil media, including the chemistry of individual elements is believed to be an important factor in the potential for nutrient export. Organic amendments, often compost, have been identified as the most likely source of nutrient export. The quality and stability of organic amendments can vary widely.

The biofiltration media specifications contained in the County of San Diego Low Impact Development Handbook: Appendix G -Bioretention Soil Specification (June 2014, unless superseded by more recent edition) and the City of San Diego Low Impact Development Design Manual (page B-18) (July 2011, unless superseded by more recent edition) were developed with consideration of the potential for nutrient export. These specifications include criteria for individual component characteristics and quality in order to control the overall quality of the blended mixes. As of the publication of this manual, the June 2014 County of San Diego specifications provide more detail regarding mix design and quality control.

The City and County specifications noted above were developed for general purposes to meet permeability and treatment goals. In cases where the BMP discharges to receiving waters with nutrient impairments or nutrient TMDLs, the biofiltration media should be designed with the specific goal of minimizing the potential for export of nutrients from the media. Therefore, in addition to adhering to the City or County media specifications, the following guidelines should be followed:

1. Select plant palette to minimize plant nutrient needs

A landscape architect or agronomist should be consulted to select a plant palette that minimizes nutrient needs. Utilizing plants with low nutrient needs results in less need to enrich the biofiltration soil mix. If nutrient quantity is then tailored to plants with lower nutrient needs, these plants will generally have less competition from weeds, which typically need higher nutrient content. The

following practices are recommended to minimize nutrient needs of the plant palette:

- **Utilize native, drought-tolerant plants and grasses where possible.** Native plants generally have a broader tolerance for nutrient content, and can be longer lived in leaner/lower nutrient soils.
- **Start plants from smaller starts or seed.** Younger plants are generally more tolerant of lower nutrient levels and tend to help develop soil structure as they grow. Given the lower cost of smaller plants, the project should be able to accept a plant mortality rate that is somewhat higher than starting from larger plants and providing high organic content.

2. Minimize excess nutrients in media mix

Once the low-nutrient plant palette is established (item 1), the landscape architect and/or agronomist should be consulted to assist in the design of a biofiltration media to balance the interests of plant establishment, water retention capacity (irrigation demand), and the potential for nutrient export. The following guidelines should be followed:

- **The mix should not exceed the nutrient needs of plants.** In conventional landscape design, the nutrient needs of plants are often exceeded intentionally in order to provide a factor of safety for plant survival. This practice must be avoided in biofiltration media as excess nutrients will increase the chance of export. The mix designer should keep in mind that nutrients can be added later (through mulching, tilling of amendments into the surface), but it is not possible to remove nutrients, once added.
- **The actual nutrient content and organic content of the selected organic amendment source should be determined when specifying mix proportions.** Nutrient content (i.e., C:N ratio; plant extractable nutrients) and organic content (i.e., % organic material) are relatively inexpensive to measure via standard agronomic methods and can provide important information about mix design. If mix design relies on approximate assumption about nutrient/organic content and this is not confirmed with testing (or the results of prior representative testing), it is possible that the mix could contain much more nutrient than intended.
- **Nutrients are better retained in soils with higher cation exchange capacity.** Cation exchange capacity can be increased through selection of organic material with naturally high cation exchange capacity, such as peat or coconut coir pith, and/or selection of inorganic material with high cation exchange capacity such as some sands or engineered minerals (e.g., low P-index sands, zeolites, rhyolites, etc). Including higher cation exchange capacity materials would tend to reduce the net export of nutrients. Natural silty materials also provide cation exchange capacity; however potential impacts to permeability need to be considered.
- **Focus on soil structure as well as nutrient content.** Soil structure is loosely defined as the ability of the soil to conduct and store water and nutrients as well as the degree of aeration of

the soil. Soil structure can be more important than nutrient content in plant survival and biologic health of the system. If a good soil structure can be created with very low amounts of organic amendment, plants survivability should still be provided. While soil structure generally develops with time, biofiltration media can be designed to promote earlier development of soil structure. Soil structure is enhanced by the use of amendments with high humus content (as found in well-aged organic material). In addition, soil structure can be enhanced through the use of organic material with a distribution of particle sizes (i.e., a more heterogeneous mix).

- **Consider alternatives to compost.** Compost, by nature, is a material that is continually evolving and decaying. It can be challenging to determine whether tests previously done on a given compost stock are still representative. It can also be challenging to determine how the properties of the compost will change once placed in the media bed. More stable materials such as aged coco coir pith, peat, biochar, shredded bark, and/or other amendments should be considered.

With these considerations, it is anticipated that less than 10 percent organic amendment by volume could be used, while still balancing plant survivability and water retention. If compost is used, designers should strongly consider utilizing less than 10 percent by volume.

3. Design with partial retention and/or internal water storage

An internal water storage zone, as described in Fact Sheet PR-1 is believed to improve retention of nutrients. For lined systems, an internal water storage zone worked by providing a zone that fluctuates between aerobic and anaerobic conditions, resulting in nitrification/denitrification. In soils that will allow infiltration, a partial retention design (PR-1) allows significant volume reduction and can also promote nitrification/denitrification.

Acknowledgment: This fact sheet has been adapted from the Orange County Technical Guidance Document (May 2011). It was originally developed based on input from: Deborah Deets, City of Los Angeles Bureau of Sanitation, Drew Ready, Center for Watershed Health, Rick Fisher, ASLA, City of Los Angeles Bureau of Engineering, Dr. Garn Wallace, Wallace Laboratories, Glen Dake, GDML, and Jason Schmidt, Tree People. The guidance provided herein does not reflect the individual opinions of any individual listed above and should not be cited or otherwise attributed to those listed.

E.14 BF-3 Proprietary Biofiltration Systems

The purpose of this fact sheet is to help explain the potential role of proprietary BMPs in meeting biofiltration requirements, when full retention of the DCV is not feasible. The fact sheet does not describe design criteria like the other fact sheets in this appendix because this information varies by BMP product model.

Criteria for Use of a Proprietary BMP as a Biofiltration BMP

A proprietary BMP may be acceptable as a “biofiltration BMP” under the following conditions:

- (1) The BMP meets the minimum design criteria listed in Appendix F, including the pollutant treatment performance standard in Appendix F.1;
- (2) The BMP is designed and maintained in a manner consistent with its performance certifications (See explanation in Appendix F.2); and
- (3) The BMP is acceptable at the discretion of the Port. In determining the acceptability of a BMP, the Port should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the Port, a written explanation/reason will be provided to the applicant..

Guidance for Sizing a Proprietary BMP as a Biofiltration BMP

Proprietary biofiltration BMPs must meet the same sizing guidance as non-proprietary BMPs. Sizing is typically based on capturing and treating 1.50 times the DCV not reliably retained. Guidance for sizing biofiltration BMPs to comply with requirements of this manual is provided in Appendix F.2.

E.15 FT-1 Vegetated Swales

MS4 Permit Category

Flow-thru Treatment Control

Manual Category

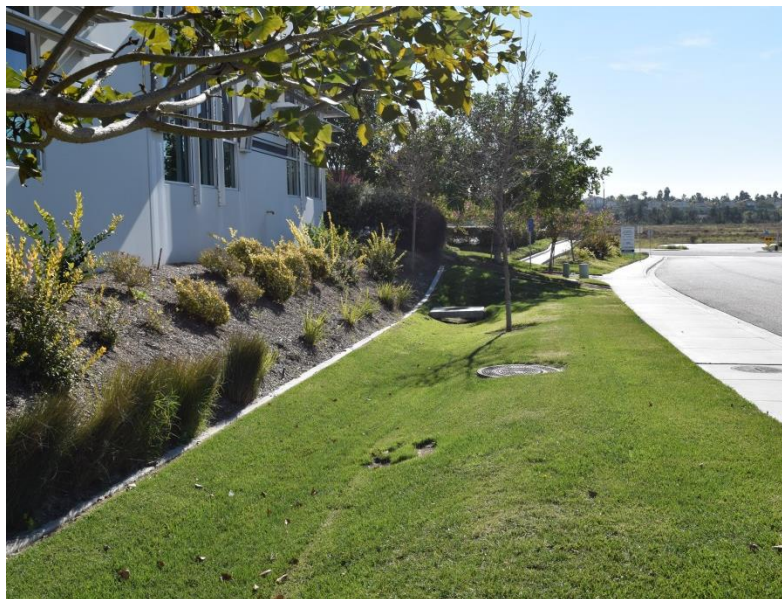
Flow-thru Treatment Control

Applicable Performance Standard

Pollutant Control

Primary Benefits

Treatment
Volume Reduction (Incidental)
Peak Flow Attenuation



Location: Eastlake Business Center, Chula Vista, California; Photo Credit: Eric Mosolgo

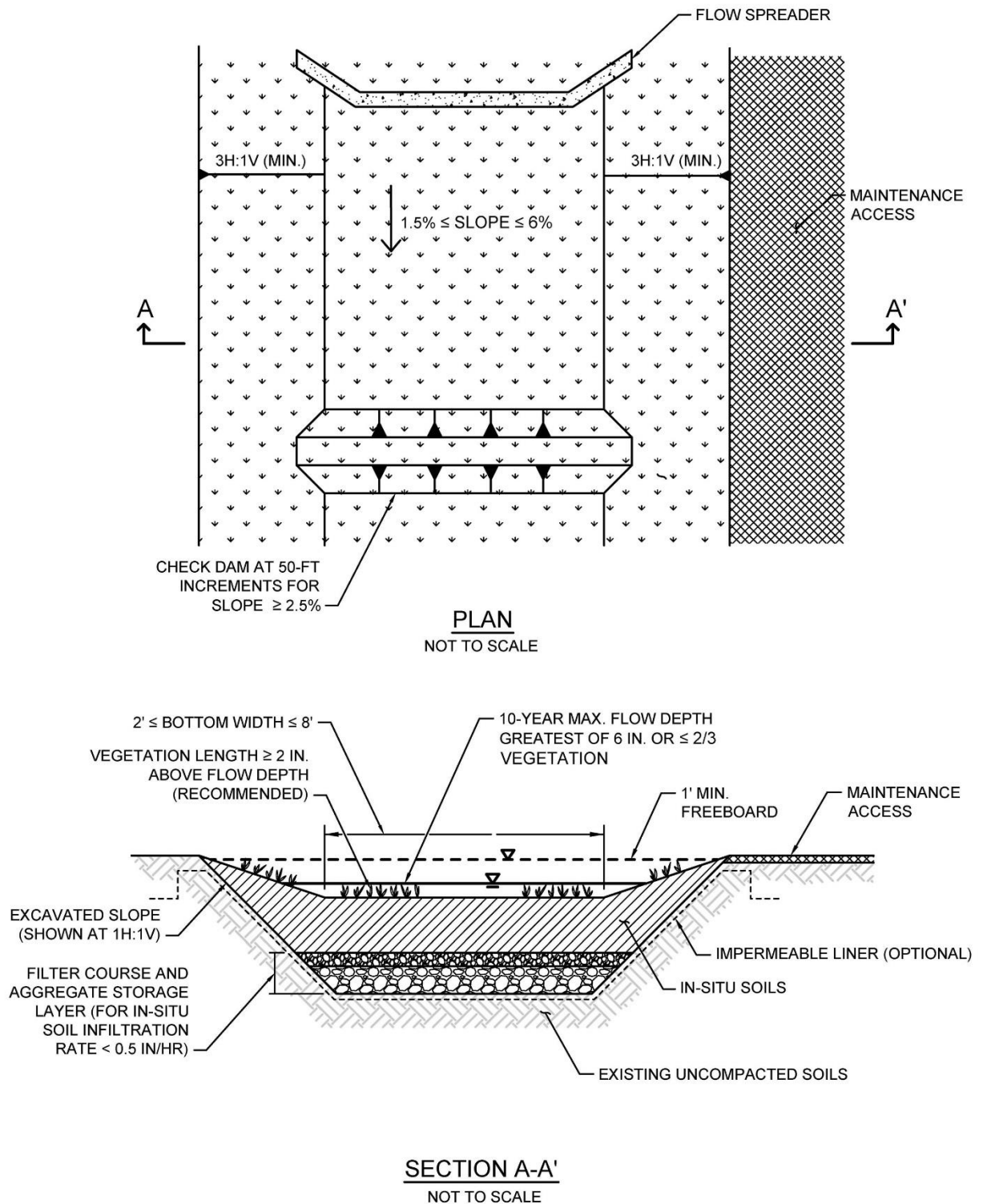
Description

Vegetated swales are shallow, open channels that are designed to remove storm water pollutants by physically straining/filtering runoff through vegetation in the channel. Swales can be used in place of traditional curbs and gutters and are well-suited for use in linear transportation corridors to provide both conveyance and treatment via filtration. An effectively designed vegetated swale achieves uniform sheet flow through densely vegetated areas. When soil conditions allow, infiltration and

volume reduction are enhanced by adding a gravel drainage layer underneath the swale. Vegetated swales with a subsurface media layer can provide enhanced infiltration, water retention, and pollutant-removal capabilities. Pollutant removal effectiveness can also be maximized by increasing the hydraulic residence time of water in swale using weirs or check dams.

Typical vegetated swale components include:

- Inflow distribution mechanisms (e.g., flow spreader)
- Surface flow
- Vegetated surface layer
- Check dams (if required)
- Optional aggregate storage layer with underdrain(s)



Typical plan and Section view of a Vegetated Swale BMP

Design Adaptations for Project Goals

Site design BMP to reduce runoff volumes and storm peaks. Swales without underdrains are an alternative to lined channels and pipes and can provide volume reduction through infiltration. Swales can also reduce the peak runoff discharge rate by increasing the time of concentration of the site and decreasing runoff volumes and velocities.

Flow-thru treatment BMP for storm water pollutant control. The system is lined or un-lined to provide incidental infiltration with an underdrain and designed to provide pollutant removal through settling and filtration in the channel vegetation (usually grasses). This configuration is considered to provide flow-thru treatment via horizontal surface flow through the swale. Sizing for flow-thru treatment control is based on the surface flow rate through the swale that meets water quality treatment performance objectives.

Design Criteria and Considerations

Vegetated swales must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, and liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration or lateral flows should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.
<input type="checkbox"/> Contributing tributary area ≤ 2 acres.	Higher ratios increase the potential for clogging but may be acceptable for relatively clean tributary areas.
<input type="checkbox"/> Longitudinal slope is $\geq 1.5\%$ and $\leq 6\%$.	Flatter swales facilitate increased water quality treatment while minimum slopes prevent ponding.
<input type="checkbox"/> For site design goal, in-situ soil infiltration rate ≥ 0.5 in/hr (if < 0.5 in/hr, an underdrain is required and design goal is for pollutant control only).	Well-drained soils provide volume reduction and treatment. An underdrain should only be provided when soil infiltration rates are low or per geotechnical or groundwater concerns.

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<i>Surface Flow</i>		
<input type="checkbox"/>	Maximum flow depth is ≤ 6 inches or $\leq \frac{2}{3}$ the vegetation length, whichever is greater. Ideally, flow depth will be ≥ 2 inches below shortest plant species.	Flow depth must fall within the height range of the vegetation for effective water quality treatment via filtering.
	A minimum of 1 foot of freeboard is provided.	Freeboard minimizes risk of uncontrolled surface discharge.
<input type="checkbox"/>	Cross sectional shape is trapezoidal or parabolic with side slopes $\geq 3H:1V$.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
<input type="checkbox"/>	Bottom width is ≥ 2 feet and ≤ 8 feet.	A minimum of 2 feet minimizes erosion. A maximum of 8 feet prevents channel braiding.
<input type="checkbox"/>	Minimum hydraulic residence time ≥ 10 minutes.	Longer hydraulic residence time increases pollutant removal.
<input type="checkbox"/>	Swale is designed to safely convey the 10-yr storm event unless a flow splitter is included to allow only the water quality event.	Planning for larger storm events lessens the risk of property damage due to flooding.
<input type="checkbox"/>	Flow velocity is ≤ 1 ft/s for water quality event. Flow velocity for 10-yr storm event is ≤ 3 ft/s.	Lower flow velocities provide increased pollutant removal via filtration and minimize erosion.
<i>Vegetated Surface Layer (amendment with media is Optional)</i>		
<input type="checkbox"/>	Soil is amended with 2 inches of media mixed into the top 6 inches of in-situ soils, as needed, to promote plant growth (optional). For enhanced pollutant control, 2 feet of media can be used in place of in-situ soils. Media meets either of these two media specifications: City of San Diego Storm Water Standards Appendix F, February 2016); Or County of San Diego Low Impact Development Handbook, June 2014: Appendix G -Bioretention Soil Specification.	Amended soils aid in plant establishment and growth. Media replacement for in-situ soils can improve water quality treatment and site design volume reduction.

<i>Siting and Design</i>		<i>Intent/Rationale</i>
<input type="checkbox"/>	Vegetation is appropriately selected low-growing, erosion-resistant plant species that effectively bind the soil, thrive under site-specific climatic conditions and require little or no irrigation.	Plants suited to the climate and expected flow conditions are more likely to survive.
<i>Check Dams</i>		
<input type="checkbox"/>	Check dams are provided at 50-foot increments for slopes $\geq 2.5\%$.	Check dams prevent erosion and increase the hydraulic residence time by lowering flow velocities and providing ponding opportunities.
<i>Filter Course Layer (For Underdrain Design)</i>		
<input type="checkbox"/>	A filter course is used to prevent migration of fines through layers of the facility. Filter fabric is not used.	Migration of media can cause clogging of the aggregate storage layer void spaces or subgrade. Filter fabric is more likely to clog.
<input type="checkbox"/>	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
<input type="checkbox"/>	Filter course calculations assessing suitability for particle migration prevention have been completed.	Gradation relationship between layers can evaluate factors (e.g., bridging, permeability, and uniformity) to determine if particle sizing is appropriate or if an intermediate layer is needed.
<i>Aggregate Storage Layer (For Underdrain Design)</i>		
<input type="checkbox"/>	The depth of aggregate provided (12-inch typical) and storage layer configuration is adequate for providing conveyance for underdrain flows to the outlet structure.	Proper storage layer configuration and underdrain placement will minimize facility drawdown time.
<input type="checkbox"/>	Aggregate used for the aggregate storage layer is washed and free of fines.	Washing aggregate will help eliminate fines that could clog aggregate storage layer void spaces or underdrain.
<i>Inflow and Underdrain Structures</i>		
<input type="checkbox"/>	Inflow and underdrains are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve hydraulic performance by allowing perforations to remain unblocked.
<input type="checkbox"/> Minimum underdrain diameter is 6 inches.	Smaller diameter underdrains are prone to clogging.
<input type="checkbox"/> Underdrains are made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
<input type="checkbox"/> An underdrain cleanout with a minimum 6-inch diameter and lockable cap is placed every 250 to 300 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance.

Conceptual Design and Sizing Approach for Site Design

1. Determine the areas where vegetated swales can be used in the site design to replace traditional curb and gutter facilities and provide volume reduction through infiltration.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design vegetated swales for storm water pollutant control only, the following steps should be taken:

1. Verify that siting and design criteria have been met, including bottom width and longitudinal and side slope requirements.
2. Calculate the design flow rate per Appendix B based on expected site design runoff for tributary areas.
3. Use the sizing worksheet to determine flow-thru treatment sizing of the vegetated swale and if flow velocity, flow depth, and hydraulic residence time meet required criteria. Swale configuration should be adjusted as necessary to meet design requirements.

E.16 FT-2 Media Filters

MS4 Permit Category

Flow-thru Treatment Control

Manual Category

Flow-thru Treatment Control

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Treatment

Peak Flow Attenuation (Optional)



Photo Credit: Contech Stormwater Solutions

Description

Media filters are manufactured devices that consist of a series of modular filters packed with engineered media that can be contained in a catch basin, manhole, or vault that provide treatment through filtration and sedimentation. The manhole or vault may be divided into multiple chambers where the first chamber acts as a presettling basin for removal of coarse sediment while the next

chamber acts as the filter bay and houses the filter cartridges. A variety of media types are available from various manufacturers that can target pollutants of concern via primarily filtration, sorption, ion exchange, and precipitation. **Specific products must be selected to meet the flow-thru BMP selection requirements described in Appendix B.6.** Treatment effectiveness is contingent upon proper maintenance of filter units.

Typical media filter components include:

- Vault for flow storage and media housing
- Inlet and outlet
- Media filters

Design Adaptations for Project Goals

Flow-thru treatment BMP for storm water pollutant control. Water quality treatment is provided through filtration. This configuration is considered to provide flow-thru treatment, not biofiltration treatment. Storage provided within the vault restricted by an outlet is considered detention storage and is included in calculations for the flow-thru treatment volume.

Integrated storm water flow control and pollutant control configuration. Media filters can also be designed for flow rate and duration control via additional detention storage. The vault storage can be designed to accommodate higher volumes than the storm water pollutant control volume and can utilize multi-stage outlets to mitigate both the duration and rate of flows within a prescribed range.

Design Criteria and Considerations

Media filters must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, and liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> Recommended for tributary areas with limited available surface area or where surface BMPs would restrict uses.	Maintenance needs may be more labor intensive for media filters than surface BMPs. Lack of surface visibility creates additional risk that maintenance needs may not be completed in a timely manner.
<input type="checkbox"/> Vault storage drawdown time ≤ 96 hours.	Provides vector control.
<input type="checkbox"/> Vault storage drawdown time ≤ 36 hours if the vault is used for equalization of flows for pollutant treatment.	Provides required capacity to treat back to back storms. Exception to the 36 hour drawdown criteria is allowed if additional vault storage is provided using the curves in Appendix B.4.2.
<i>Inflow and Outflow Structures</i>	
<input type="checkbox"/> Inflow and outflow structures are accessible by required equipment (e.g., vector truck) for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design a media filter for storm water pollutant control only (no flow control required), the following steps should be taken

1. Verify that the selected BMP complies with BMP selection requirements in Appendix B.6.
2. Verify that placement and tributary area requirements have been met.
3. Calculate the required DCV and/or flow rate per Appendix B.6.3 based on expected site design runoff for tributary areas.
4. Media filter can be designed either for DCV or flow rate. To estimate the drawdown time, divide the vault storage by the treatment rate of media filters.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant vault storage volume, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that placement and tributary area requirements have been met.
2. Iteratively determine the vault storage volume required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows to MS4.
3. If a media filter cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with appropriate storage volume such as an underground vault can be used to provide remaining controls.
4. After the media filter has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.
5. Verify that the vault drawdown time is 96 hours or less. To estimate the drawdown time:
 - a. Divide the vault volume by the filter surface area.
 - b. Divide the result (a) by the design filter rate.

E.17 FT-3 Sand Filters

MS4 Permit Category

Flow-thru Treatment Control

Manual Category

Flow-thru Treatment Control

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Treatment

Volume Reduction (Incidental)

Peak Flow Attenuation (Optional)



Photo Credit: City of San Diego LID Manual

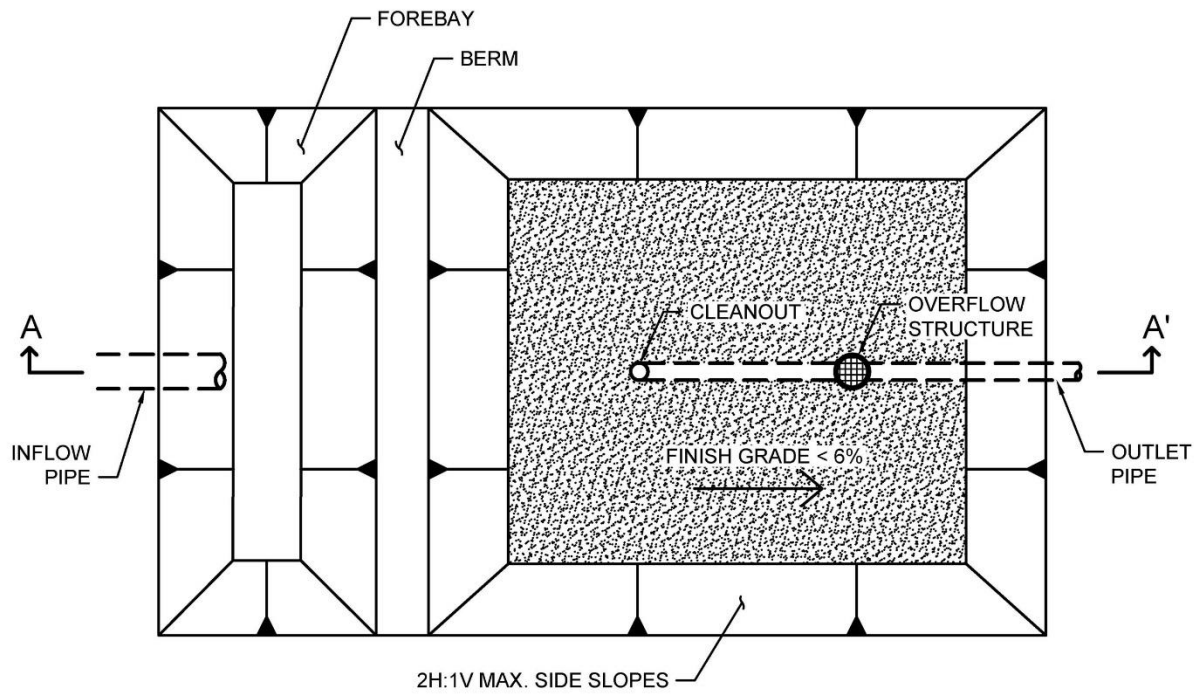
Description

Sand filters operate by filtering storm water through a constructed sand bed with an underdrain system. Runoff enters the filter and spreads over the surface. Sand filter beds can be enclosed within concrete structures or within earthen containment. As flows increase, water backs up on the surface of the filter where it is held until it can percolate through the sand. The treatment pathway is downward (vertical) through the media to an underdrain system that is connected to the downstream storm drain

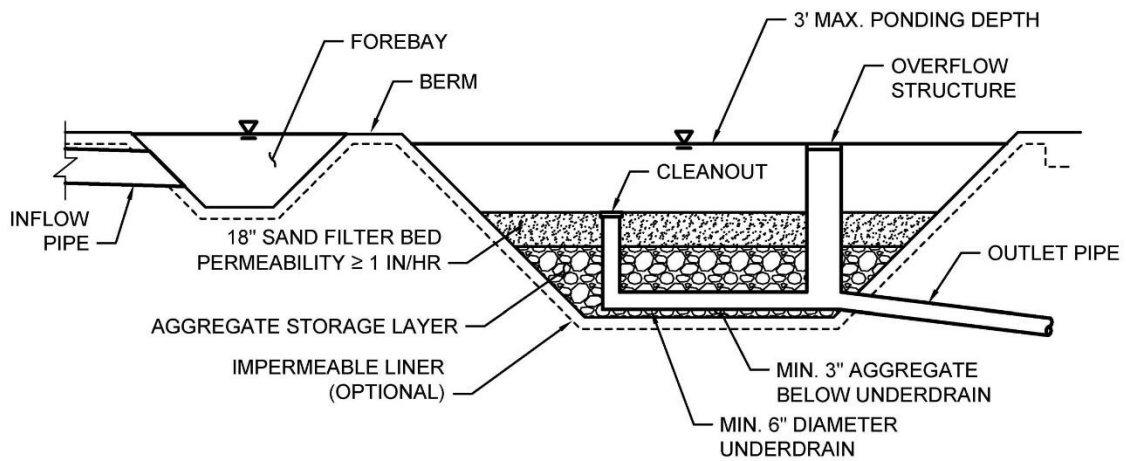
system. As storm water passes through the sand, pollutants are trapped on the surface of the filter, in the small pore spaces between sand grains or are adsorbed to the sand surface. The high filtration rates of sand filters, which allow a large runoff volume to pass through the media in a short amount of time, can provide efficient treatment for storm water runoff.

Typical sand filter components include:

- Forebay for pretreatment/energy dissipation
- Surface ponding for captured flows
- Sand filter bed
- Aggregate storage layer with underdrain(s)
- Overflow structure



PLAN
NOT TO SCALE



SECTION A-A'
NOT TO SCALE

Typical plan and Section view of a Sand Filter BMP

Design Adaptations for Project Goals

Flow-thru treatment BMP for storm water pollutant control. The system is lined or un-lined to provide incidental infiltration, and an underdrain is provided at the bottom to carry away filtered runoff. This configuration is considered to provide flow-thru treatment via vertical flow through the sand filter bed. Storage provided above the underdrain within surface ponding, the sand filter bed, and aggregate storage is considered included in the flow-thru treatment volume. Saturated storage within the aggregate storage layer can be added to this design by including an upturned elbow installed at the downstream end of the underdrain or via an internal weir structure designed to maintain a specific water level elevation.

Integrated storm water flow control and pollutant control configuration. The system can be designed to provide flow rate and duration control by primarily providing increased surface ponding and/or having a deeper aggregate storage layer above the underdrain. This will allow for significant detention storage, which can be controlled via inclusion of an outlet structure at the downstream end of the underdrain.

Design Criteria and Considerations

Sand filters must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, and liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration or lateral flows should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.

Appendix E: BMP Design Fact Sheets

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Contributing tributary area (≤ 5 acres).	<p>Bigger BMPs require additional design features for proper performance.</p> <p>Contributing tributary area greater than 5 acres may be allowed at the discretion of the Port if the following conditions are met: 1) incorporate design features (e.g. flow spreaders) to minimizing short circuiting of flows in the BMP and 2) incorporate additional design features requested by the Port for proper performance of the BMP.</p>
<input type="checkbox"/> Finish grade of facility is $< 6\%$.	Flatter surfaces reduce erosion and channelization within the facility.
<input type="checkbox"/> Earthen side slopes are $\geq 3H:1V$.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
<input type="checkbox"/> Surface ponding is limited to a 36-hour drawdown time.	Provides required capacity to treat back to back storms. Exception to the 36 hour drawdown criteria is allowed if additional surface storage is provided using the curves in Appendix B.4.2.
<input type="checkbox"/> Surface ponding is limited to a 96-hour drawdown time.	Prolonged surface ponding can create a vector hazard.
<input type="checkbox"/> Maximum ponding depth does not exceed 3 feet.	Surface ponding capacity lowers subsurface storage requirements and results in lower cost facilities. Deep surface ponding raises safety concerns.
<input type="checkbox"/> Sand filter bed consists of clean washed concrete or masonry sand (passing $\frac{1}{4}$ inch sieve) or sand similar to the ASTM C33 gradation.	Washing sand will help eliminate fines that could clog the void spaces of the aggregate storage layer.
<input type="checkbox"/> Sand filter bed permeability is at least 1 in/hr.	A high filtration rate through the media allows flows to quickly enter the aggregate storage layer, thereby minimizing bypass.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Sand filter bed depth is at least 18 inches deep.	Different pollutants are removed in various zones of the media using several mechanisms. Some pollutants bound to sediment, such as metals, are typically removed within 18 inches of the media.
<input type="checkbox"/> Aggregate storage should be washed, bank-run gravel.	Washing aggregate will help eliminate fines that could clog the aggregate storage layer void spaces or subgrade.
<input type="checkbox"/> The depth of aggregate provided (12-inch typical) and storage layer configuration is adequate for providing conveyance for underdrain flows to the outlet structure.	Proper storage layer configuration and underdrain placement will minimize facility drawdown time.
<input type="checkbox"/> Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/> Inflow must be non-erosive sheet flow (≤ 3 ft/s) unless an energy-dissipation device, flow diversion/splitter or forebay is installed.	Concentrated flow and/or excessive volumes can cause erosion in a sand filter and can be detrimental to the treatment capacity of the system.
<input type="checkbox"/> Underdrain outlet elevation should be a minimum of 3 inches above the bottom elevation of the aggregate storage layer.	A minimal separation from subgrade or the liner lessens the risk of fines entering the underdrain and can improve hydraulic performance by allowing perforations to remain unblocked.
<input type="checkbox"/> Minimum underdrain diameter is 6 inches.	Smaller diameter underdrains are prone to clogging.
<input type="checkbox"/> Underdrains should be made of slotted, PVC pipe conforming to ASTM D 3034 or equivalent or corrugated, HDPE pipe conforming to AASHTO 252M or equivalent.	Slotted underdrains provide greater intake capacity, clog resistant drainage, and reduced entrance velocity into the pipe, thereby reducing the chances of solids migration.
<input type="checkbox"/> Overflow is safely conveyed to a downstream storm drain system or discharge point.	Planning for overflow lessens the risk of property damage due to flooding.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design a sand filter for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, and maximum finish grade slope.
2. Calculate the required DCV and/or flow rate per Appendix B.6.3 based on expected site design runoff for tributary areas.
3. Sand filter can be designed either for DCV or flow rate. To estimate the drawdown time, divide the average ponding depth by the permeability of the filter sand.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding and/or aggregate storage volumes, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the Manual.

1. Verify that siting and design criteria have been met, including placement requirements, contributing tributary area, and maximum finish grade slope.
2. Iteratively determine the facility footprint area, surface ponding and/or aggregate storage layer depth required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If a sand filter cannot fully provide the flow rate and duration control required by the MS4 permit, an upstream or downstream structure with appropriate storage volume such as an underground vault can be used to provide remaining controls.
4. After the sand filter has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.18 FT-4 Dry Extended Detention Basin

MS4 Permit Category

Flow-thru Treatment Control

Manual Category

Flow-thru Treatment Control

Applicable Performance Standard

Pollutant Control

Flow Control

Primary Benefits

Treatment

Volume Reduction (Incidental)

Peak Flow Attenuation



Location: Rolling Hills Ranch, Chula Vista, California; Photo Credit: Eric Mosolgo

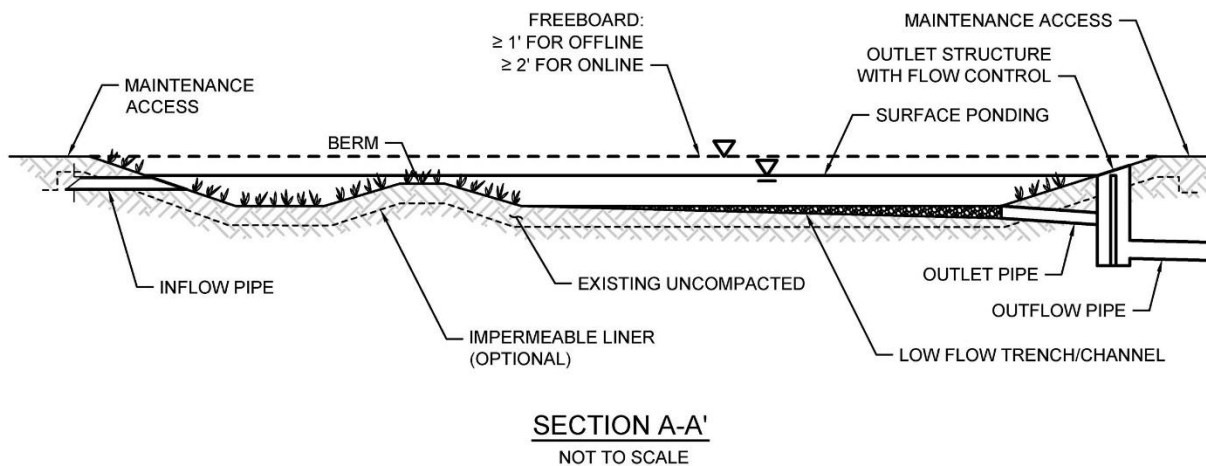
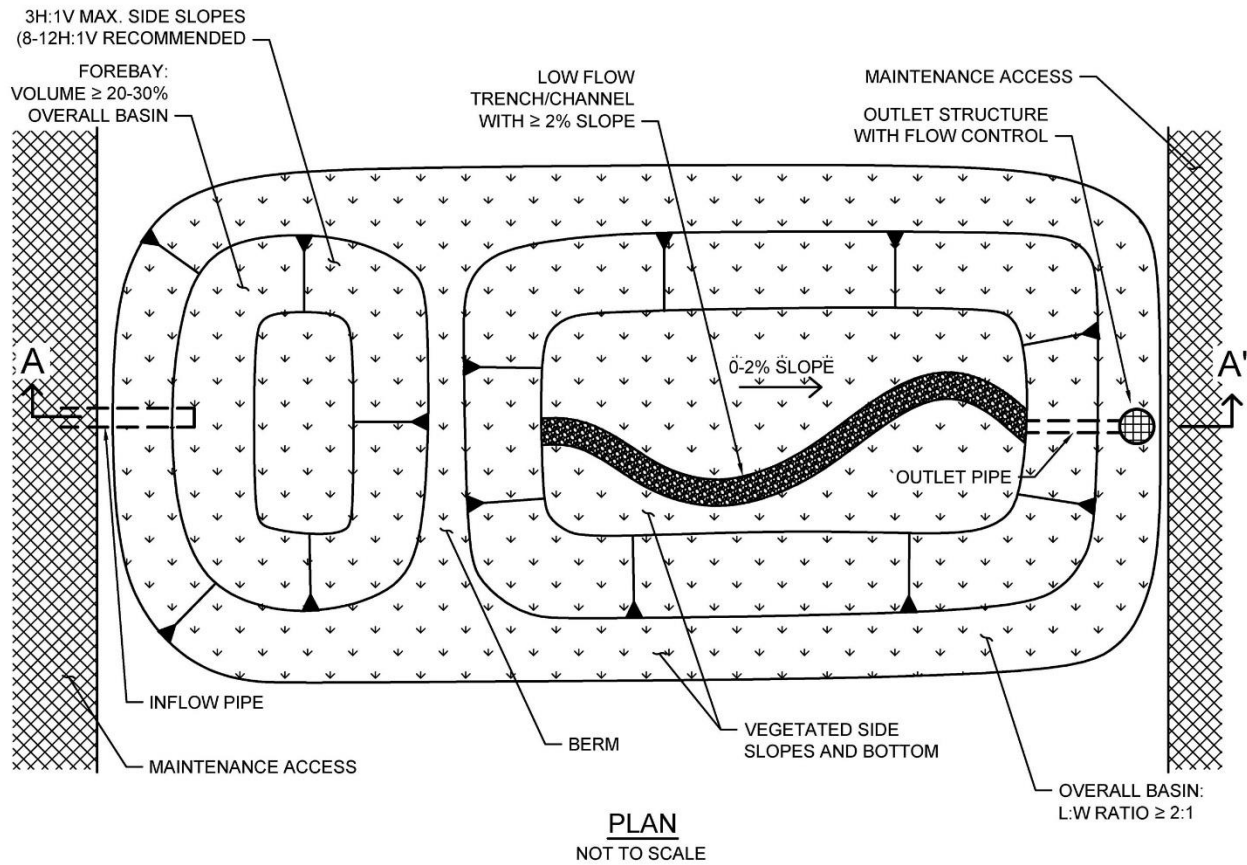
Description

Dry extended detention basins are basins that have been designed to detain storm water for an extended period to allow sedimentation and typically drain completely between storm events. A portion of the dissolved pollutant load may also be removed by filtration, uptake by vegetation, and/or through infiltration. The slopes, bottom, and forebay of dry extended detention basins are typically vegetated. Considerable storm water volume reduction can occur in dry extended detention basins

when they are located in permeable soils and are not lined with an impermeable barrier. dry extended detention basins are generally appropriate for developments of ten acres or larger, and have the potential for multiple uses including parks, playing fields, tennis courts, open space, and overflow parking lots. They can also be used to provide flow control by modifying the outlet control structure and providing additional detention storage.

Typical dry extended detention basins components include:

- Forebay for pretreatment
- Surface ponding for captured flows
- Vegetation selected based on basin use, climate, and ponding depth
- Low flow channel, outlet, and overflow device
- Impermeable liner or uncompacted native soils at the bottom of the facility



Typical plan and Section view of a Dry Extended Detention Basin BMP

Design Adaptations for Project Goals

Flow-thru treatment BMP for storm water pollutant control. The system is lined or un-lined to provide incidental infiltration and designed to detain storm water to allow particulates and associated pollutants to settle out. This configuration is considered to provide flow-thru treatment, not biofiltration treatment. Storage provided as surface ponding above a restricted outlet invert is considered detention storage and is included in calculations for the flow-thru treatment volume.

Integrated storm water flow control and pollutant control configuration. Dry extended detention basins can also be designed for flow control. The surface ponding can be designed to accommodate higher volumes than the storm water pollutant control volume and can utilize multi-stage outlets to mitigate both the duration and rate of flows within a prescribed range.

Design Criteria and Considerations

Dry extended detention basins must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the Port if it is determined to be appropriate:

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Placement observes geotechnical recommendations regarding potential hazards (e.g., slope stability, landslides, and liquefaction zones) and setbacks (e.g., slopes, foundations, utilities).	Must not negatively impact existing site geotechnical concerns.
<input type="checkbox"/> An impermeable liner or other hydraulic restriction layer is included if site constraints indicate that infiltration or lateral flows should not be allowed.	Lining prevents storm water from impacting groundwater and/or sensitive environmental or geotechnical features. Incidental infiltration, when allowable, can aid in pollutant removal and groundwater recharge.
<input type="checkbox"/> Contributing tributary area is large (typically ≥ 10 acres).	Dry extended detention basins require significant space and are more cost-effective for treating larger drainage areas.
<input type="checkbox"/> Longitudinal basin bottom slope is 0 - 2%.	Flatter slopes promote ponding and settling of particles.
<input type="checkbox"/> Basin length to width ratio is $\geq 2:1$ (L:W).	A larger length to width ratio provides a longer flow path to promote settling.
<input type="checkbox"/> Forebay is included that encompasses 20 - 30% of the basin volume.	A forebay to trap sediment can decrease frequency of required maintenance.

<i>Siting and Design</i>	<i>Intent/Rationale</i>
<input type="checkbox"/> Side slopes are $\geq 3H:1V$.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
<input type="checkbox"/> Surface ponding drawdown time is between 24 and 96 hours.	Minimum drawdown time of 24 hours allows for adequate settling time and maximizes pollutant removal. Maximum drawdown time of 96 hours provides vector control.
<input type="checkbox"/> Minimum freeboard provided is ≥ 1 foot for offline facilities and ≥ 2 feet for online facilities.	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
<input type="checkbox"/> Inflow and outflow structures are accessible by required equipment (e.g., vector truck) for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
<input type="checkbox"/> A low flow channel or trench with a $\geq 2\%$ slope is provided. A gravel infiltration trench is provided where infiltration is allowable.	Aids in draining or infiltrating dry weather flows.
<input type="checkbox"/> Overflow is safely conveyed to a downstream storm drain system or discharge point. Size overflow structure to pass 100-year peak flow.	Planning for overflow lessens the risk of property damage due to flooding.
<input type="checkbox"/> The maximum rate at which runoff is discharged is set below the erosive threshold for the site.	Extended low flows can have erosive effects.

Conceptual Design and Sizing Approach for Storm Water Pollutant Control Only

To design dry extended detention basins for storm water pollutant control only (no flow control required), the following steps should be taken:

1. Verify that siting and criteria have been met, including placement requirements, contributing tributary area, forebay volume, and maximum slopes for basin sides and bottom.
2. Calculate the DCV per Appendix B based on expected site design runoff for tributary areas.
3. Use the sizing worksheet to determine flow-thru treatment sizing of the surface ponding of the dry extended detention basin, which includes calculations for a maximum 96-hour drawdown time.

Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

Control of flow rates and/or durations will typically require significant surface ponding volume, and therefore the following steps should be taken prior to determination of storm water pollutant control design. Pre-development and allowable post-project flow rates and durations should be determined as discussed in Chapter 6 of the manual.

1. Verify that siting and criteria have been met, including placement requirements, tributary area, and maximum slopes for basin sides and bottom.
2. Iteratively determine the surface ponding required to provide detention storage to reduce flow rates and durations to allowable limits. Flow rates and durations can be controlled from detention storage by altering outlet structure orifice size(s) and/or water control levels. Multi-level orifices can be used within an outlet structure to control the full range of flows.
3. If a dry extended detention basin cannot fully provide the flow rate and duration control required by this manual, an upstream or downstream structure with appropriate storage volume such as an additional basin or underground vault can be used to provide remaining controls.
4. After the dry extended detention basin has been designed to meet flow control requirements, calculations must be completed to verify if storm water pollutant control requirements to treat the DCV have been met.

E.19 FT-5 Proprietary Flow-Thru Treatment Control BMPs

The purpose of this fact sheet is to help explain the potential role of proprietary BMPs in meeting flow thru treatment control BMP requirements. The fact sheet does not describe design criteria like the other fact sheets in this appendix because this information varies by BMP product model.

Criteria for Use of a Proprietary BMP as a Flow-Thru Treatment Control BMP

A proprietary BMP may be acceptable as a “flow-thru treatment control BMP” under the following conditions:

- (1) The BMP is selected and sized consistent with the method and criteria described in Appendix B.6;
- (2) The BMP is designed and maintained in a manner consistent with its performance certifications (See explanation in Appendix B.6); and
- (3) The BMP is acceptable at the discretion of the Port. In determining the acceptability of a BMP, the Port should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the Port, a written explanation/reason will be provided to the applicant..

Guidance for Sizing Proprietary BMPs

Proprietary flow-thru BMPs must meet the same sizing guidance as other flow-thru treatment control BMPs. Guidance for sizing flow-thru BMPs to comply with requirements of this manual is provided in Appendix B.6.

E.20 PL Plant List

Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Un-Lined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
		Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray) ⁽¹⁾		Basin Side Slopes	Section A Treatment-Only Bioretention in Hydrologic Soil Group A or B Soils	Section B Treatment-Only Bioretention in Hydrologic Soil Group C or D soils	Section C Treatment Plus Flow Control Bioretention in Hydrologic Soil Group A or B Soils	Section D Treatment Plus Flow Control Bioretention in Hydrologic Soil Group C or D Soils	NO Applicable to Un-lined Facilities Only (Bioretention Only)	YES Can Use in Lined or Un-Lined Facility (Flow-Through Planter OR Bioretention)
Latin Name	Common Name			Basin Bottom							
TREES ⁽²⁾											
Alnus rhombifolia	White Alder	X		X	X	X	X	X	X	X	
Platanus racemosa	California Sycamore	X		X	X	X	X	X	X	X	
Salix lasiolepis	Arroyo Willow	X			X	X	X	X	X	X	
Salix lucida	Lance-Leaf Willow	X			X	X	X	X	X	X	
Sambucus mexicana	Blue Elderberry	X			X	X	X	X	X	X	
SHRUBS / GROUNDCOVER											
Achillea millefolium	Yarrow	X			X	X	X				X
Agrostis palens	Thingrass	X			X	X	X	X	X		X
Anemopsis californica	Yerba Manza	X			X	X	X	X	X		X
Baccharis douglasii	Marsh Baccahris	X	X	X		X	X	X	X		X
Carex praegracillis	California Field Sedge	X	X	X		X	X	X	X		X
Carex spissa	San Diego Sedge	X	X	X		X	X	X	X		X
Carex subfusca	Rusty Sedge	X	X	X	X	X	X	X	X		X
Distichlis spicata	Salt Grass	X	X	X		X	X	X	X		X
Eleocharis macrostachya	Pale Spike Rush	X	X	X		X	X	X	X		X
Festuca rubra	Red Fescue	X	X	X	X	X	X				X
Festuca californica	California Fescue	X	X		X	X	X				X
Iva hayesiana	Hayes Iva	X			X	X	X				X
Juncus Mexicana	Mexican Rush	X	X	X	X	X	X	X	X		X
Jucus patens	California Gray Rush	X	X	X	X	X	X	X	X		X
Leymus condensatus ‘Canyon Prince’	Canyon Prince Wild Rye	X	X	X	X	X	X	X	X		X
Mahonia nevinii	Nevin’s Barberry	X			X	X	X	X	X		X
Muhlenburgia rigens	Deergrass	X	X	X	X	X	X	X	X		X
Mimulus cardinalis	Scarlet Monkeyflower	X		X	X	X	X				X
Ribes speciosum	Fushia Flowering Goose.	X			X	X	X				X
Rosa californica	California Wild Rose	X	X		X	X	X				X
Scirpus cenuus	Low Bullrush	X	X	X		X	X	X	X		X
Sisyrinchium bellum	Blue-eyed Grass	X			X	X	X				X

1. All plants will benefit from some supplemental irrigation during hot dry summer months, particularly those on basin side slopes and further inland.
2. All trees should be planted a min. of 10’ away from any drain pipes or structures.

BMP DESIGN MANUAL

Biofiltration Standard and Checklist

Appendix F Biofiltration Standard and Checklist

Introduction

The MS4 Permit and this manual define a specific category of storm water pollutant treatment BMPs called “biofiltration BMPs.” The MS4 Permit (Section E.3.c.1) states:

Biofiltration BMPs must be designed to have an appropriate hydraulic loading rate to maximize storm water retention and pollutant removal, as well as to prevent erosion, scour, and channeling within the BMP, and must be sized to:

- a) **Treat 1.5 times the DCV not reliably retained onsite, OR**
- b) **Treat the DCV not reliably retained onsite with a flow-thru design that has a total volume, including pore spaces and pre-filter detention volume, sized to hold at least 0.75 times the portion of the DCV not reliably retained onsite.**

A project applicant must be able to affirmatively demonstrate that a given BMP is designed and sized in a manner consistent with this definition to be considered as a “biofiltration BMP” as part of a compliant storm water management plan. Retention is defined in the MS4 Permit as evapotranspiration, infiltration, and harvest and use of storm water vs. discharge to a surface water system.

Contents and Intended Uses

This appendix contains a checklist of the key underlying criteria that must be met for a BMP to be considered a biofiltration BMP. The purpose of this checklist is to facilitate consistent review and approval of biofiltration BMPs that meet the “biofiltration standard” defined by the MS4 Permit.

This checklist includes specific design criteria that are essential to defining a system as a biofiltration BMP; however it does not present a complete design basis. This checklist was used to develop BMP Fact Sheets for PR-1 biofiltration with partial retention and BF-1 biofiltration, which do present a complete design basis. Therefore, biofiltration BMPs that substantially meet all aspects of the Fact sheets PR-1 or BF-1 should be able to complete this checklist without additional documentation beyond what would already be required for a project submittal.

Appendix F: Biofiltration Standard and Checklist

Other biofiltration BMP designs⁸ (including both non-proprietary and proprietary designs) may also meet the underlying MS4 Permit requirements to be considered biofiltration BMPs. These BMPs may be classified as biofiltration BMPs if they (1) meet the minimum design criteria listed in this appendix, including the pollutant treatment performance standard in Appendix F.1, (2) are designed and maintained in a manner consistent with their performance certifications (See explanation in Appendix F.2), if applicable, and (3) are acceptable at the discretion of the Port. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met.

Organization

The checklist in this appendix is organized into the seven (7) main objectives associated with biofiltration BMP design. It describes the associated minimum criteria that must be met in order to qualify a biofiltration BMP as meeting the biofiltration standard. The seven main objectives are listed below. Specific design criteria and associated manual references associated with each of these objectives is provided in the checklist in the following section.

1. Biofiltration BMPs shall be allowed only as described in the BMP selection process in this manual (i.e., retention feasibility hierarchy).
2. Biofiltration BMPs must be sized using acceptable sizing methods described in this manual.
3. Biofiltration BMPs must be sited and designed to achieve maximum feasible infiltration and evapotranspiration.
4. Biofiltration BMPs must be designed with a hydraulic loading rate to maximize pollutant retention, preserve pollutant control/sequestration processes, and minimize potential for pollutant washout.
5. Biofiltration BMPs must be designed to promote appropriate biological activity to support and maintain treatment processes.
6. Biofiltration BMPs must be designed to prevent erosion, scour, and channeling within the BMP.
7. Biofiltration BMP must include operations and maintenance design features and planning

⁸ Defined as biofiltration designs that do not conform to the specific design criteria described in Fact Sheets PR-1 or BF-1. This category includes proprietary BMPs that are sold by a vendor as well as non-proprietary BMPs that are designed and constructed of primarily of more elementary construction materials.

considerations to provide for continued effectiveness of pollutant and flow control functions.

Biofiltration Criteria Checklist

The applicant shall provide documentation of compliance with each criterion in this checklist as part of the project submittal. The right column of this checklist identifies the submittal information that is recommended to document compliance with each criterion. Biofiltration BMPs that substantially meet all aspects of Fact Sheets PR-1 or BF-1 should still use this checklist; however additional documentation (beyond what is already required for project submittal) should not be required.

1. Biofiltration BMPs shall be allowed to be used only as described in the BMP selection process based on a documented feasibility analysis.

Intent: This manual defines a specific prioritization of pollutant treatment BMPs, where BMPs that retain water (retained includes evapotranspired, infiltrated, and/or harvested and used) must be used before considering BMPs that have a biofiltered discharge to the MS4 or surface waters. Use of a biofiltration BMP in a manner in conflict with this prioritization (i.e., without a feasibility analysis justifying its use) is not permitted, regardless of the adequacy of the sizing and design of the system.

- | | | |
|--------------------------|---|---|
| <input type="checkbox"/> | The project applicant has demonstrated that it is not technically feasible to retain the full DCV onsite. | Document feasibility analysis and findings in SWQMP per Appendix C. |
|--------------------------|---|---|

2. Biofiltration BMPs must be sized using acceptable sizing methods.

Intent: The MS4 Permit and this manual defines specific sizing methods that must be used to size biofiltration BMPs. Sizing of biofiltration BMPs is a fundamental factor in the amount of storm water that can be treated and also influences volume and pollutant retention processes.

- | | | |
|--------------------------|--|---|
| <input type="checkbox"/> | The project applicant has demonstrated that biofiltration BMPs are sized to meet one of the biofiltration sizing options available (Appendix B.5). | Submit sizing worksheets (Appendix B.5) or other equivalent documentation with the SWQMP. |
|--------------------------|--|---|

3. Biofiltration BMPs must be sited and designed to achieve maximum feasible infiltration and evapotranspiration.

Intent: Various decisions about BMP placement and design influence how much water is retained via infiltration and evapotranspiration. The MS4 Permit requires that biofiltration BMPs achieve maximum feasible retention (evapotranspiration and infiltration) of storm water volume.

Appendix F: Biofiltration Standard and Checklist

<input type="checkbox"/>	The biofiltration BMP is sited to allow for maximum infiltration of runoff volume based on the feasibility factors considered in site planning efforts. It is also designed to maximize evapotranspiration through the use of amended media and plants (biofiltration designs without amended media and plants may be permissible; see Item 5).	Document site planning and feasibility analyses in SWQMP per Section 5.4.
<input type="checkbox"/>	For biofiltration BMPs categorized as “Partial Infiltration Condition” the infiltration storage depth in the biofiltration design has been selected to drain in 36 hours (+/-25%) or an alternative value shown to maximize infiltration on the site.	Included documentation of estimated infiltration rate per Appendix D; provide calculations using Appendix B.4 and B.5 to show that the infiltration storage depth meets this criterion. Note, depths that are too shallow or too deep may not be acceptable.
<input type="checkbox"/>	For biofiltration BMP locations categorized as “Partial Infiltration Condition,” the infiltration storage is over the entire bottom of the biofiltration BMP footprint.	Document on plans that the infiltration storage covers the entire bottom of the BMP (i.e., not just underdrain trenches); or an equivalent footprint elsewhere on the site.
<input type="checkbox"/>	For biofiltration BMP locations categorized as “Partial Infiltration Condition,” the sizing factor used for the infiltration storage area is not less than the minimum biofiltration BMP sizing factors calculated using Worksheet B.5.1 to achieve 40% average annual percent capture within the BMP or downstream of the BMP. .	Provide a table that compares the minimum sizing factor per Appendix B.5 to the provided sizing factor. Note: The infiltration storage area could be a separate storage feature located downstream of the biofiltration BMP, not necessarily within the same footprint.
<input type="checkbox"/>	An impermeable liner or other hydraulic restriction layer is only used when needed to avoid geotechnical and/or subsurface contamination issues in locations identified as “No Infiltration Condition.”	If using an impermeable liner or hydraulic restriction layer, provide documentation of feasibility findings per Appendix C that recommend the use of this feature.

Appendix F: Biofiltration Standard and Checklist

<input type="checkbox"/>	The use of “compact” biofiltration BMP design ⁹ is permitted only in conditions identified as “No Infiltration Condition” and where site-specific documentation demonstrates that the use of larger footprint biofiltration BMPs would be infeasible.	Provide documentation of feasibility findings that recommend no infiltration is feasible. Provide site-specific information to demonstrate that a larger footprint biofiltration BMP would not be feasible.
4. Biofiltration BMPs must be designed with a hydraulic loading rate to maximize pollutant retention, preserve pollutant control processes, and minimize potential for pollutant washout.		
Intent: Various decisions about biofiltration BMP design influence the degree to which pollutants are retained. The MS4 Permit requires that biofiltration BMPs achieve maximum feasible retention of storm water pollutants.		
<input type="checkbox"/>	Media selected for the biofiltration BMP meets minimum quality and material specifications per 2016 City Storm Water Standards or County LID Manual, including the maximum allowable design filtration rate and minimum thickness of media.	Provide documentation that media meets the specifications in 2016 City Storm Water Standards or County LID Manual.
OR		
<input type="checkbox"/>	Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in the 2016 City Storm Water Standards or County LID Manual, field scale testing data are provided to demonstrate that proposed media meets the pollutant treatment performance criteria in Section F.1 below.	Provide documentation of performance information as described in Section F.1.

⁹ Compact biofiltration BMPs are defined as features with infiltration storage footprint less than the minimum sizing factors required to achieve 40% volume retention. Note that if a biofiltration BMP is accompanied by an infiltrating area downstream that has a footprint equal to at least the minimum sizing factors calculated using Worksheet B.5.1 assuming a partial infiltration condition, then it is not considered to be a compact biofiltration BMP for the purpose of Item 4 of the checklist. For potential configurations with a higher rate biofiltration BMP upstream of a larger footprint infiltration area, the BMP would still need to comply with Item 5 of this checklist for pollutant treatment effectiveness.

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<input type="checkbox"/>	To the extent practicable, filtration rates are outlet controlled (e.g., via an underdrain and orifice/weir) instead of controlled by the infiltration rate of the media.	Include outlet control in designs or provide documentation of why outlet control is not practicable.
<input type="checkbox"/>	The water surface drains to at least 12 inches below the media surface within 24 hours from the end of storm event flow to preserve plant health and promote healthy soil structure.	<p>Include calculations to demonstrate that drawdown rate is adequate.</p> <p>Surface ponding drawdown time greater than 24-hours but less than 96 hours may be allowed at the discretion of the [City Engineer] if certified by a landscape architect or agronomist.</p>
<input type="checkbox"/>	If nutrients are a pollutant of concern, design of the biofiltration BMP follows nutrient-sensitive design criteria.	Follow specifications for nutrient sensitive design in Fact Sheet BF-2. Or provide alternative documentation that nutrient treatment is addressed and potential for nutrient release is minimized.
<input type="checkbox"/>	Media gradation calculations or geotextile selection calculations demonstrate that migration of media between layers will be prevented and permeability will be preserved.	Follow specification for choking layer or geotextile in Fact Sheet PR-1 or BF-1. Or include calculations to demonstrate that choking layer is appropriately specified.
5. Biofiltration BMPs must be designed to promote appropriate biological activity to support and maintain treatment processes. <p>Intent: Biological processes are an important element of biofiltration performance and longevity.</p>		
<input type="checkbox"/>	Plants have been selected to be tolerant of project climate, design ponding depths and the treatment media composition.	Provide documentation justifying plant selection. Refer to the plant list in Appendix E.20.
<input type="checkbox"/>	Plants have been selected to minimize irrigation requirements.	Provide documentation describing irrigation requirements for establishment and long term operation.
<input type="checkbox"/>	Plant location and growth will not impede expected long-term media filtration rates and will enhance long term infiltration rates to the extent possible.	Provide documentation justifying plant selection. Refer to the plant list in Appendix E.20.
<input type="checkbox"/>	If plants are not part of the biofiltration design, other biological processes are supported as needed to sustain treatment processes (e.g., biofilm in a subsurface flow wetland).	For biofiltration designs without plants, describe the biological processes that will support effective treatment and how they will be sustained.

6. Biofiltration BMPs must be designed with a hydraulic loading rate to prevent erosion, scour, and channeling within the BMP.

Intent: Erosion, scour, and/or channeling can disrupt treatment processes and reduce biofiltration effectiveness.

<input type="checkbox"/>	Scour protection has been provided for both sheet flow and pipe inflows to the BMP, where needed.	Provide documentation of scour protection as described in Fact Sheets PR-1 or BF-1 or approved equivalent.
<input type="checkbox"/>	Where scour protection has not been provided, flows into and within the BMP are kept to non-erosive velocities.	Provide documentation of design checks for erosive velocities as described in Fact Sheets PR-1 or BF-1 or approved equivalent.
<input type="checkbox"/>	For proprietary BMPs, the BMP is used in a manner consistent with manufacturer guidelines and conditions of its third-party certification ¹⁰ (i.e., maximum tributary area, maximum inflow velocities, etc., as applicable).	Provide copy of manufacturer recommendations and conditions of third-party certification.

7. Biofiltration BMP must include operations and maintenance design features and planning considerations for continued effectiveness of pollutant and flow control functions.

Intent: Biofiltration BMPs require regular maintenance in order provide ongoing function as intended. Additionally, it is not possible to foresee and avoid potential issues as part of design; therefore plans must be in place to correct issues if they arise.

<input type="checkbox"/>	The biofiltration BMP O&M plan describes specific inspection activities, regular/periodic maintenance activities and specific corrective actions relating to scour, erosion, channeling, media clogging, vegetation health, and inflow and outflow structures.	Include O&M plan with project submittal as described in Chapter 7.
<input type="checkbox"/>	Adequate site area and features have been provided for BMP inspection and maintenance access.	Illustrate maintenance access routes, setbacks, maintenance features as needed on project water quality plans.

¹⁰ Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the New Jersey Corporation for Advanced Technology programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification

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For proprietary biofiltration BMPs, the BMP maintenance plan is consistent with manufacturer guidelines and conditions of its third-party certification (i.e., maintenance activities, frequencies).

Provide copy of manufacturer recommendations and conditions of third-party certification.

F.1 Pollutant Treatment Performance Standard

Standard biofiltration BMPs that are designed following the criteria in Fact Sheets PR-1 and BF-1 are presumed to meet the pollutant treatment performance standard associated with biofiltration BMPs. This presumption is based on the MS4 Permit Fact Sheet which cites analyses of standard biofiltration BMPs conducted in the Ventura County Technical Guidance Manual (July 2011).

For BMPs that do not meet the biofiltration media specification and/or the range of acceptable media filtration rates described in Fact Sheet, PR-1 and BF-1, additional documentation must be provided to demonstrate that adequate pollutant treatment performance is provided to be considered a biofiltration BMP. Project applicants have three options for documenting compliance:

- 1) Project applicants may provide documentation to substantiate that the minor modifications to the design is expected to provide equal or better pollutant removal performance for the project pollutants of concern than would be provided by a biofiltration design that complies with the criteria in Fact Sheets PR-1 and BF-1. Minor modifications are design elements that deviate only slightly from standard design criteria and are expected to either not impact performance or to improve performance compared to standard biofiltration designs. The reviewing agency has the discretion to accept or reject this documentation and/or request additional documentation to substantiate equivalent or better performance to BF-1 or PR-1, as applicable. Examples of minor deviations include:
 - Different particle size distribution of aggregate, with documentation that system filtration rate will meet specifications.
 - Alternative source of organic components, with documentation of material suitability and stability from appropriate testing agency.
 - Specialized amendments to provide additional treatment mechanisms, and which have negligible potential to upset other treatment mechanisms or otherwise deteriorate performances.
- 2) For approved proprietary BMPs, project applicants may provide evidence that the BMP has been certified for use as part of the Washington State Technology Assessment Protocol-Ecology certification program and meets each of the following requirements:
 - a. The applicant must demonstrate (using the checklist in this Appendix) that the BMP meets all other conditions to be considered as a biofiltration BMP. For example, a cartridge media filter or hydrodynamic separator would not meet biofiltration BMP design criteria regardless of Technology Acceptance Protocol-Ecology certification because they do not support effective biological processes.

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- b. The applicant must select BMPs that have an active Technology Acceptance Protocol-Ecology certification, with General Use Level Designation for the appropriate project pollutants of concern as identified in Table F.1-1. The list of certified technologies is updated as new technologies are approved (link below). Technologies with Pilot Use Level Designation and Conditional Use Level Designations are not acceptable. Refer to:
<http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>.
 - c. The applicant must demonstrate that BMP is being used in a manner consistent with all conditions of the Technology Acceptance Protocol-Ecology certification while meeting the flow rate or volume design criteria that is required for biofiltration BMPs under this manual. Conditions of Technology Acceptance Protocol-Ecology certification are available by clicking on the technology name at the website listed in bullet b. Additional discussion about sizing of proprietary biofiltration BMPs to comply with applicable sizing standards is provided below in Section F.2.
 - d. For projects within the public right of way and/or public projects: the product must be acceptable to the [City Engineer] with respect to maintainability and long term operation of the product. In determining the acceptability of a product the [City Engineer] should consider, as applicable, maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business, and other relevant factors. If a proposed BMP is not accepted by the [City Engineer], a written explanation/reason will be provided to the applicant.
- 3) For BMPs that do not fall into options 1 or 2 above, the [City Engineer] may allow the applicant to submit alternative third-party documentation that the pollutant treatment performance of the system is consistent with the performance levels associated with the necessary Technology Acceptance Protocol-Ecology certifications. Table F.1-1 describes the required levels of certification and Table F.1-2 describes the pollutant treatment performance levels associated with each level of certification. Acceptance of this approach is at the sole discretion of the [City Engineer]. If a proposed BMP is not accepted by the [City Engineer], a written explanation/reason will be provided to the applicant. If Technology Acceptance Protocol-Ecology certifications are not available, preference shall be given to:
- a. Verified third-party, field-scale testing performance under the Technology Acceptance Reciprocity Partnership Tier II Protocol. This protocol is no longer operated, however this is considered to be a valid protocol and historic verifications are considered to be representative provided that product models being proposed are consistent with those

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that were tested. Technology Acceptance Reciprocity Partnership verifications were conducted under New Jersey Corporation for Advance Testing and are archived at the website linked below. Note that Technology Acceptance Reciprocity Partnership verifications must be matched to pollutant treatment standards in Table F.1-2 then matched to an equivalent Technology Acceptance Protocol-Ecology certification in Table F.1-1.

- b. Verified third-party, field-scale testing performance under the New Jersey Corporation for Advance Testing protocol. Note that New Jersey Corporation for Advance Testing verifications must be matched to pollutant treatment standards in Table F.1-2 then matched to an equivalent Technology Acceptance Protocol-Ecology certification in Table F.1-1.

A list of field-scale verified technologies under Technology Acceptance Reciprocity Partnership Tier II and New Jersey Corporation for Advance Testing can be accessed at: <http://www.njcat.org/verification-process/technology-verification-database.html> (refer to field verified technologies only).

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Table F.1-1: Required Technology Acceptance Protocol-Ecology Certifications for Pollutants of Concern for Biofiltration Performance Standard

Project Pollutant of Concern	Required Technology Acceptance Protocol-Ecology Certification for Biofiltration Performance Standard
Trash	Basic Treatment OR Phosphorus Treatment OR Enhanced Treatment
Sediments	Basic Treatment OR Phosphorus Treatment OR Enhanced Treatment
Oil and Grease	Basic Treatment OR Phosphorus Treatment OR Enhanced Treatment
Nutrients	Phosphorus Treatment ¹
Metals	Enhanced Treatment
Pesticides	Basic Treatment (including filtration) ² OR Phosphorus Treatment OR Enhanced Treatment
Organics	Basic Treatment (including filtration) ² OR Phosphorus Treatment OR Enhanced Treatment
Bacteria and Viruses	Basic Treatment (including bacteria removal processes) ³ OR Phosphorus Treatment OR Enhanced Treatment

1 – There is no Technology Acceptance Protocol-Ecology equivalent for nitrogen compounds; however systems that are designed to retain phosphorus (as well as meet basic treatment designation), generally also provide treatment of nitrogen compounds. Where nitrogen is a pollutant of concern, relative performance of available certified systems for nitrogen removal should be considered in BMP selection.

2 – Pesticides, organics, and oxygen demanding substances are typically addressed by particle filtration consistent with the level of treatment required to achieve Basic treatment certification; if a system with Basic treatment certification does not provide filtration, it is not acceptable for pesticides, organics or oxygen demanding substances.

3 – There is no Technology Acceptance Protocol-Ecology equivalent for pathogens (viruses and bacteria), and testing data are limited because of typical sample hold times. Systems with Technology Acceptance Protocol-Ecology Basic Treatment must include one or more significant bacteria removal process such as media filtration, physical sorption, predation, reduced redox conditions, and/or solar inactivation. Where design options are available to enhance pathogen removal (i.e., pathogen-specific media mix offered by vendor), this design variation should be used.

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Table F.1-2: Performance Standards for Technology Acceptance Protocol-Ecology Certification

Performance Goal	Influent Range	Criteria
Basic Treatment	20 – 100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS
	100 – 200 mg/L TSS	$\geq 80\%$ TSS removal
	>200 mg/L TSS	$> 80\%$ TSS removal
Enhanced (Dissolved Metals) Treatment	Dissolved copper 0.005 – 0.02 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as $>30\%$ dissolved copper removal
	Dissolved zinc 0.02 – 0.3 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as $>60\%$ dissolved zinc removal
Phosphorous Treatment	Total phosphorous 0.1 – 0.5 mg/L	Must meet basic treatment goal and exhibit $\geq 50\%$ total phosphorous removal
Oil Treatment	Total petroleum hydrocarbon > 10 mg/L	No ongoing or recurring visible sheen in effluent Daily average effluent Total petroleum hydrocarbon concentration < 10 mg/L Maximum effluent Total petroleum hydrocarbon concentration for a 15 mg/L for a discrete (grab) sample
Pretreatment	50 – 100 mg/L TSS	≤ 50 mg/L TSS
	≥ 200 mg/L TSS	$\geq 50\%$ TSS removal

F.2 Guidance on Sizing and Design of Approved Equivalent Proprietary Biofiltration Systems

This section explains the general process for design and sizing of approved equivalent proprietary biofiltration systems. This section assumes that the BMPs have been selected based on the criteria in Section F.1.

F.2.1 Guidance on Design per Conditions of Certification/Verification

The biofiltration standard and checklist in this appendix requires that “the BMP is used in a manner consistent with manufacturer guidelines and conditions of its third-party certification.” Practically, what this means is that the BMP is used in the same way in which it was tested and certified. For example, it is not acceptable for a BMP of a given size to be certified/verified with a 100 gallon per minute treatment rate and be applied at a 150 gallon per minute treatment rate in a design.

Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification. It is common for these approvals to specify the specific model of BMP, design capacity for given unit sizes, type of media that is the basis for approval, and/or other parameter. The applicant must demonstrate conclusively that the proposed application of the BMP is consistent with these criteria.

For alternate non-proprietary systems that do not have a Technology Acceptance Protocol-Ecology / Technology Acceptance Reciprocity Partnership / New Jersey Corporation for Advance Testing certification (but which still must provide quantitative data per Appendix F.1), it must be demonstrate that the configuration and design proposed for the project is reasonably consistent with the configuration and design under which the BMP was tested to demonstrate compliance with Appendix F.1.

F.2.2 Sizing of Flow-Based Biofiltration BMP

This sizing method is only available when the BMP meets the pollutant treatment performance standard in Appendix F.1.

Approved equivalent proprietary biofiltration systems for meeting PDP standards are typically designed as flow-based BMPs (i.e., a constant treatment capacity with negligible storage volume). Proprietary biofiltration is only acceptable if the sizing criteria in this Appendix and the retention performance standard identified in Appendix B.5 are satisfied. The applicable sizing method for biofiltration for this type of BMP is to treat 1.5 times the flow based DCV. The applicable sizing method for biofiltration is therefore reduced to: Treat 1.5 times the DCV.

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The following steps should be followed to demonstrate that the system is sized to treat 1.5 times the DCV.

1. Calculate the flow rate required to meet the pollutant treatment performance standard without scaling for the 1.5 factor. Options include either:
 - Calculate the runoff flow rate from a 0.2 inch per hour uniform intensity precipitation event (See methodology Appendix B.6.3), or
 - Conduct a continuous simulation analysis to compute the size required to capture and treat 80 percent of average annual runoff; for small catchments, 5-minute precipitation data should be used to account for short time of concentration. Nearest rain gage with 5-minute precipitation data is allowed for this analysis.
2. Multiply the flow rate from Step 1 by 1.5 to compute the design flow rate for the biofiltration system.
3. Based on the conditions of certification/verification (discussed above), establish the design capacity, as a flow rate, of a given sized unit.
4. Demonstrates that an appropriate unit size and number of units is provided to provide a flow rate that meets the required flow rate from Step 2.
5. Provide a downstream retention BMP that achieves volume reduction equivalent to a non-proprietary BMP sized in accordance with Worksheet B.5-1.

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Worksheet F.2-1: Target Volume Retention Criteria

Target Volume Retention Criteria			Worksheet F.2-1	
BMP ID	DMA(s) Draining to BMP			
1	Area draining to the BMP			sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)			
3	85 th percentile 24-hour rainfall depth			inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]			cu. ft.
Volume Retention Requirement				
5	<p>Measured infiltration rate in the DMA</p> <p>Note:</p> <p>When mapped hydrologic soil groups are used:</p> <ul style="list-style-type: none"> Enter 0.10 for NRCS Type D soils. Include a map documenting the NRCS hydrologic soil type in the SWQMP. Enter 0.30 for NRCS Type C soils. Include a map documenting the NRCS hydrologic soil type in the SWQMP. <p>When the no infiltration condition applies and the actual measured infiltration rate is unknown:</p> <ul style="list-style-type: none"> Enter 0.0 in/hr if there are known geotechnical and/or groundwater hazards, and document the source used to identify the hazards in the SWQMP. Enter 0.05 if there are no documented geotechnical and/or groundwater hazards. 			in/hr.
6	Factor of safety		2	
7	Reliable infiltration rate, for biofiltration BMP sizing [Line 5/ Line 6]			in/hr.
8	<p>Average annual volume reduction target</p> <p>When Line 7 > 0.01 in/hr. = Minimum (40, 166.9 x Line 7 + 6.62)</p> <p>When Line 7 ≤ 0.01 in/hr. = 3.5%</p>			%
9	<p>Fraction of DCV to be retained (Figure B.4-1)</p> <p>When Line 8 > 8% = 0.0000013 x Line 8³ - 0.000057 x Line 8² + 0.0086 x Line 8 - 0.014</p> <p>When Line 8 ≤ 8% = 0.023</p>			
10	Target volume retention [Line 9 x Line 4]			cu. ft.

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Worksheet F.2-2: Volume Retention for Site Design BMPs

Volume Retention for Site Design BMPs			Worksheet F.2-2	
Category	#	Description		Units
Standard Drainage Basin Inputs	1	Drainage Basin ID or Name		unitless
	2	85th Percentile 24-hr Storm Depth		inches
	3	Impervious Surfaces <u>Not Directed to Dispersion Area</u> (C=0.90)		sq-ft
	4	Semi-Pervious Surfaces <u>Not Serving as Dispersion Area</u> (C=0.30)		sq-ft
	5	Engineered Pervious Surfaces <u>Not Serving as Dispersion Area</u> (C=0.10)		sq-ft
	6	Natural Type A Soil <u>Not Serving as Dispersion Area</u> (C=0.10)		sq-ft
	7	Natural Type B Soil <u>Not Serving as Dispersion Area</u> (C=0.14)		sq-ft
	8	Natural Type C Soil <u>Not Serving as Dispersion Area</u> (C=0.23)		sq-ft
	9	Natural Type D Soil <u>Not Serving as Dispersion Area</u> (C=0.30)		sq-ft
Dispersion Area, Tree Well & Rain Barrel Inputs (Optional)	10	Does Tributary Incorporate Dispersion, Tree Wells, and/or Rain Barrels?		yes/no
	11	Impervious Surfaces Directed to Dispersion Area per SD-5 (Ci=0.90)		sq-ft
	12	Semi-Pervious Surfaces Serving as Dispersion Area per SD-5 (Ci=0.30)		sq-ft
	13	Engineered Pervious Surfaces Serving as Dispersion Area per SD-5 (Ci=0.10)		sq-ft
	14	Natural Type A Soil Serving as Dispersion Area per SD-5 (Ci=0.10)		sq-ft
	15	Natural Type B Soil Serving as Dispersion Area per SD-5 (Ci=0.14)		sq-ft
	16	Natural Type C Soil Serving as Dispersion Area per SD-5 (Ci=0.23)		sq-ft
	17	Natural Type D Soil Serving as Dispersion Area per SD-5 (Ci=0.30)		sq-ft
	18	Number of Tree Wells Proposed per SD-1		#
	19	Average Mature Tree Canopy Diameter		ft
	20	Number of Rain Barrels Proposed per SD-8		#
	21	Average Rain Barrel Size		gal
Initial Runoff Factor Calculation	22	Total Tributary Area		sq-ft
	23	Initial Runoff Factor for Standard Drainage Areas		unitless
	24	Initial Runoff Factor for Dispersed & Dispersion Areas		unitless
	25	Initial Weighted Runoff Factor		unitless
	26	Initial Design Capture Volume		cubic-feet
Dispersion Area Adjustments	27	Total Impervious Area Dispersed to Pervious Surface		sq-ft
	28	Total Pervious Dispersion Area		sq-ft
	29	Ratio of Dispersed Impervious Area to Pervious Dispersion Area		ratio
	30	Adjustment Factor for Dispersed & Dispersion Areas		ratio

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Volume Retention for Site Design BMPs			Worksheet F.2-2	
Category	#	Description		Units
	31	Runoff Factor After Dispersion Techniques		unitless
	32	Design Capture Volume After Dispersion Techniques		cubic-feet
Tree & Barrel Adjustments	33	Total Tree Well Volume Reduction		cubic-feet
	34	Total Rain Barrel Volume Reduction		cubic-feet
Results	35	Final Adjusted Runoff Factor		unitless
	36	Final Effective Tributary Area		sq-ft
	37	Initial Design Capture Volume Retained by Site Design Elements		cubic-feet
	38	Final Design Capture Volume Tributary to BMP		cubic-feet

Worksheet F.2-2 Line Item Notes

1. User Input from stormwater plans.
2. User input from BMPDM Figure B.1-1.
3. User Input from stormwater plans.
4. User Input from stormwater plans.
5. User Input from stormwater plans.
6. User Input from stormwater plans.
7. User Input from stormwater plans.
8. User Input from stormwater plans.
9. User Input from stormwater plans.
10. User Input. Default is "No". Select Yes if any of the referenced elements are proposed.
11. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
13. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
14. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
15. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
16. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
17. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-5.
18. User Input. Must satisfy criteria from Fact Sheet SD-1.
19. User Input. Must satisfy criteria from Fact Sheet SD-1. Acceptable range from 0-30 feet.
20. User Input. Must satisfy criteria from Fact Sheet SD-8. Cannot provide more than a 25% reduction to initial DCV.
21. User Input. Must satisfy criteria from Fact Sheet SD-8. Acceptable range 0-100 gallons for generic volume reductions.
22. Sum of Lines 3 through 17.
23. $[0.9(\text{Line } 3) + 0.3(\text{Line } 4 + \text{Line } 9) + 0.1(\text{Line } 5 + \text{Line } 6) + 0.14(\text{Line } 7) + 0.23(\text{Line } 8)] / (\text{Sum of Lines } 3 \text{ through Line } 9)$
24. $[0.9(\text{Line } 11) + 0.3(\text{Line } 12 + \text{Line } 17) + 0.1(\text{Line } 13 + \text{Line } 14) + 0.14(\text{Line } 15) + 0.23(\text{Line } 16)] / (\text{Sum of Lines } 11 \text{ through Line } 17)$
25. $[(\text{Line } 23 \times (\text{Sum of Lines } 3 \text{ through } 9) + \text{Line } 24 \times (\text{Sum of Lines } 11 \text{ through } 17))] / \text{Line } 22$
26. $(\text{Line } 2/12) \times \text{Line } 22 \times \text{Line } 25$
27. Line 11
28. Summation of Lines 12-17.
29. $[\text{Line } 27 / \text{Line } 28]$. If greater than 4.0 dispersion benefits are not quantified.
30. Lookup values from Table B.1-1 weighted with respect to distribution of dispersion areas specified in Lines 12-17.
31. $[\text{Line } 23 \times (\text{Sum of Lines } 3 \text{ through Line } 9) + \text{Line } 24 \times \text{Line } 30 \times (\text{Sum of Lines } 11 \text{ through Line } 17)] / \text{Line } 22$
32. $(\text{Line } 2/12) \times \text{Line } 22 \times \text{Line } 31$
33. $[\text{Line } 18 \times \text{Lookup value from Section B.2.2.1 of BMP Design Manual}]$
34. $[\text{Line } 20 \times \text{Line } 21/7.48]$. If Line 21 > 100 or Line 10 is "n/a" or "no", then this value must be zero.
35. $\text{Line } 31 \times [1 - ((\text{Line } 33 + \text{Line } 34)/(\text{Line } 32))]$. Value must be between zero and one.
36. $\text{Line } 22 \times \text{Line } 35$
37. $[(\text{Line } 26 - \text{Line } 32) + \text{Line } 33 + \text{Line } 34]$
38. $[\text{Line } 26 - \text{Line } 37]$. Minimum result of 0.

F.3 Biofiltration Soil Media Composition, Testing, and Installation

Biofiltration Soil Media (BSM) is intended to filter storm water and support plant growth while minimizing the leaching of potential pollutants. This specification includes requirements that apply to BSM used in stormwater treatment BMPs, including bioretention and biofiltration. Biofiltration Soil Media is also referred to as Engineered Soil Media and Bioretention Soil Media.

F.3.1 BLENDED BSM CRITERIA AND TESTING REQUIREMENTS

Blended BSM shall consist of 60% to 80% by volume sand, up to 20% by volume topsoil, and up to 20% by volume compost. Sand, Topsoil, and Compost used in BSM shall conform to requirements listed in Sections F.3.2, F.3.3, and F.3.4, respectively. For bioretention/biofiltration with outlet-controlled designs, it is likely that topsoil will need to be omitted or reduced to achieve permeability targets.

Alternative mix components and proportions may be utilized, provided that the whole blended mix conforms to whole BSM criteria, detailed in Section F.3.1.2 through F.3.1.4. Alternative mix designs may include alternative proportions and/or alternative organic amendments. Alternative mixes are subject to approval by the Port. Alternative mixes that use an alternative organic component (rather than compost) may be necessary when BMPs are installed in areas with nitrogen or phosphorus impaired receiving waters in order to meet more stringent BSM quality requirements as detailed in Section F.3.1.4.

F.3.1.1 Testing and Submittals

At least 30 days prior to ordering materials, the Contractor shall submit the following to the Port reviewer (upon request): source/supplier of BSM, location of source/supplier, a physical sample of the BSM, whole BSM test results from a third-party independent laboratory, test results for individual component materials as required, and description of proposed methods and schedule for mixing, delivery, and placement of BSM. The test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

Test results shall demonstrate conformance to agronomic suitability and hydraulic suitability criteria listed in Sections F.3.1.2 and F.3.1.3, respectively. BSM for use in BMPs in areas with water quality impairments in receiving waters shall also comply with applicable Chemical Suitability criteria in Section F.3.1.4. No delivery, placement, or planting of BSM shall begin until test results confirm the suitability of the BSM. The Contractor shall submit a written request for approval which shall be accompanied by written analysis results from a written report of a testing agency. The testing agency must be registered by the State for agronomic soil evaluation laboratory test fees shall be paid for by the Contractor. BSM criteria may also be modified at the discretion of the Port if the contractor demonstrates that suitable BSM materials cannot be feasibly sourced within a 50-mile radius of the project site and a good faith effort has been undertaken to investigate available materials. BSM that

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meets other specifications approved for use by the County of San Diego or other local agencies may be accepted as meeting the “good faith effort” standard at the discretion of the Port.

F.3.1.2 Agronomic Suitability

The BSM shall conform to the requirements herein to support plant growth. BSM which requires amending to comply with the below specifications shall be uniformly blended and tested in its blended state prior to testing and delivery.

- a) pH range shall be between 6.0-8.5.
- b) Salinity shall be between 0.5 and 3.0 millimho/cm (as measure by electrical conductivity)
- c) Sodium absorption ratio (SAR) shall be less than 5.0
- d) Chloride shall be less than 800 ppm.
- e) Cation exchange capacity shall be greater than 10 meq/100 g.
- f) Organic matter shall be between 2 and 5%.
- g) Carbon:Nitrogen ratio shall be between 12 and 40 (15 to 40 preferred).

Textural class fraction shall adhere to limits in Table F.3.1.2, as determined by ASTM Method D422 or an approved alternative method:

TABLE F.3.1.2

Textural Class (ASTM D422)	Size Range	Mass Fraction (percent)
Gravel	Larger than 2 mm	0 to 25 of total sample
Clay	Smaller than 0.005 mm	0 to 5 of non-gravel fraction

Test results shall show the following information:

- a) Date of testing
- b) Project name, contractor name, and source of materials and supplier name
- c) Copies of all testing reports including, at a minimum, analytical results sufficient to confirm compliance with all requirements listed in this section.

F.3.1.3 Hydraulic Suitability

BSM shall meet the have appropriate hydraulic properties for filtering stormwater. The BSM shall conform to the requirements herein to support plant growth. BSM which requires amending, shall be uniformly blended and tested in its blended state prior to testing and delivery.

F.3.1.3.1 Testing

The saturated hydraulic conductivity of the whole BSM shall be measured according to the method detailed in the measurement of hydraulic conductivity (USDA Handbook 60, method 34b), commonly available as part of standard agronomic soil evaluation, or ASTM D24234 Permeability of Granular Soils (at approximately 85% relative compaction Standard Proctor, ASTM D698). BSM shall conform to hydraulic criteria associated with the BMP design configuration that best applies to the facility where the BSM will be installed (Section F.3.1.3.2 or F.3.1.3.3).

F.3.1.3.2 Systems with Unrestricted Underdrain System (i.e., media control)

For systems with underdrains that are not restricted, the BSM shall meet the minimum and maximum measured hydraulic conductivity found in Table F.3.1.3 to ensure adequate flow rate through the BMP and longevity of the system but reduce excessive velocities through the media. In all cases, an upturned elbow system on the underdrain, measuring 9 to 12 inches above the invert of the underdrain, should be used to control velocities in the underdrain pipe and reduce potential for solid migration through the system.

F.3.1.3.3 Systems with Restricted Underdrain System (i.e., outlet control)

For systems in which the flow rate of water through the media is controlled via an outlet control device (e.g., orifice or valve) affixed to the outlet of the underdrain system, the hydraulic conductivity of the media should meet the requirements in Table F.3.1.3 and the outlet control device should control the flow rate to between 5 and 12 inches per hour. This configuration reduces the sensitivity of system performance to the hydraulic conductivity, compaction, and clogging of the material, reduces the likelihood of preferential flow through media, and allows more precise design and control of system flow rates. For these reasons, outlet control should be considered the preferred design option over unrestricted underdrain systems.

F.3.1.3.3 Systems without Underdrains

For systems without underdrains, the BSM shall have a hydraulic conductivity of at least 5 inches per hour, or at least 2 times higher than the design infiltration rate of the underlying soil, whichever is greater.

TABLE F.3.1.3

Underdrain System	Hydraulic Conductivity Requirements	
	Minimum (in/hr)	Maximum (in/hr)
Unrestricted (media control)	8	24
Restricted (outlet control) Preferred Design Option.	20	80

F.3.1.4 Chemical Suitability for Areas Draining to Impaired Receiving Waters

The chemical suitability criteria listed in this section do not apply to systems without underdrains, unless groundwater is impaired or susceptible to nutrient contamination. Limits for a given parameter only apply if that parameter is associated with a water quality impairment, priority water quality condition, and/or TMDL in the receiving water. Limits may be waived at the discretion of the Port if it is determined that it is unreasonable to meet the specification using locally-available materials (available within 100 miles).

F.3.1.4.1 Testing

Potential for pollutant leaching shall be assessed using either the Saturated Media Extract Method (aka, Saturation Extract) that is commonly performed by agronomic laboratories or the Synthetic Precipitation Leaching Procedure (SPLP) (EPA SW-846, Method 1312). If the saturation extract method is used, samples may be rinsed with up to five pore volumes before collecting extract for analysis.

F.3.1.4.1 BSM Limits in Areas Draining to Impaired Receiving Waters

The limits in this section are in terms of the concentration of a parameter in water that has been contacted with the BSM.

TABLE F.3.1.4.2

Applicable Pollutant(s)	Saturation Extract or SPLP Criteria
Phosphorus*	< 1 mg/L
Zinc	< 1 mg/L
Copper	< 0.04 mg/L
Lead	< 0.025 mg/L
Arsenic	< 0.02 mg/L
Cadmium	< 0.01 mg/L

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Mercury	< 0.01 mg/L
Selenium	< 0.01 mg/L

F.3.1.4.3 Alternative BSM for Reduced Phosphorus Leaching

In areas with impaired receiving waters, alternative BSM should be considered, especially if receiving waters are phosphorus impaired. BSM with 20% compost may result in phosphorus leaching and soluble phosphorus test results in excess of the 1 mg/L limit presented in Table F.3.1.4.2. Alternative organic amendments, such as coco coir pith and/or composted wood products, in place of compost should be considered in these areas. Sand and soil components with higher levels of iron and aluminum should also be considered to limit the solubility of phosphorus.

F.3.1.4.4 Nitrogen Impaired Receiving Waters

In areas with a downstream water quality impairment or TMDL for nitrogen, a combination of BSM composition and BMP design shall be used to reduce the potential for nitrate leaching from BMPs.

- BSM: The C:N ratio of BSM shall be between 15 and 40 to reduce the potential for nitrate leaching.
- BMP design: BMPs shall be designed to either enhance infiltration into underlying soils or with internal water storage to promote reduction of nitrogen:
 - If a BMP is installed with a liner, the BMP must include an internal saturated zone, consisting of at least an 18-inch thick layer of gravel, to enhance denitrification.
 - If a BMP does not include a liner, it must be installed with a retention zone below the underdrain discharge elevation, consisting of at least an 18-inch thick layer of gravel, to enhance infiltration into underlying soils.

F.3.2 SAND FOR BSM

Sand used in BSM should preferably be washed prior to delivery. If sand is not washed it must still meet sieve analysis requirements in Table F.3.2.1.

F.3.2.1 Gradation Limits

A sieve analysis shall be performed in accordance with California Test 202, ASTM D 422, or approved equivalent method to demonstrate compliance with the gradation limits shown in Table F.3.2.1. Fines passing the No. 200 sieve shall be non-plastic.

TABLE F.3.2.1

Sieve Size (ASTM D422)	Percentage Passing Sieve (by weight)	
	Minimum	Maximum
3/8 inch	100	100
#4	90	100
#8	70	100
#16	40	95
#30	15	70
#40	5	55
#100	0	15
#200	0	5

F.3.3 TOPSOIL FOR BSM

Topsoil shall be free of hazardous materials and shall be consistent with a common definition of topsoil. Decomposed granite and derivatives of decomposed granite are not considered to be topsoil for the purpose of this specification.

F.3.3.1 Textural Class

Topsoil shall be classified as a sandy loam or a loamy sand according to the US Department of Agriculture soil classification system. In addition, a textural class analysis shall be performed in accordance with ASTM D422, or an approved alternative method to demonstrate compliance with the gradation limits in Table F.3.3.1.

TABLE F.3.3.1

Textural Class (ASTM D422)	Size Range	Mass Fraction (percent)
Gravel	Larger than 2 mm	0 to 25 of total sample
Clay	Smaller than 0.005 mm	0 to 15 of non-gravel fraction

F.3.4 803-5 COMPOST FOR BSM

Compost shall be produced at a facility inspected and regulated by the local enforcement agency for CalRecycle. Compost should also preferably be certified by the U.S. Composting Council's Seal of Testing Assurance Program (USCC STA) or an approved equivalent program. Compost shall not be produced from biosolids feedstock.

F.3.4.1 Gradation Limits

A sieve analysis shall be performed in accordance with ASTM D 422 or approved equivalent method to demonstrate compliance with the gradation limits show in Table F.3.4.1.

TABLE F.3.4.1

Sieve Size (ASTM D422)	Percent Passing Sieve (by weight)
1/2"	97 to 100
2 mm	40 to 90

F.3.4.2 Material Content

Organic Material Content shall be 35% to 100% by dry weight and moisture shall be 25% to 60% wet weight basis. Physical contaminants (manmade inert materials) shall not exceed 1% by dry weight.

F.3.4.3 Compost Testing

Compost shall meet the following requirements as demonstrated through standard agronomic testing methods:

- a) **Carbon to nitrogen (C:N) ratio.** C:N shall be between 15:1 and 40:1, preferably above 20:1 to reduce the potential for nitrogen leaching/washout.
- b) **pH.** pH shall be between 6.0 and 8.5.
- c) **Soluble Salt Concentration.** Soluble Salt Concentration shall be less than 10 dS/m. (Method TMECC 4.10-A, USDA and U.S. Composting Council).
- d) **Stability.** Carbon Dioxide evolution rate shall be less than 3.0 mg CO₂-C per g compost organic matter (OM) per day or less than 6 mg CO₂-C per g compost carbon per day, whichever unit is reported. (Method TMECC 5.08-B, USDA and U.S. Composting Council). Alternatively, a Solvita rating of 5.5 or higher is acceptable.

F.3.4.3.1 Pathogens and Pollutant Limits

Select pathogens shall pass US EPA Class A standard, 40 CFR Section 503.32(a). Trace Metals shall pass US EPA Class A standard, 40 CFR Section 503.13, Table 1 for Ceiling Concentrations.

F.3.5 803-6 DELIVERY, STORAGE, HANDLING, AND PAYMENT

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. The Contractor shall protect soils and mixes from absorbing excess water and from erosion at all times.

F.3.5.1 Delivery

The Contractor shall not deliver or place soils in wet or muddy conditions.

F.3.5.2 Storage

The Contractor shall not store materials unprotected during large rainfall events (>0.25 inches). If water is introduced into the material while it is stockpiled, the Contractor shall allow the material to drain to the acceptance of the Port before placement.

F.3.5.3 Handling and Placement

BSM shall be lightly compacted and placed in loose lifts approximately 12 inches (300 mm) to ensure reasonable settlement without excessive compaction. Compaction within the BSM area should not exceed 75 to 85% standard proctor within the BSM. Machinery shall not be used in the bioretention facility to place the BSM. A conveyor or spray system shall be used for media placement in large facilities. Low ground pressure equipment may be authorized for large facilities at the discretion of the Port. Placement methods and BSM quantities shall account for approximately 10% loss of volume due to settling. Planting methods and timing shall account for settling of media without exposing plant root systems.

F.3.5.4 Hydraulic Suitability

The Port may request up to three double ring infiltrometer tests (ASTM D3385) or approved alternative tests to confirm that the placed material meets applicable hydraulic suitability criteria. In the event that the infiltration rate of placed material does not meet applicable criteria, the Port may require replacement and/or de-compaction of materials.

F.3.5.5 Quality Control and Acceptance

Close adherence to the material quality controls herein is necessary in order to support healthy vegetation, minimize pollutant leaching, and assure sufficient permeability to infiltrate/filter runoff during the life of the facility. Amendments may be included to adjust agronomic properties. Acceptance of the material will be based on test results certified to be representative. Test results shall

be conducted no more than 120 days prior to delivery of the blended BSM to the project site. For projects installing more than 100 cubic yards of BSM, batch specific tests of the blended mix shall be provided to the Port for every 100 cubic yards of BSM along with a site plan showing the placement locations of each BSM batch within the facility.

F.3.5.6 Measurement and Payment

Quantities of mixed BSM will be measured as shown in the Bid. The volumetric quantity of mixed BSM to be paid for shall be the volume of BSM placed within the limits of the dimensions shown on the Plans.

F.3.6 AGGREGATE MATERIALS FOR BIORETENTION AND BIOFILTRATION DRAINAGE LAYERS

This section provides material specifications for drainage layers below BSM in bioretention BMPs. This consists of a two-layer filter course placed below the BSM and above an open-graded aggregate stone reservoir.

F.3.6.1 Rock and Sand Materials for Drainage Layers

All sand and stone products used in BSM drainage layers shall be clean and thoroughly washed.

F.3.6.1.1 Filter Course

Graded aggregate choker material is installed as a filter course to separate BSM from the drainage rock reservoir layer. The purpose of this layer is to limit migration of sand or other fines from the BSM. The filter course consists of two layers of choking material increasing in particle size. The top layer (closest to the BSM) of the filter course shall be constructed of thoroughly washed ASTM C33 Choker Sand as detailed in Table 200-1.5.5 of the WHITEBOOK. The bottom layer of the filter course shall be constructed of thoroughly washed ASTM No. 8 aggregate material conforming to gradation limits contained in Table 200-1.2.1 the WHITEBOOK.

F.3.6.1.2 Open-Graded Aggregate Stone

Open-graded aggregate material is installed below filter course layers to provide additional storm water storage capacity and contain the underdrain pipe(s). This layer shall be constructed of thoroughly washed AASHTO No. 57 open graded aggregate material conforming to gradation limits contained in Table 200-1.2.1 the WHITEBOOK.

F.3.6.2 Layer Thicknesses and Construction

Aggregate shall be deposited on underlying layers at a uniform quantity per linear foot (meter), which quantity will provide the required compacted thickness within the tolerances specified herein without resorting to spotting, picking up, or otherwise shifting the aggregate material.

F.3.6.2.1 Filter Course Layers

Each of the two filter course layers (top layer of ASTM C33 Choker Sand and bottom layer of ASTM No. 8) shall be installed to a thickness of 3 inches (75 mm). Both layers shall be spread in single layers. Marker stakes should be used to ensure uniform lift thickness.

F.3.6.2.2 Aggregate Drainage and Storage Layer

The thickness of the aggregate drainage and storage layer (AASHTO No. 57) will depend on site specific design and shall be detailed in contract documents.

F.3.6.2.3 Spreading

Drainage layers shall be as delivered as uniform mixtures and each layer shall be spread in one operation. Segregation within each aggregate layer shall be avoided and the layers shall be free from pockets of coarse or fine material.

F.3.6.2.4 Compacting

Filter course material and aggregate storage material shall be lightly compacted to approximately 80% standard proctor without the use of vibratory compaction.

F.3.6.3 Measurement and Payment

Quantities of graded aggregate choker material and opengraded aggregate storage material will be measured as shown in the Bid. The volumetric quantities of graded aggregate choker stone material and open-graded storage material shall be those placed within the limits of the dimensions shown on the Plans. The weight of material to be paid for will be determined by deducting (from the weight of material delivered to the Work) the weight of water in the material (at the time of weighing) in excess of 1% more than the optimum moisture content. No payment will be made for the weight of water deducted as provided in this subsection.

F.3.7 SUMMARY

Summary of BSM specification requirements for the City of San Diego and County of San Diego included in Table F.3.7.

TABLE F.3.7

Component	Requirement
BSM Material Composition	Sand: 60-80% by volume Topsoil: 0-20% by volume Compost: 20% by volume

Appendix F: Biofiltration Standard and Checklist

Alternative Blends Acceptable?	Yes, but they must meet performance-based specifications.
Sand Type	Washed sand conforming to particle size distribution
Topsoil Type	Sandy loam or loamy sand with clay < 15% and gravel < 25%
Compost Type	From a CalRecycle permitted facility. Biosolids derived materials are not acceptable
BSM Permeability	8-24 inches/hour for BMPs without outlet control; 15-80 inches/hour for BMPs with outlet control; testing is required to demonstrate.
Agronomic Suitability Requirements	Limits for salts and potential toxins. C:N ratio between 12 and 40.
Water Quality Related Limits?	Requirements related to specific pollutants when water quality of receiving waters is impaired for those pollutants.

B M P D E S I G N M A N U A L

**Guidance for Continuous
Simulation and Hydromodification
Management Sizing Factors**



Appendix G Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

G.1 Guidance for Continuous Simulation Hydrologic Modeling for Hydromodification Management Studies in San Diego County Region 9

G.1.1 Introduction

Continuous simulation hydrologic modeling is used to demonstrate compliance with the performance standards for hydromodification management in San Diego. There are several available hydrologic models that can perform continuous simulation analyses. Each has different methods and parameters for determining the amount of rainfall that becomes runoff, and for representing the hydraulic operations of certain structural BMPs such as biofiltration with partial retention or biofiltration. This Appendix is intended to:

- Identify acceptable models for continuous simulation hydrologic analyses for hydromodification management;
- Provide guidance for selecting climatology input to the models;
- Provide standards for rainfall loss parameters to be used in the models;
- Provide standards for defining physical characteristics of LID components; and
- Provide guidance for demonstrating compliance with performance standards for hydromodification management.

This Appendix is not a user's manual for any of the acceptable models, nor a comprehensive manual for preparing a hydrologic model. This Appendix provides guidance for selecting model input parameters for the specific purpose of hydromodification management studies. The model preparer must be familiar with the user's manual for the selected software to determine how the parameters are entered to the model.

G.1.2 Software for Continuous Simulation Hydrologic Modeling

The following software models may be used for hydromodification management studies in San Diego:

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

- HSPF – Hydrologic Simulation Program-FORTRAN, distributed by USEPA, public domain.
- SDHM – San Diego Hydrology Model, distributed by Clear Creek Solutions, Inc. This is an HSPF-based model with a proprietary interface that has been customized for use in San Diego for hydromodification management studies.
- SWMM – Storm Water Management Model, distributed by USEPA, public domain.

Third-party and proprietary software, such as XPSWMM or PCSWMM, may be used for hydromodification management studies in San Diego, provided that:

- Input and output data from the software can interface with public domain software such as SWMM. In other words, input files from the third party software should have sufficient functionality to allow export to public domain software for independent validation.
- The software's hydromodification control processes are substantiated.

G.1.3 Climatology Parameters

G.1.3.1 Rainfall

In all software applications for preparation of hydromodification management studies in San Diego, rainfall data must be selected from approved data sets that have been prepared for this purpose. As part of the development of the March 2011 Final HMP, long-term hourly rainfall records were prepared for public use. The rainfall record files are provided on the Project Clean Water website. The rainfall station map is provided in the March 2011 Final HMP and is included in this Appendix as Figure G.1-1.

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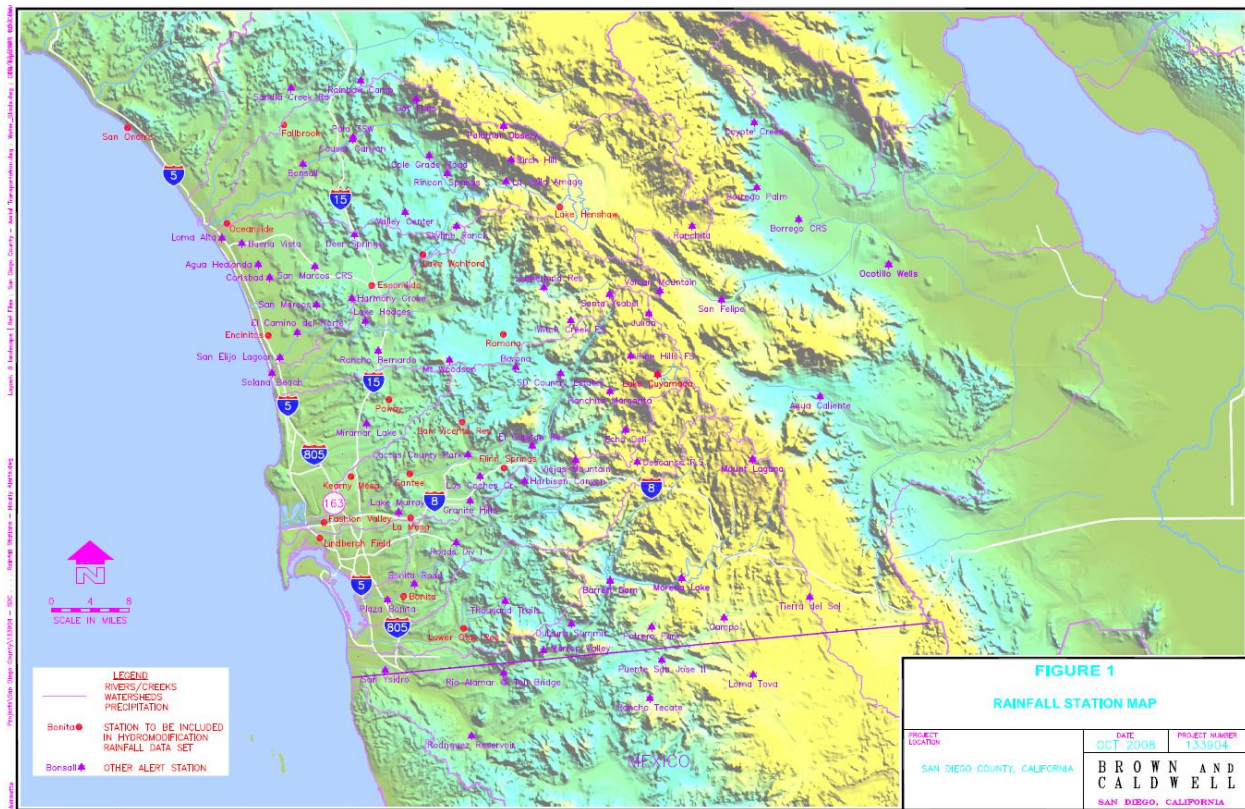


Figure G.1-1: Rainfall Station Map

Project applicants preparing continuous simulation models shall select the most appropriate rainfall data set from the rainfall record files provided on the Project Clean Water website. For a given project location, the following factors should be considered in the selection of the appropriate rainfall data set:

- In most cases, the rainfall data set in closest proximity to the project site will be the appropriate choice (refer to the rainfall station map).
- In some cases, the rainfall data set in closest proximity to the project site may not be the most applicable data set. Such a scenario could involve a data set with an elevation significantly different from the project site. In addition to a simple elevation comparison, the project proponent may also consult with the San Diego County's average annual precipitation isopluvial map, which is provided in the San Diego County Hydrology Manual (2003). Review of this map could provide an initial estimate as to whether the project site is in a similar rainfall zone as compared to the rainfall stations. Generally, precipitation totals in San Diego County increase with increasing elevation.
- Where possible, rainfall data sets should be chosen so that the data set and the project location are both located in the same topographic zone (coastal, foothill, mountain) and major

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watershed unit (Upper San Luis Rey, Lower San Luis Rey, Upper San Diego River, Lower San Diego River, etc.).

For SDHM users, the approved rainfall data sets are pre-loaded into the software package. SDHM users may select the appropriate rainfall gage within the SDHM program. HSPF or SWMM users shall download the appropriate rainfall record from the Project Clean Water website and load it into the software program.

Both the pre-development and post-project model simulation period shall encompass the entire rainfall record provided in the approved rainfall data set. Scaling the rainfall data is not permitted.

G.1.3.2 Potential Evapotranspiration

Project applicants preparing continuous simulation models shall select a data set from the sources described below to represent potential evapotranspiration.

For HSPF users, this parameter may be entered as an hourly time series. The hourly time series that was used to develop the BMP Sizing Calculator parameters is provided on the project clean water website and may be used for hydromodification management studies in San Diego. For SDHM users, the hourly evaporation data set is pre-loaded into the program. HSPF users may download the evaporation record from the Project Clean Water website and load it into the software program.

For HSPF or SWMM users, this parameter may be entered as monthly values in inches per month or inches per day. Monthly values may be obtained from the California Irrigation Management Information System "Reference Evapotranspiration Zones" brochure and map (herein "CIMIS ETo Zone Map"), prepared by California Department of Water Resources, dated January 2012. The CIMIS ETo Zone Map is available from www.cimis.gov, and is provided in this Appendix as Figure G.1-2. Determine the appropriate reference evapotranspiration zone for the project from the CIMIS ETo Zone Map. The monthly average reference evapotranspiration values are provided below in Table G.1-1.

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

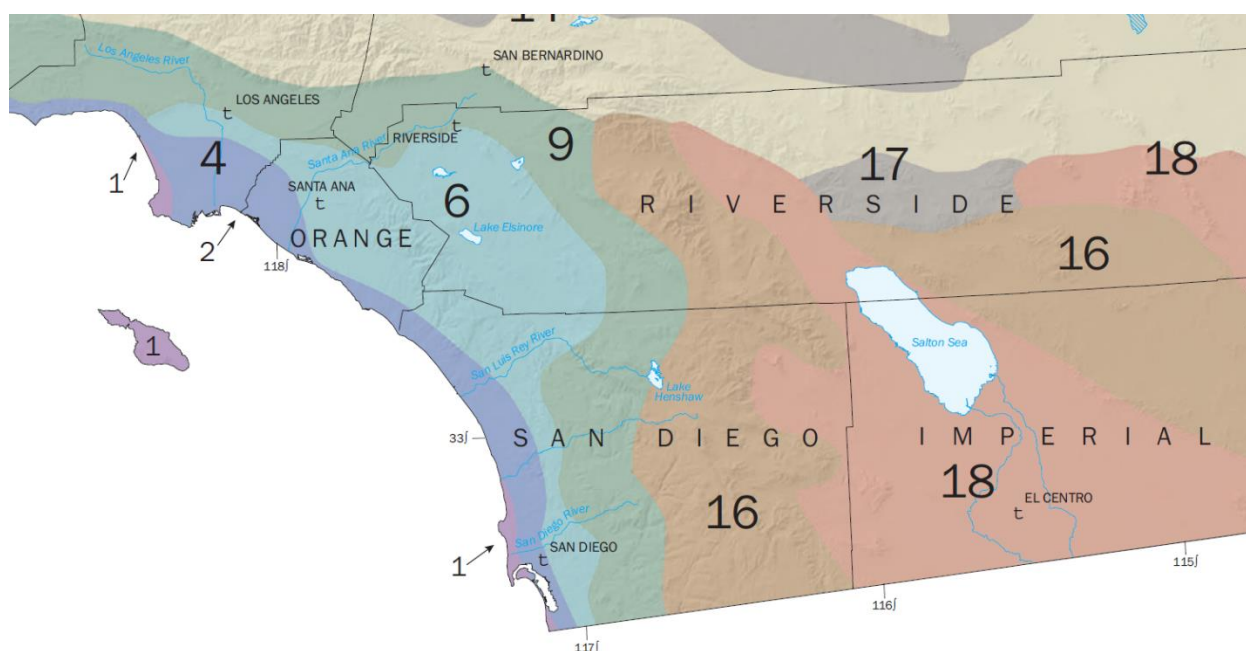


Figure G.1-2: California Irrigation Management Information System "Reference Evapotranspiration Zones"

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**Table G.1-1: Monthly Average Reference Evapotranspiration by ETo Zone
(inches/month and inches/day) for use in SWMM Models for Hydromodification Management Studies in San Diego County
CIMIS Zones 1, 4, 6, 9, and 16 (See CIMIS ETo Zone Map)**

	January	February	March	April	May	June	July	August	September	October	November	December
Zone	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month
1	0.93	1.4	2.48	3.3	4.03	4.5	4.65	4.03	3.3	2.48	1.2	0.62
4	1.86	2.24	3.41	4.5	5.27	5.7	5.89	5.58	4.5	3.41	2.4	1.86
6	1.86	2.24	3.41	4.8	5.58	6.3	6.51	6.2	4.8	3.72	2.4	1.86
9	2.17	2.8	4.03	5.1	5.89	6.6	7.44	6.82	5.7	4.03	2.7	1.86
16	1.55	2.52	4.03	5.7	7.75	8.7	9.3	8.37	6.3	4.34	2.4	1.55
	January	February	March	April	May	June	July	August	September	October	November	December
Days	31	28	31	30	31	30	31	31	30	31	30	31
Zone	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day
1	0.030	0.050	0.080	0.110	0.130	0.150	0.150	0.130	0.110	0.080	0.040	0.020
4	0.060	0.080	0.110	0.150	0.170	0.190	0.190	0.180	0.150	0.110	0.080	0.060
6	0.060	0.080	0.110	0.160	0.180	0.210	0.210	0.200	0.160	0.120	0.080	0.060
9	0.070	0.100	0.130	0.170	0.190	0.220	0.240	0.220	0.190	0.130	0.090	0.060
16	0.050	0.090	0.130	0.190	0.250	0.290	0.300	0.270	0.210	0.140	0.080	0.050

G.1.4 Land Characteristics and Loss

In all software applications for preparation of hydromodification management studies in San Diego, rainfall loss parameters must be consistent with this Appendix unless the preparer can provide documentation to substantiate use of other parameters, subject to local jurisdiction approval. HSPF and SWMM use different processes and different sets of parameters. SDHM is based on HSPF, therefore parameters for SDHM and HSPF are presented together in Section G.1.4.1. Parameters that have been pre-loaded into SDHM may be used for other HSPF hydromodification management studies outside of SDHM. Parameters for SWMM are presented separately in Section G.1.4.2.

G.1.4.1 Rainfall Loss Parameters for HSPF and SDHM

Rainfall losses in HSPF are characterized by PERLND/PWATER parameters and IMPLND parameters, which describe processes occurring when rainfall lands on pervious lands and impervious lands, respectively. "BASINS Technical Notice 6, Estimating Hydrology and Hydraulic Parameters for HSPF," prepared by the USEPA, dated July 2000, provides details regarding these parameters and summary tables of possible ranges of these parameters. Table G.1-2, excerpted from the above-mentioned document, presents the ranges of these parameters.

For HSPF studies for hydromodification management in San Diego, PERLND/PWATER parameters and IMPLND parameters shall fall within the "possible" range provided in EPA Technical Note 6. To select specific parameters, HSPF users may use the parameters established for development of the San Diego BMP Sizing Calculator, and/or the parameters that have been established for SDHM. Parameters for the San Diego BMP Sizing Calculator and SDHM are based on research conducted specifically for HSPF modeling in San Diego.

Documentation of parameters selected for the San Diego BMP Sizing Calculator is presented in the document titled, San Diego BMP Sizing Calculator Methodology, prepared by Brown and Caldwell, dated January 2012 (herein "BMP Sizing Calculator Methodology"). The PERLND/PWATER parameters selected for development of the San Diego BMP Sizing Calculator represent a single composite pervious land cover that is representative of most pre-development conditions for sites that would commonly be managed by the BMP Sizing Calculator. The parameters shown below in Table G.1-3 are excerpted from the BMP Sizing Calculator Methodology.

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Table G.1-2: HSPF PERLND/PWATER and IMPLND Parameters from EPA Technical Note 6

			Range of Values					
Name	Definition	Units	Typical		Possible		Function of ...	Comment
			Min	Max	Min	Max		
PWAT – PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	Calibration
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	Calibration, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	Calibration
PWAT – PARM3								
PETMAX	Temp below which ET is reduced	deg. F	35.0	45.0	32.0	48.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30.0	35.0	30.0	40.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.0	0.20	0.0	0.50	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0.0	0.05	0.0	0.20	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0.0	0.05	0.0	0.20	Marsh/wetlands extent	Direct ET from shallow GW
PWAT – PARM4								
CEPSC	Interception storage capacity	inches	0.03	0.20	0.01	0.40	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.10	1.0	0.05	2.0	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.05	0.50	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1.0	3.0	1.0	10.0	Soils, topography, land use	Calibration, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.70	0.30	0.85	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.70	0.1	0.9	Vegetation type/density, root depth	Calibration
IWAT – PARM2								
LSUR	Length of overland flow	feet	50	150	50	250	Topography, drainage system	Estimate from maps, GIS, or field survey
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.05	0.001	0.15	Topography, drainage	Estimate from maps, GIS, or field survey
NSUR	Manning's n (roughness) for overland flow	none	0.03	0.10	0.01	0.15	Impervious surface conditions	Typical range is 0.05 to 0.10 for roads/parking lots
RETSC	Retention storage capacity	inches	0.03	0.10	0.01	0.30	Impervious surface conditions	Typical range is 0.03 to 0.10 for roads/parking lots
IWAT – PARM3 (PETMAX and PETMIN, same values as shown for PWAT – PARM3)								

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Table G.1-3: HSPF PERLND/PWATER Parameters from BMP Sizing Calculator Methodology

		Hydrologic Soil Group A			Hydrologic Soil Group B			Hydrologic Soil Group C			Hydrologic Soil Group D		
	Slope	5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
PWAT_PARAM2	Units												
FOREST	None	0	0	0	0	0	0	0	0	0	0	0	0
LZSN	inches	5.2	4.8	4.5	5.0	4.7	4.4	4.8	4.5	4.2	4.8	4.5	4.2
INFILT	in/hr	0.090	0.070	0.045	0.070	0.055	0.040	0.050	0.040	0.032	0.040	0.030	0.020
LSUR	Feet	200	200	200	200	200	200	200	200	200	200	200	200
SLSUR	ft/ft	0.05	0.1	0.15	0.05	0.1	0.15	0.05	0.1	0.15	0.05	0.1	0.15
KVARY	1/inches	3	3	3	3	3	3	3	3	3	3	3	3
AGWRC	None	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PWAT_PARAM3													
PETMAX (F)	F	35	35	35	35	35	35	35	35	35	35	35	35
PETMIN (F)	F	30	30	30	30	30	30	30	30	30	30	30	30
INFEXP	None	2	2	2	2	2	2	2	2	2	2	2	2
INFILD	None	2	2	2	2	2	2	2	2	2	2	2	2
DEEPFR	None	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BASETP	None	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
AGEWTP	None	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
PWAT_PARAM4													
CEPSC	inches	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
UZSN	inches	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
NSUR	None	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
INTFW	None	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
IRC	None	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LZETP	None	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

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Parameters within SDHM are documented in "San Diego Hydrology Model User Manual," prepared by Clear Creek Solutions, Inc. (as of the development of the Manual, the current version of the SDHM User Manual is dated January 2012). Parameters established for SDHM represent "grass" (non-turf grasslands), "dirt," "gravel," and "urban" cover. The documented PERLND and IMPLND parameters for the various land covers and soil types have been pre-loaded into SDHM. SDHM users shall use the parameters that have been pre-loaded into the program without modification unless the preparer can provide documentation to substantiate use of other parameters.

G.1.4.2 Rainfall Loss Parameters for SWMM

In SWMM, rainfall loss parameters (parameters that describe processes occurring when rainfall lands on pervious lands and impervious lands) are entered in the "subcatchment" module. In addition to specifying parameters, the SWMM user must also select an infiltration model.

The SWMM Manual provides details regarding the subcatchment parameters and summary tables of possible ranges of these parameters. For SWMM studies for hydromodification management in San Diego, subcatchment parameters shall fall within the range provided in the SWMM Manual. Some of the parameters depend on the selection of the infiltration model. For consistency across the San Diego region, SWMM users shall use the Green-Ampt infiltration model for hydromodification management studies. Table G.1-4 presents SWMM subcatchment parameters for use in hydromodification management studies in the San Diego region.

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Table G.1-4: Subcatchment Parameters for SWMM Studies for Hydromodification Management in San Diego

SWMM Parameter Name	Unit	Range	Use in San Diego
Name X-Coordinate Y-Coordinate Description Tag Rain Gage Outlet	N/A	N/A – project-specific	Project-specific
Area	acres (ac)	Project-specific	Project-specific
Width	feet (ft)	Project-specific	Project-specific
% Slope	percent (%)	Project-specific	Project-specific
% Imperv	percent (%)	Project-specific	Project-specific
N-imperv	--	0.011 – 0.024 presented in Table A.6 of SWMM Manual	default use 0.012 for smooth concrete, otherwise provide documentation of other surface consistent with Table A.6 of SWMM Manual
N-Perv	--	0.05 – 0.80 presented in Table A.6 of SWMM Manual	default use 0.15 for short prairie grass, otherwise provide documentation of other surface consistent with Table A.6 of SWMM Manual
Dstore-Imperv	inches	0.05 – 0.10 inches presented in Table A.5 of SWMM Manual	0.05
Dstore-Perv	inches	0.10 – 0.30 inches presented in Table A.5 of SWMM Manual	0.10
%ZeroImperv	percent (%)	0% – 100%	25%
Subarea routing	--	OUTLET IMPERVIOUS PERVIOUS	Project-specific, typically OUTLET
Percent Routed	%	0% – 100%	Project-specific, typically 100%
Infiltration	Method	HORTON GREEN_AMPT CURVE_NUMBER	GREEN_AMPT

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SWMM Parameter Name	Unit	Range	Use in San Diego
Suction Head (Green-Ampt)	Inches	1.93 – 12.60 presented in Table A.2 of SWMM Manual	Hydrologic Soil Group A: 1.5 Hydrologic Soil Group B: 3.0 Hydrologic Soil Group C: 6.0 Hydrologic Soil Group D: 9.0
Conductivity (Green-Ampt)	Inches per hour	0.01 – 4.74 presented in Table A.2 of SWMM Manual by soil texture class 0.00 – ≥ 0.45 presented in Table A.3 of SWMM Manual by hydrologic soil group	Hydrologic Soil Group A: 0.3 Hydrologic Soil Group B: 0.2 Hydrologic Soil Group C: 0.1 Hydrologic Soil Group D: 0.025 Note: reduce conductivity by 25% in the post-project condition when native soils will be compacted. Conductivity may also be reduced by 25% in the pre-development condition model for redevelopment areas that are currently concrete or asphalt but must be modeled according to their underlying soil characteristics. For fill soils in post-project condition, see Section G.1.4.3.
Initial Deficit (Green-Ampt)		The difference between soil porosity and initial moisture content. Based on the values provided in Table A.2 of SWMM Manual, the range for completely dry soil would be 0.097 to 0.375	Hydrologic Soil Group A: 0.30 Hydrologic Soil Group B: 0.31 Hydrologic Soil Group C: 0.32 Hydrologic Soil Group D: 0.33 Note: in long-term continuous simulation, this value is not important as the soil will reach equilibrium after a few storm events regardless of the initial moisture content specified.
Groundwater	yes/no	yes/no	NO
LID Controls			Project Specific

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SWMM Parameter Name	Unit	Range	Use in San Diego
Snow Pack Land Uses Initial Buildup Curb Length			Not applicable to hydromodification management studies

G.1.4.3 Pervious Area Rainfall Loss Parameters in Post-Project Condition (HSPF, SDHM, and SWMM)

The following guidance applies to HSPF, SDHM, and SWMM. When modeling pervious areas in the post-project condition, fill soils shall be modeled as hydrologic soil group Type D soils, or the project applicant may provide an actual expected infiltration rate for the fill soil based on testing (must be approved by the Port for use in the model). Where landscaped areas on fill soils will be re-tilled and/or amended in the post-project condition, the landscaped areas may be modeled as Type C soils. Areas to be re-tilled and/or amended in the post-project condition must be shown on the project plans. For undisturbed pervious areas (i.e., native soils, no fill), use the actual hydrologic soil group, the same as in the pre-development condition.

G.1.5 Modeling Structural BMPs (Ponds AND LID Features)

There are many ways to model structural BMPs. There are standard modules for several pond or LID elements included in SDHM and SWMM. Users may also set up project-specific stage-storage-discharge relationships representing structural BMPs. Regardless of the modeling method, certain characteristics of the structural BMP, including infiltration of water from the bottom of the structural BMP into native soils, porosity of bioretention soils and/or gravel sublayers, and other program-specific parameters must be consistent with those presented below, unless the preparer can provide documentation to substantiate use of other parameters, subject to local jurisdiction approval. The geometry of structural BMPs is project-specific and shall match the project plans.

G.1.5.1 Infiltration into Native Soils Below Structural BMPs

Infiltration into native soils below structural BMPs may be modeled as a constant outflow rate equal to the project site-specific design infiltration rate (Worksheet D.5-1) multiplied by the area of the infiltrating surface (and converted to cubic feet per second). This infiltration rate is not the same as an infiltration parameter used in the calculation of rainfall losses, such as the HSPF INFILT parameter or the Green-Ampt conductivity parameter in the SWMM subcatchment module. It must be site-specific and must be determined based on the methods presented in Appendix D of this manual.

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For preliminary analysis when site-specific geotechnical investigation has not been completed, project applicants proposing infiltration into native soils as part of the structural BMP design shall prepare a sensitivity analysis to determine a potential range for the structural BMP size based on a range of potential infiltration rates. As shown in Appendices C and D of this manual, many factors influence the ability to infiltrate storm water. Therefore even when soils types A and B are present, which are generally expected to infiltrate storm water, the possibility that a very low infiltration rate could be determined at design level must be considered. The range of potential infiltration rates for preliminary analysis is shown below in Table G.1-5.

Table G.1-5: Range of Potential Infiltration Rates to be Studied for Sensitivity Analysis when Native Infiltration is Proposed but Site-Specific Geotechnical Investigation has not been Completed

Hydrologic Soil Group at Location of Proposed Structural BMP	Low Infiltration Rate for Preliminary Study (inches/hour)	High Infiltration Rate for Preliminary Study (inches/hour)
A	0.02	2.4
B	0.02	0.52
C	0	0.08
D	0	0.02

The infiltration rates shown above are for preliminary investigation only. Final design of a structural BMP must be based on the project site-specific design infiltration rate (Worksheet D.5-1).

G.1.5.2 Structural BMPs That Do Not Include Sub-Layers (Ponds)

To model a pond, basin, or other depressed area that does not include processing runoff through sublayers of amended soil and/or gravel, create a stage storage discharge relationship for the pond, and supply the information to the model according to the program requirements. For HSPF users, the stage-storage-discharge relationship is provided in FTABLES. SDHM users may use the TRAPEZOIDAL POND element for a trapezoidal pond or IRREGULAR POND element to request the program to create the stage-storage-discharge relationship, use the SSD TABLE element to supply a user-created stage-storage-discharge relationship, or use other available modules such as TANK or VAULT. For SWMM users, the stage-storage relationship is supplied in the storage unit module, and the stage-discharge relationship may be represented by various other modules such as the orifice, weir, or outlet modules. Stage-storage and stage-discharge curves for structural BMPs must be fully documented in the project-specific HMP report and must be consistent with the structural BMP(s) shown on project plans.

For user-created stage-discharge relationships, refer to local drainage manual criteria for equations representing hydraulic behavior of outlet structures. Users relying on the software to develop the

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stage-discharge relationship may use the equations built into the program. This manual does not recommend that all program modules calculating stage-discharge relationships must be uniform because the flows to be controlled for hydromodification management are low flows, calculated differently from the single-storm event peak flows studied for flood control purposes, and hydromodification management performance standards do not represent any performance standard for flood control drainage design. Note that for design of emergency outlet structures, and any calculations related to single-storm event routing for flood control drainage design, stage-discharge calculations must be consistent with the local drainage design requirements. This may require separate calculations for stage-discharge relationship pursuant to local manuals. The HMP flow rates shall not be used for flood control calculations.

G.1.5.3 Structural BMPs That Include Sub-Layers (Bioretention and Other LID)

G.1.5.3.1 Characteristics of Engineered Soil Media

The engineered soil media used in bioretention, biofiltration with partial retention, and biofiltration structural BMPs is a sandy loam. The following parameters presented in Table G.1-6 are characteristics of a sandy loam for use in continuous simulation models.

Table G.1-6: Characteristics of Sandy Loam to Represent Engineered Soil Media in Continuous Simulation for Hydromodification Management Studies in San Diego

Soil Texture	Porosity	Field Capacity	Wilting Point	Conductivity	Suction Head
Sandy Loam	0.4	0.2	0.1	5 inches/hour	1.5 inches

- Porosity is the volume of pore space (voids) relative to the total volume of soil (as a fraction).
- Field Capacity is the volume of pore water relative to total volume after the soil has been allowed to drain fully (as a fraction). Below this level, vertical drainage of water through the soil layer does not occur.
- Wilting point is the volume of pore water relative to total volume for a well dried soil where only bound water remains (as a fraction). The moisture content of the soil cannot fall below this limit.
- Conductivity is the hydraulic conductivity for the fully saturated soil (in/hr or mm/hr).
- Suction head is the average value of soil capillary suction along the wetting front (inches or mm).

Figures G.1-3 and G.1-4, from <http://www.stevenswater.com/articles/irrigationscheduling.aspx>,

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illustrate unsaturated soil and soil saturation, field capacity, and wilting point.

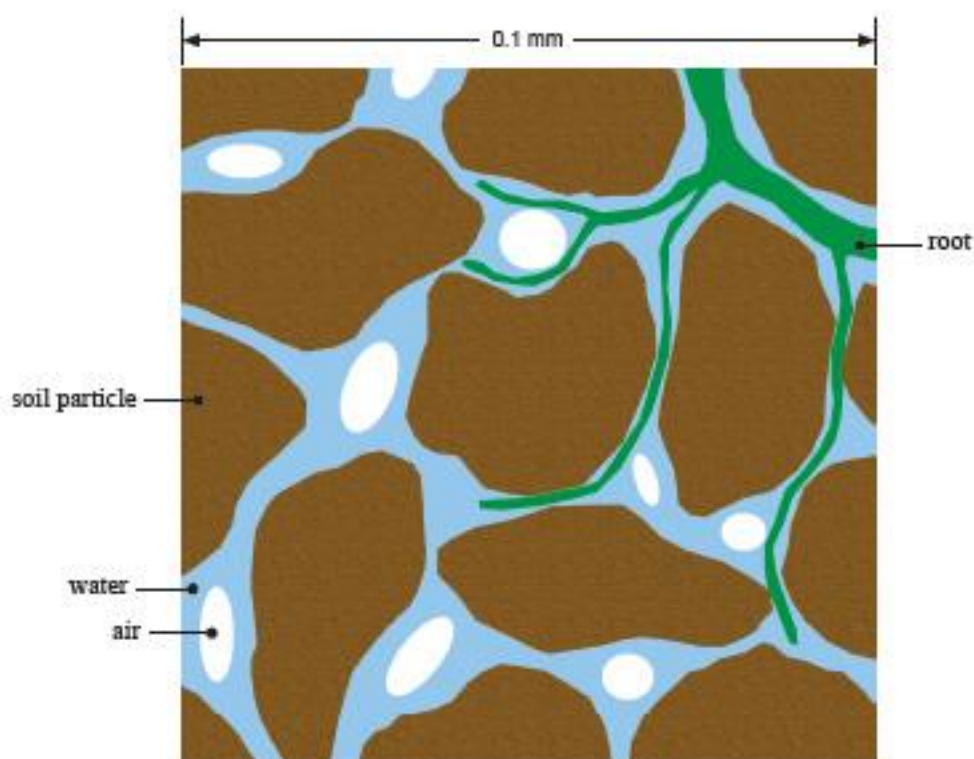


Figure G.1-3: Unsaturated Soil Composition

Unsaturated soil is composed of solid particles, organic material and pores. The pore space will contain air and water.

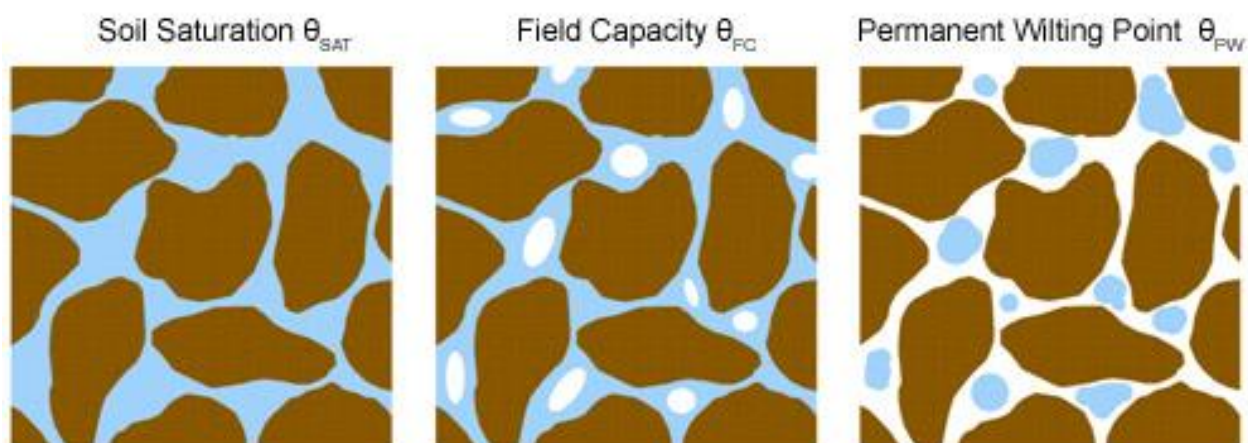


Figure G.1-4: Soil saturation, field capacity, and wilting point

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G.1.5.3.2 Characteristics of Gravel

For the purpose of hydromodification management studies, it may be assumed that water moves freely through gravel, not limited by hydraulic properties of the gravel. For the purpose of calculating available volume, use porosity of 0.4, or void ratio of 0.67. Porosity is equal to void ratio divided by $(1 + \text{void ratio})$.

G.1.5.3.3 Additional Guidance for SDHM Users

The module titled "bioretention/rain garden element" may be used to represent bioretention or biofiltration BMPs. SDHM users using the available "bioretention/rain garden element" shall customize the soil media characteristics to use the parameters from Table G.1-6 above, and select "gravel" for gravel sublayers. All other input variables are project-specific. "Native infiltration" refers to infiltration from the bottom of the structural BMP into the native soil. This variable is project-specific, see Section G.1.5.1.

G.1.5.3.4 Additional Guidance for SWMM Users

The "bio-retention cell" LID control may be used to represent bioretention or biofiltration BMPs. Table G.1-7 provides parameters required for the standard "bio-retention cell" available in SWMM. The parameters are entered in the LID Control Editor.

Table G.1-7: Parameters for SWMM "Bio-Retention Cell" Module for Hydromodification Management Studies in San Diego

SWMM Parameter Name	Unit	Use in San Diego
<i>Surface</i>		
Berm Height also known as Storage Depth	inches	Project-specific
Vegetative Volume Fraction also known as Vegetative Cover Fraction	---	0
Surface Roughness	---	0 (this parameter is not applicable to bio-retention cell)
Surface Slope	---	0 (this parameter is not applicable to bio-retention cell)
<i>Soil</i>		
Thickness	inches	project-specific
Porosity	---	0.40
Field Capacity	---	0.2

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SWMM Parameter Name	Unit	Use in San Diego
Wilting Point	---	0.1
Conductivity	Inches/hour	5
Conductivity Slope	---	5
Suction Head	inches	1.5
<i>Storage</i>		
Thickness also known as Height	inches	Project-specific
Void Ratio	---	0.67
Seepage Rate also known as Conductivity	Inches/hour	Conductivity from the storage layer refers to infiltration from the bottom of the structural BMP into the native soil. This variable is project-specific, see Section G.5.1. Use 0 if the bio-retention cell includes an impermeable liner
Clogging Factor	---	0
<i>Underdrain</i>		
Flow Coefficient Also known as Drain Coefficient	---	Project-specific
Flow Exponent Also known as Drain Exponent	---	Project-specific, typically 0.5
Offset Height Also known as Drain Offset Height	Inches	Project-specific

G.1.6 Flow Frequency and Duration

The continuous simulation model will generate a flow record corresponding to the frequency of the rainfall data input as its output. This flow record must then be processed to determine pre-development and post-project flow rates and durations. Compliance with hydromodification management requirements of this manual is achieved when results for flow duration meet the performance standards. The performance standard is as follows (also presented in Chapter 6 of this manual):

1. For flow rates ranging from 10 percent, 30 percent or 50 percent of the pre-development 2-year runoff event ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) to the pre-development 10-year runoff event (Q_{10}), the post-project discharge rates and durations must not exceed the pre-development rates and

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durations by more than 10 percent. The specific lower flow threshold will depend on the erosion susceptibility of the receiving stream for the project site (see Section 6.3.4).

To demonstrate that a flow control facility meets the hydromodification management performance standard, a flow duration summary must be generated and compared for pre-development and post-project conditions. The following guidelines shall be used for determining flow rates and durations.

G.1.6.1 Determining Flow Rates from Continuous Hourly Flow Output

Flow rates for hydromodification management studies in San Diego must be based on partial duration series analysis of the continuous hourly flow output. Partial duration series frequency calculations consider multiple storm events in a given year. To construct the partial duration series:

1. Parse the continuous hourly flow data into discrete runoff events. The following separation criteria may be used for separation of flow events: a new discrete event is designated when the flow falls below an artificially low flow value based on a fraction of the contributing watershed area (e.g., 0.002 to 0.005 cfs/acre) for a time period of 24 hours. Project applicants may consider other separation criteria provided the separation interval is not more than 24 hours and the criteria is clearly described in the submittal document.
2. Rank the peak flows from each discrete flow event, and compute the return interval or plotting position for each event.

Readers who are unfamiliar with how to compute the partial-duration series should consult reference books or online resources for additional information. For example, *Hydrology for Engineers*, by Linsley et al., 1982, discusses partial-duration series on pages 373-374 and computing recurrence intervals or plotting positions on page 359. *Handbook of Applied Hydrology*, by Chow, 1964, contains a detailed discussion of flow frequency analysis, including Annual Exceedance, Partial-Duration and Extreme Value series methods, in Chapter 8. The US Geological Survey (USGS) has several hydrologic study reports available online that use partial duration series statistics (see <http://water.usgs.gov/> and http://water.usgs.gov/osw/bulletin17b/AGU_Langbein_1949.pdf).

Pre-development Q_2 and Q_{10} shall be determined from the partial duration analysis for the pre-development hourly flow record. Pre-development Q_{10} is the upper threshold of flow rates to be controlled in the post-project condition. The lower flow threshold is a fraction of the pre-development Q_2 determined based on the erosion susceptibility of the receiving stream. Simply multiply the pre-development Q_2 by the appropriate fraction (e.g., $0.1Q_2$) to determine the lower flow threshold.

G.1.6.2 Determining Flow Durations from Continuous Hourly Flow Output

Flow durations must be summarized within the range of flows to control. Flow duration statistics provide a simple summary of how often a particular flow rate is exceeded. To prepare this summary:

1. Rank the entire hourly runoff time series output.

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2. Extract the portion of the ranked hourly time series output from the lower flow threshold to the upper flow threshold – this is the portion of the record to be summarized.
3. Divide the applicable portion of the record into 100 equal flow bins (compute the difference between the upper flow threshold (cfs) and lower flow threshold (cfs) and divide this value by 99 to establish the flow bin size).
4. Count the number of hours of flow that fall into each flow bin.

Both pre-development and post-project flow duration summary must be based on the entire length of the flow record. Compare the post-project flow duration summary to the pre-development flow duration summary to determine if it meets performance criteria for post-project flow rates and durations (criteria presented under Section G.1.6).

G.2 Sizing Factors for Hydromodification Management BMPs

This section presents sizing factors for design of flow control structural BMPs based on the sizing factor method identified in Chapter 6.3.5.1. The sizing factors are re-printed from the "San Diego BMP Sizing Calculator Methodology," dated January 2012, prepared by Brown and Caldwell (herein "BMP Sizing Calculator Methodology"). The sizing factors are linked to the specific details and descriptions that were presented in the BMP Sizing Calculator Methodology, with limited options for modifications. The sizing factors were developed based on the 2007 MS4 Permit. Although the sizing factors were developed under the 2007 MS4 Permit, the unit runoff ratios and some sizing factors developed for flow control facility sizing may still be applied at the discretion of the [City Engineer]. Some of the original sizing factors developed based on the 2007 MS4 Permit and presented in the BMP Sizing Calculator Methodology are not compatible with new requirements of the 2013 MS4 Permit, and therefore are not included in this manual. The sizing factor method is intended for simple studies that do not include diversion, do not include significant offsite area draining through the project from upstream, and do not include offsite area downstream of the project area. Use of the sizing factors is limited to the specific structural BMPs described in this Appendix. Sizing factors are available for the following specific structural BMPs:

- Full infiltration condition:
 - **Infiltration:** sizing factors available for A and B soils represent a below-ground structure (dry well)
 - **Bioretention:** sizing factors available for A and B soils represent a bioretention area with engineered soil media and gravel storage layer, with no underdrain and no impermeable liner
- Partial infiltration condition:
 - **Biofiltration with partial retention:** sizing factors available for C and D soils represent a bioretention area with engineered soil media and gravel storage layer, with an underdrain, with gravel storage below the underdrain, with no impermeable liner
- No infiltration condition:
 - **Biofiltration:** sizing factors available for C and D soils represent a bioretention area with engineered soil media and gravel storage layer, with an underdrain, without gravel storage below the underdrain, with no impermeable liner
 - **Biofiltration (formerly known as "flow-through planter") with impermeable liner:** sizing factors available for C and D soils represent a biofiltration system with engineered soil media and gravel storage layer, with an underdrain, with or without

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gravel storage below the underdrain, with an impermeable liner

- Other:
 - **Cistern:** sizing factors available for A, B, C, or D soils represent a vessel with a low flow orifice outlet to meet the hydromodification management performance standard.

Sizing factors were created based on three rainfall basins: Lindbergh Field, Oceanside, and Lake Wohlford.

The following information is needed to use the sizing factors:

- Determine the appropriate rainfall basin for the project site from Figure G.2-1, Rainfall Basin Map
- Hydrologic soil group at the project site (use available information pertaining to existing underlying soil type such as soil maps published by the Natural Resources Conservation Service)
- Pre-development and post-project slope categories (low = 0% – 5%, moderate = 5% – 15%, steep = >15%)
- Area tributary to the structural BMP
- Area weighted runoff factor (C) for the area draining to the BMP from Table G.2-1. Note: runoff coefficients and adjustments presented in Appendices B.1 and B.2 are for pollutant control only and are not applicable for hydromodification management studies
- Fraction of Q2 to control (see Chapter 6.3.4)

When using the sizing factor method, Worksheet G.2-1 may be used to present the calculations of the required minimum areas and/or volumes of BMPs as applicable.

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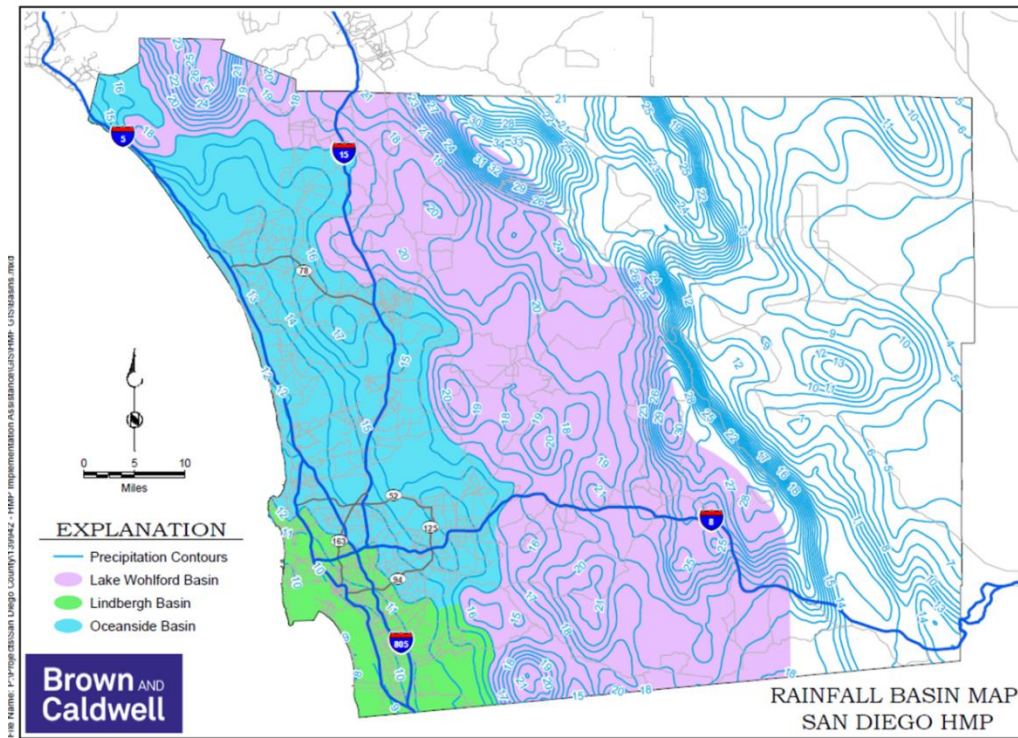


Figure G.2-1: Appropriate Rain Gauge for Project Sites

Table G.2-1: Runoff factors for surfaces draining to BMPs for Hydromodification Sizing Factor Method

Surface	Runoff Factor
Roofs	1.0
Concrete	1.0
Pervious Concrete	0.10
Porous Asphalt	0.10
Grouted Unit Pavers	1.0
Solid Unit Pavers on granular base, min. 3/16 inch joint space	0.20
Crushed Aggregate	0.10
Turf block	0.10
Amended, mulched soils	0.10
Landscape	0.10

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Worksheet G.2-1: Sizing Factor Worksheet

Site Information			
Project Name:		Hydrologic Unit	
Project Applicant:		Rain: Gauge:	
Jurisdiction:		Total Project Area:	
Assessor's Parcel Number :		Low Flow Threshold:	
BMP Name:		BMP Type:	

Areas Draining to BMP						Sizing Factors			Minimum BMP Size		
DMA Name	Area (sf)	Soil Type	Pre-Project Slope	Post Project Surface Type	Runoff Factor (From Table G.2-1)	Surface Area	Surface Volume	Subsurface Volume	Surface Area (sf)	Surface Volume (cf)	Subsurface Volume (cf)
Total DMA Area								Minimum BMP Size*			
								Proposed BMP Size*			

*Minimum BMP Size = Total of rows above.

*Proposed BMP Size \geq Minimum BMP size.

G.2.1 Unit Runoff Ratios

Table G.2-2 presents unit runoff ratios for calculating pre-development Q_2 , to be used when applicable to determine the lower flow threshold for low flow orifice sizing for biofiltration with partial retention, biofiltration, biofiltration with impermeable liner, or cistern BMPs. There is no low flow orifice in the infiltration BMP or bioretention BMP. The unit runoff ratios are re-printed from the BMP Sizing Calculator methodology. Unit runoff ratios for "urban" and "impervious" cover categories were not transferred to this manual due to the requirement to control runoff to pre-development condition (see Chapter 6.3.3).

How to use the unit runoff ratios:

Obtain unit runoff ratio from Table G.2-2 based on the project's rainfall basin, hydrologic soil group, and pre-development slope (for redevelopment projects, pre-development slope may be considered if historic topographic information is available, otherwise use pre-project slope). Multiply the area tributary to the structural BMP (A, acres) by the unit runoff ratio (Q_2 , cfs/acre) to determine the pre-development Q_2 to determine the lower flow threshold, to use for low flow orifice sizing.

Table G.2-2: Unit Runoff Ratios for Sizing Factor Method

Unit Runoff Ratios for Sizing Factor Method					
Rain Gauge	Soil	Cover	Slope	Q_2 (cfs/acre)	Q_{10} (cfs/ac)
Lake Wohlford	A	Scrub	Low	0.136	0.369
Lake Wohlford	A	Scrub	Moderate	0.207	0.416
Lake Wohlford	A	Scrub	Steep	0.244	0.47
Lake Wohlford	B	Scrub	Low	0.208	0.414
Lake Wohlford	B	Scrub	Moderate	0.227	0.448
Lake Wohlford	B	Scrub	Steep	0.253	0.482
Lake Wohlford	C	Scrub	Low	0.245	0.458
Lake Wohlford	C	Scrub	Moderate	0.253	0.481
Lake Wohlford	C	Scrub	Steep	0.302	0.517
Lake Wohlford	D	Scrub	Low	0.253	0.48
Lake Wohlford	D	Scrub	Moderate	0.292	0.516
Lake Wohlford	D	Scrub	Steep	0.351	0.538

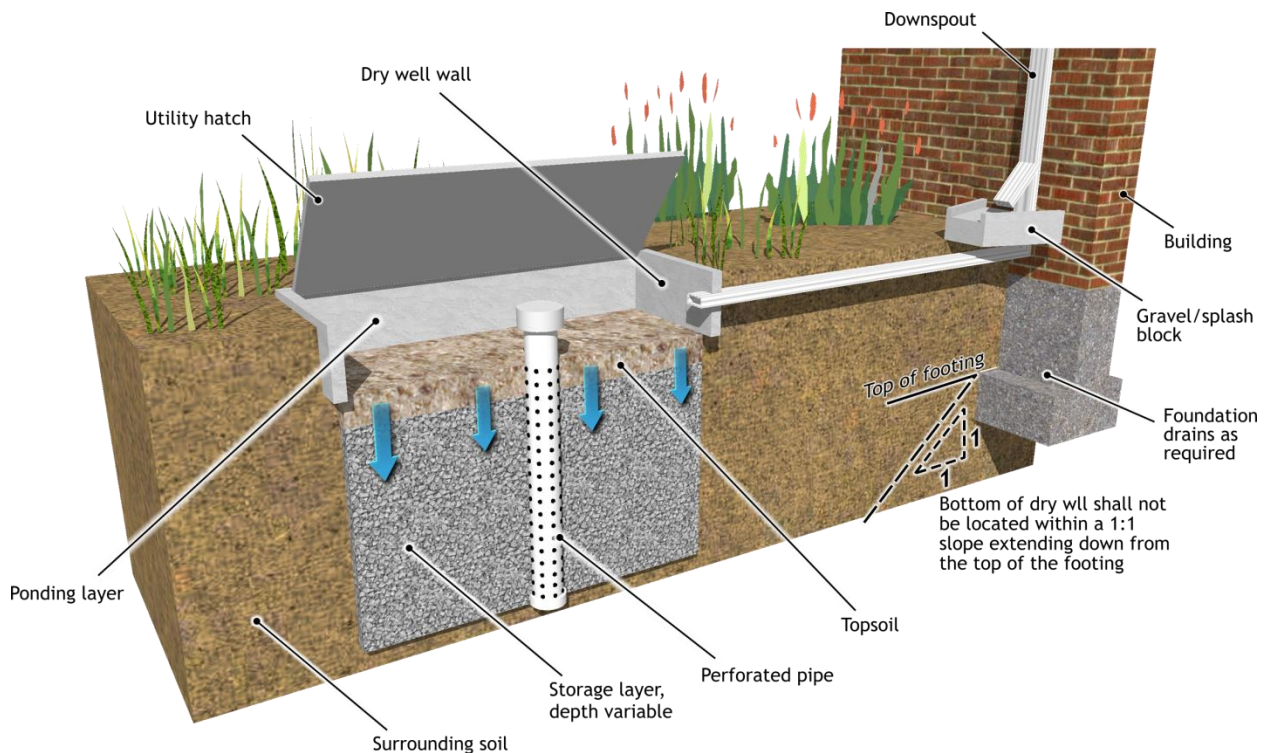
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Unit Runoff Ratios for Sizing Factor Method					
Rain Gauge	Soil	Cover	Slope	Q ₂ (cfs/acre)	Q ₁₀ (cfs/ac)
Oceanside	A	Scrub	Low	0.035	0.32
Oceanside	A	Scrub	Moderate	0.093	0.367
Oceanside	A	Scrub	Steep	0.163	0.42
Oceanside	B	Scrub	Low	0.08	0.365
Oceanside	B	Scrub	Moderate	0.134	0.4
Oceanside	B	Scrub	Steep	0.181	0.433
Oceanside	C	Scrub	Low	0.146	0.411
Oceanside	C	Scrub	Moderate	0.185	0.433
Oceanside	C	Scrub	Steep	0.217	0.458
Oceanside	D	Scrub	Low	0.175	0.434
Oceanside	D	Scrub	Moderate	0.212	0.455
Oceanside	D	Scrub	Steep	0.244	0.571
Lindbergh	A	Scrub	Low	0.003	0.081
Lindbergh	A	Scrub	Moderate	0.018	0.137
Lindbergh	A	Scrub	Steep	0.061	0.211
Lindbergh	B	Scrub	Low	0.011	0.134
Lindbergh	B	Scrub	Moderate	0.033	0.174
Lindbergh	B	Scrub	Steep	0.077	0.23
Lindbergh	C	Scrub	Low	0.028	0.19
Lindbergh	C	Scrub	Moderate	0.075	0.232
Lindbergh	C	Scrub	Steep	0.108	0.274
Lindbergh	D	Scrub	Low	0.05	0.228
Lindbergh	D	Scrub	Moderate	0.104	0.266
Lindbergh	D	Scrub	Steep	0.143	0.319

G.2.2 Sizing Factors for "Infiltration" BMP

Table G.2-3 presents sizing factors for calculating the required surface area (A) and volume (V1) for an infiltration BMP. There is no underdrain and therefore no low flow orifice in the infiltration BMP. Sizing factors were developed for hydrologic soil groups A and B only. This BMP is not applicable in hydrologic soil groups C and D. The infiltration BMP is a below-ground structure (dry well) that consists of three layers:

- Ponding layer: a nominal 6-inch ponding layer should be included below the access hatch to allow for water spreading and infiltration during intense storms.
- Soil layer [topsoil layer]: 12 inches of soil should be included to remove pollutants.
- Free draining layer [storage layer]: The drywell is sized assuming a 6-foot deep free draining layer. However, designers could use shallower facility depths [provided the minimum volume and surface area are met].



Infiltration Facility BMP Example Illustration

Reference: "San Diego BMP Sizing Calculator Methodology," prepared by Brown and Caldwell, dated January 2012

How to use the sizing factors for flow control BMP Sizing:

Obtain sizing factors from Table G.2-3 based on the project's lower flow threshold fraction of Q2, hydrologic soil group, pre-development slope, and rain gauge (rainfall basin). Multiply the area

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tributary to the structural BMP (A, square feet) by the area weighted runoff factor (C, unitless) (see Table G.2-1) by the sizing factors to determine the required surface area (A, square feet) and volume (V₁, cubic feet) for the infiltration BMP. The civil engineer shall provide the necessary volume and surface area of the BMP on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

To use this BMP as a combined pollutant control and flow control BMP, determine the size of the BMP using the sizing factors, then refer to Appendix B.4 to check whether the BMP meets performance standards for infiltration for pollutant control. If necessary, increase the surface area to meet the drawdown requirement for pollutant control.

Table G.2-3: Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method

Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	A	Flat	Lindbergh	0.040	0.1040	N/A
0.5Q ₂	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.5Q ₂	A	Steep	Lindbergh	0.035	0.0910	N/A
0.5Q ₂	B	Flat	Lindbergh	0.058	0.1495	N/A
0.5Q ₂	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.5Q ₂	B	Steep	Lindbergh	0.050	0.1300	N/A
0.5Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Flat	Oceanside	0.045	0.1170	N/A
0.5Q ₂	A	Moderate	Oceanside	0.045	0.1170	N/A
0.5Q ₂	A	Steep	Oceanside	0.040	0.1040	N/A
0.5Q ₂	B	Flat	Oceanside	0.065	0.1690	N/A
0.5Q ₂	B	Moderate	Oceanside	0.065	0.1690	N/A
0.5Q ₂	B	Steep	Oceanside	0.060	0.1560	N/A
0.5Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	D	Flat	Oceanside	N/A	N/A	N/A

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Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Flat	L Wohlford	0.050	0.1300	N/A
0.5Q ₂	A	Moderate	L Wohlford	0.050	0.1300	N/A
0.5Q ₂	A	Steep	L Wohlford	0.040	0.1040	N/A
0.5Q ₂	B	Flat	L Wohlford	0.078	0.2015	N/A
0.5Q ₂	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.5Q ₂	B	Steep	L Wohlford	0.065	0.1690	N/A
0.5Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	A	Flat	Lindbergh	0.040	0.1040	N/A
0.3Q ₂	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.3Q ₂	A	Steep	Lindbergh	0.035	0.0910	N/A
0.3Q ₂	B	Flat	Lindbergh	0.058	0.1495	N/A
0.3Q ₂	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.3Q ₂	B	Steep	Lindbergh	0.050	0.1300	N/A
0.3Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Flat	Oceanside	0.045	0.1170	N/A
0.3Q ₂	A	Moderate	Oceanside	0.045	0.1170	N/A
0.3Q ₂	A	Steep	Oceanside	0.040	0.1040	N/A
0.3Q ₂	B	Flat	Oceanside	0.065	0.1690	N/A
0.3Q ₂	B	Moderate	Oceanside	0.065	0.1690	N/A
0.3Q ₂	B	Steep	Oceanside	0.060	0.1560	N/A
0.3Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Flat	L Wohlford	0.050	0.1300	N/A
0.3Q ₂	A	Moderate	L Wohlford	0.050	0.1300	N/A
0.3Q ₂	A	Steep	L Wohlford	0.040	0.1040	N/A
0.3Q ₂	B	Flat	L Wohlford	0.078	0.2015	N/A
0.3Q ₂	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.3Q ₂	B	Steep	L Wohlford	0.065	0.1690	N/A
0.3Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Flat	Lindbergh	0.040	0.1040	N/A
0.1Q ₂	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.1Q ₂	A	Steep	Lindbergh	0.035	0.0910	N/A
0.1Q ₂	B	Flat	Lindbergh	0.058	0.1495	N/A
0.1Q ₂	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.1Q ₂	B	Steep	Lindbergh	0.050	0.1300	N/A
0.1Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Flat	Oceanside	0.045	0.1170	N/A
0.1Q ₂	A	Moderate	Oceanside	0.045	0.1170	N/A
0.1Q ₂	A	Steep	Oceanside	0.040	0.1040	N/A
0.1Q ₂	B	Flat	Oceanside	0.065	0.1690	N/A
0.1Q ₂	B	Moderate	Oceanside	0.065	0.1690	N/A
0.1Q ₂	B	Steep	Oceanside	0.060	0.1560	N/A

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Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.1Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Flat	L Wohlford	0.050	0.1300	N/A
0.1Q ₂	A	Moderate	L Wohlford	0.050	0.1300	N/A
0.1Q ₂	A	Steep	L Wohlford	0.040	0.1040	N/A
0.1Q ₂	B	Flat	L Wohlford	0.078	0.2015	N/A
0.1Q ₂	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.1Q ₂	B	Steep	L Wohlford	0.065	0.1690	N/A
0.1Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A

Q₂ = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Surface area sizing factor for flow control

V₁ = Infiltration volume sizing factor for flow control

Definitions for "N/A"

- Soil groups A and B: N/A in column V₂ means there is no V₂ element in this infiltration BMP for soil groups A and B
- Soil groups C and D: N/A across all elements (A, V₁, V₂) means sizing factors were not developed for an infiltration BMP for soil groups C and D

G.2.3 Sizing Factors for Bioretention

Table G.2-4 presents sizing factors for calculating the required surface area (A) and surface volume (V1) for the bioretention BMP. The bioretention BMP consists of two layers:

- Ponding layer: 10-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- Growing medium: 18-inches of soil [bioretention soil media]

This BMP is applicable in soil groups A and B. This BMP does not include an underdrain or a low flow orifice. This BMP does not include an impermeable layer at the bottom of the facility to prevent infiltration into underlying soils, regardless of hydrologic soil group. If a facility is to be lined, the designer must use the sizing factors for biofiltration with impermeable layer (formerly known as "flow-through planter").

How to use the sizing factors for flow control BMP Sizing:

Obtain sizing factors from Table G.2-4 based on the project's lower flow threshold fraction of Q_2 , hydrologic soil group, pre-development slope, and rain gauge (rainfall basin). Multiply the area tributary to the structural BMP (A, square feet) by the area weighted runoff factor (C, unitless) (see Table G.2-1) by the sizing factors to determine the required surface area (A, square feet) and surface volume (V1, cubic feet). Note the surface volume is the ponding layer. The BMP must also include 18 inches of bioretention soil media which does not contribute to V1. The civil engineer shall provide the necessary volume and surface area of the BMP on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

To use this BMP as a combined pollutant control and flow control BMP, determine the size of the BMP using the sizing factors, then refer to Appendix B.4 to check whether the BMP meets performance standards for infiltration for pollutant control. If necessary, adjust the surface area, depth of storage layer, or depth of growing medium as needed to meet pollutant control standards.

Table G.2-4: Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method

Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	A	Flat	Lindbergh	0.060	0.0500	N/A
0.5Q ₂	A	Moderate	Lindbergh	0.055	0.0458	N/A
0.5Q ₂	A	Steep	Lindbergh	0.045	0.0375	N/A

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Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	B	Flat	Lindbergh	0.093	0.0771	N/A
0.5Q ₂	B	Moderate	Lindbergh	0.085	0.0708	N/A
0.5Q ₂	B	Steep	Lindbergh	0.065	0.0542	N/A
0.5Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Flat	Oceanside	0.070	0.0583	N/A
0.5Q ₂	A	Moderate	Oceanside	0.065	0.0542	N/A
0.5Q ₂	A	Steep	Oceanside	0.060	0.0500	N/A
0.5Q ₂	B	Flat	Oceanside	0.098	0.0813	N/A
0.5Q ₂	B	Moderate	Oceanside	0.090	0.0750	N/A
0.5Q ₂	B	Steep	Oceanside	0.075	0.0625	N/A
0.5Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	D	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Flat	L Wohlford	0.050	0.0417	N/A
0.5Q ₂	A	Moderate	L Wohlford	0.045	0.0375	N/A
0.5Q ₂	A	Steep	L Wohlford	0.040	0.0333	N/A
0.5Q ₂	B	Flat	L Wohlford	0.048	0.0396	N/A
0.5Q ₂	B	Moderate	L Wohlford	0.045	0.0375	N/A
0.5Q ₂	B	Steep	L Wohlford	0.040	0.0333	N/A
0.5Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A

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Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	A	Flat	Lindbergh	0.060	0.0500	N/A
0.3Q ₂	A	Moderate	Lindbergh	0.055	0.0458	N/A
0.3Q ₂	A	Steep	Lindbergh	0.045	0.0375	N/A
0.3Q ₂	B	Flat	Lindbergh	0.098	0.0813	N/A
0.3Q ₂	B	Moderate	Lindbergh	0.090	0.0750	N/A
0.3Q ₂	B	Steep	Lindbergh	0.070	0.0583	N/A
0.3Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Flat	Oceanside	0.070	0.0583	N/A
0.3Q ₂	A	Moderate	Oceanside	0.065	0.0542	N/A
0.3Q ₂	A	Steep	Oceanside	0.060	0.0500	N/A
0.3Q ₂	B	Flat	Oceanside	0.098	0.0813	N/A
0.3Q ₂	B	Moderate	Oceanside	0.090	0.0750	N/A
0.3Q ₂	B	Steep	Oceanside	0.075	0.0625	N/A
0.3Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Flat	L Wohlford	0.050	0.0417	N/A
0.3Q ₂	A	Moderate	L Wohlford	0.045	0.0375	N/A
0.3Q ₂	A	Steep	L Wohlford	0.040	0.0333	N/A
0.3Q ₂	B	Flat	L Wohlford	0.060	0.0500	N/A
0.3Q ₂	B	Moderate	L Wohlford	0.055	0.0458	N/A
0.3Q ₂	B	Steep	L Wohlford	0.045	0.0375	N/A
0.3Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Flat	Lindbergh	0.060	0.0500	N/A
0.1Q ₂	A	Moderate	Lindbergh	0.055	0.0458	N/A
0.1Q ₂	A	Steep	Lindbergh	0.045	0.0375	N/A
0.1Q ₂	B	Flat	Lindbergh	0.100	0.0833	N/A
0.1Q ₂	B	Moderate	Lindbergh	0.095	0.0792	N/A
0.1Q ₂	B	Steep	Lindbergh	0.080	0.0667	N/A
0.1Q ₂	C	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	D	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Flat	Oceanside	0.070	0.0583	N/A
0.1Q ₂	A	Moderate	Oceanside	0.065	0.0542	N/A
0.1Q ₂	A	Steep	Oceanside	0.060	0.0500	N/A
0.1Q ₂	B	Flat	Oceanside	0.103	0.0854	N/A
0.1Q ₂	B	Moderate	Oceanside	0.090	0.0750	N/A
0.1Q ₂	B	Steep	Oceanside	0.075	0.0625	N/A
0.1Q ₂	C	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	D	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Flat	L Wohlford	0.050	0.0417	N/A
0.1Q ₂	A	Moderate	L Wohlford	0.045	0.0375	N/A
0.1Q ₂	A	Steep	L Wohlford	0.040	0.0333	N/A
0.1Q ₂	B	Flat	L Wohlford	0.090	0.0750	N/A
0.1Q ₂	B	Moderate	L Wohlford	0.085	0.0708	N/A
0.1Q ₂	B	Steep	L Wohlford	0.065	0.0542	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Bioretention BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.1Q ₂	C	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	D	Steep	L Wohlford	N/A	N/A	N/A

Q₂ = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Surface area sizing factor for flow control

V₁ = Surface volume sizing factor for flow control

Definitions for "N/A"

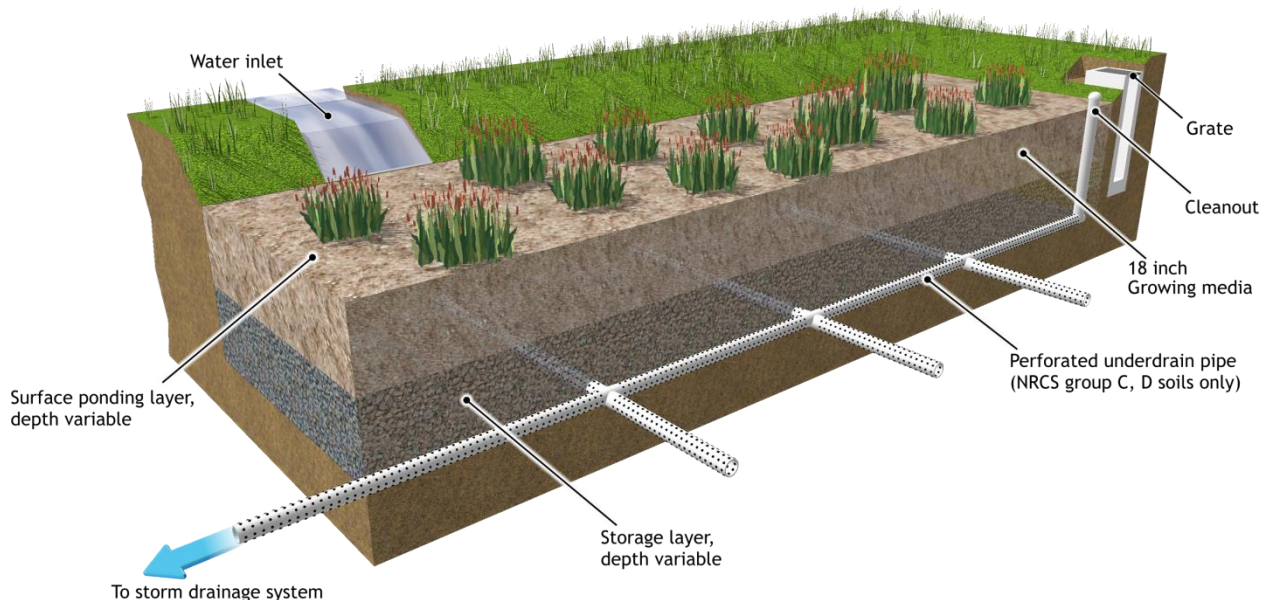
- Soil groups A and B: N/A in column V2 means there is no V2 element in this bioretention BMP for soil groups A and B
- Soil groups C and D: N/A in all elements (A, V1, V2) for soil groups C and D means sizing factors developed for "bioretention" in soil groups C and D under the 2007 MS4 Permit are not applicable in the "bioretention" category under the 2013 MS4 Permit because they were developed with the assumption that an underdrain is operating. Refer to Appendix G.2.4, Sizing Factors for Biofiltration with Partial Retention and Biofiltration

G.2.4 Sizing Factors for Biofiltration with Partial Retention and Biofiltration

Table G.2-5 presents sizing factors for calculating the required surface area (A), surface volume (V1), and sub-surface volume (V2) for a biofiltration with partial retention and biofiltration BMP. The BMPs consist of three layers:

- Ponding layer: 10-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- Growing medium: 18-inches of soil [bioretention soil media]
- Storage layer: 30-inches of gravel at 40 percent porosity [18 inches active storage above underdrain is required, additional dead storage depth below underdrain is optional and can vary]

This BMP is applicable in soil groups C and D. This BMP includes an underdrain with a low flow orifice 18 inches (1.5 feet) below the bottom of the growing medium. This BMP can include additional dead storage below the underdrain. This BMP does not include an impermeable layer at the bottom of the facility to prevent infiltration into underlying soils, regardless of hydrologic soil group. If a facility is to be lined, the designer must use the sizing factors for biofiltration with impermeable liner (formerly known as "flow-through planter").



Biofiltration BMP Example Illustration

Reference: "San Diego BMP Sizing Calculator Methodology," prepared by Brown and Caldwell, dated January 2012

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

How to use the sizing factors for flow control BMP Sizing:

Obtain sizing factors from Table G.2-5 based on the project's lower flow threshold fraction of Q_2 , hydrologic soil group, pre-development slope, and rain gauge (rainfall basin). Multiply the area tributary to the structural BMP (A, square feet) by the area weighted runoff factor (C, unitless) (see Table G.2-1) by the sizing factors to determine the required surface area (A, square feet), surface volume (V₁, cubic feet), and sub-surface volume (V₂, cubic feet). Select a low flow orifice for the underdrain that will discharge the lower flow threshold flow when there is 1.5 feet of head over the underdrain orifice. The civil engineer shall provide the necessary volume and surface area of the BMP and the underdrain and orifice detail on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

To use this BMP as a combined pollutant control and flow control BMP, determine the size of the BMP using the sizing factors. For BMPs without dead storage below the underdrain, then refer to Appendix B.5 and Appendix F to check whether the BMP meets performance standards for biofiltration for pollutant control. If necessary, adjust the surface area, depth of storage layer, or depth of growing medium as needed to meet pollutant control standards. For BMPs with dead storage below the underdrain, refer to Appendix B.4 to determine the portion of the DCV to be infiltrated for pollutant control, then Appendix B.5 and Appendix F to check whether the BMP meets performance standards for biofiltration for pollutant control for the balance of the DCV. If necessary, adjust the surface area, depth of storage layer, or depth of growing medium as needed to meet pollutant control standards.

Table G.2-5: Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention and Biofiltration BMPs Designed Using Sizing Factor Method

Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention and Biofiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Flat	Lindbergh	0.100	0.0833	0.0600
0.5Q ₂	C	Moderate	Lindbergh	0.100	0.0833	0.0600
0.5Q ₂	C	Steep	Lindbergh	0.075	0.0625	0.0450
0.5Q ₂	D	Flat	Lindbergh	0.080	0.0667	0.0480

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention and Biofiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	D	Moderate	Lindbergh	0.080	0.0667	0.0480
0.5Q ₂	D	Steep	Lindbergh	0.060	0.0500	0.0360
0.5Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Flat	Oceanside	0.075	0.0625	0.0450
0.5Q ₂	C	Moderate	Oceanside	0.075	0.0625	0.0450
0.5Q ₂	C	Steep	Oceanside	0.060	0.0500	0.0360
0.5Q ₂	D	Flat	Oceanside	0.065	0.0542	0.0390
0.5Q ₂	D	Moderate	Oceanside	0.065	0.0542	0.0390
0.5Q ₂	D	Steep	Oceanside	0.050	0.0417	0.0300
0.5Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Flat	L Wohlford	0.065	0.0542	0.0390
0.5Q ₂	C	Moderate	L Wohlford	0.065	0.0542	0.0390
0.5Q ₂	C	Steep	L Wohlford	0.050	0.0417	0.0300
0.5Q ₂	D	Flat	L Wohlford	0.055	0.0458	0.0330
0.5Q ₂	D	Moderate	L Wohlford	0.055	0.0458	0.0330
0.5Q ₂	D	Steep	L Wohlford	0.045	0.0375	0.0270
0.3Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Flat	Lindbergh	0.110	0.0917	0.0660

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention and Biofiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	C	Moderate	Lindbergh	0.110	0.0917	0.0660
0.3Q ₂	C	Steep	Lindbergh	0.085	0.0708	0.0510
0.3Q ₂	D	Flat	Lindbergh	0.100	0.0833	0.0600
0.3Q ₂	D	Moderate	Lindbergh	0.100	0.0833	0.0600
0.3Q ₂	D	Steep	Lindbergh	0.070	0.0583	0.0420
0.3Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	C	Flat	Oceanside	0.100	0.0833	0.0600
0.3Q ₂	C	Moderate	Oceanside	0.100	0.0833	0.0600
0.3Q ₂	C	Steep	Oceanside	0.080	0.0667	0.0480
0.3Q ₂	D	Flat	Oceanside	0.085	0.0708	0.0510
0.3Q ₂	D	Moderate	Oceanside	0.085	0.0708	0.0510
0.3Q ₂	D	Steep	Oceanside	0.065	0.0542	0.0390
0.3Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Flat	L Wohlford	0.075	0.0625	0.0450
0.3Q ₂	C	Moderate	L Wohlford	0.075	0.0625	0.0450
0.3Q ₂	C	Steep	L Wohlford	0.060	0.0500	0.0360
0.3Q ₂	D	Flat	L Wohlford	0.065	0.0542	0.0390
0.3Q ₂	D	Moderate	L Wohlford	0.065	0.0542	0.0390
0.3Q ₂	D	Steep	L Wohlford	0.050	0.0417	0.0300
0.1Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention and Biofiltration BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.1Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Flat	Lindbergh	0.145	0.1208	0.0870
0.1Q ₂	C	Moderate	Lindbergh	0.145	0.1208	0.0870
0.1Q ₂	C	Steep	Lindbergh	0.120	0.1000	0.0720
0.1Q ₂	D	Flat	Lindbergh	0.160	0.1333	0.0960
0.1Q ₂	D	Moderate	Lindbergh	0.160	0.1333	0.0960
0.1Q ₂	D	Steep	Lindbergh	0.115	0.0958	0.0690
0.1Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Flat	Oceanside	0.130	0.1083	0.0780
0.1Q ₂	C	Moderate	Oceanside	0.130	0.1083	0.0780
0.1Q ₂	C	Steep	Oceanside	0.110	0.0917	0.0660
0.1Q ₂	D	Flat	Oceanside	0.130	0.1083	0.0780
0.1Q ₂	D	Moderate	Oceanside	0.130	0.1083	0.0780
0.1Q ₂	D	Steep	Oceanside	0.065	0.0542	0.0390
0.1Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Flat	L Wohlford	0.110	0.0917	0.0660
0.1Q ₂	C	Moderate	L Wohlford	0.110	0.0917	0.0660
0.1Q ₂	C	Steep	L Wohlford	0.090	0.0750	0.0540
0.1Q ₂	D	Flat	L Wohlford	0.100	0.0833	0.0600
0.1Q ₂	D	Moderate	L Wohlford	0.100	0.0833	0.0600
0.1Q ₂	D	Steep	L Wohlford	0.075	0.0625	0.0450

Q₂ = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Surface area sizing factor for flow control

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

V_1 = Surface volume sizing factor for flow control

V_2 = Subsurface volume sizing factor for flow control

Definitions for "N/A"

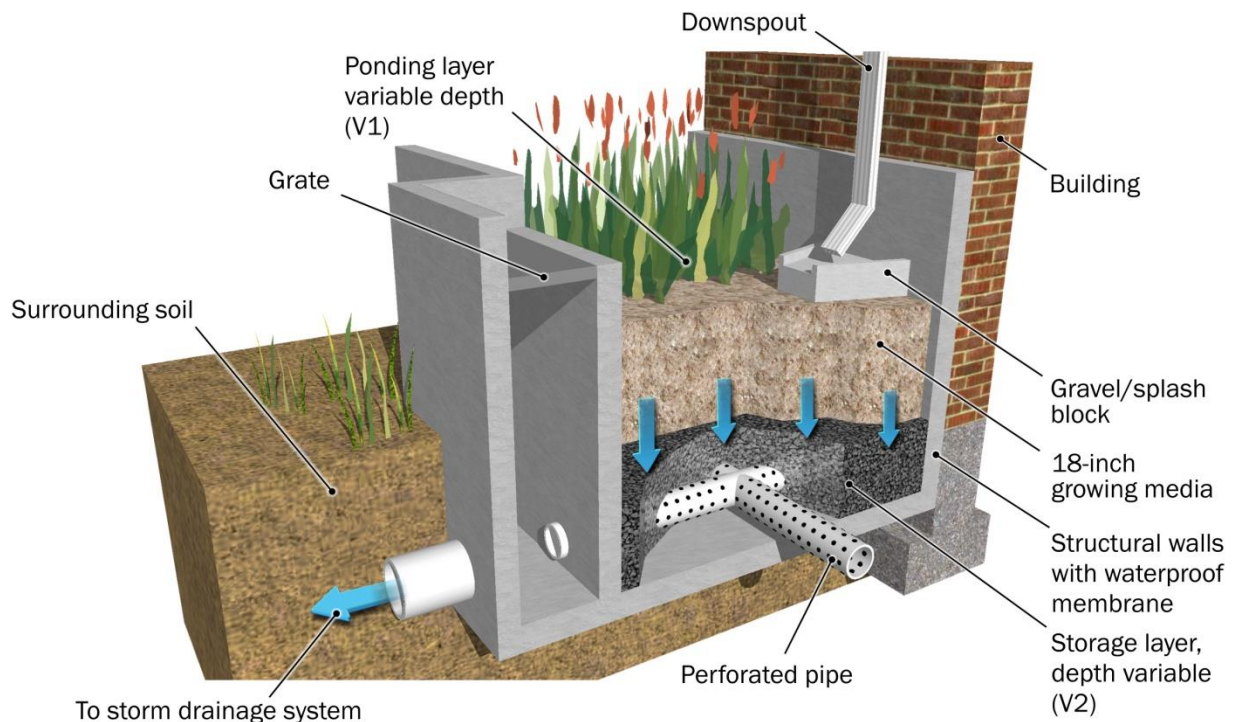
- Soil groups A and B: N/A in all elements (A, V_1 , V_2) for soil groups A and B means sizing factors were not developed for biofiltration (i.e., with an underdrain) for soil groups A and B. If no underdrain is proposed, refer to Appendix G.2.3, Sizing Factors for Bioretention. If an underdrain is proposed, use project-specific continuous simulation modeling.

G.2.5 Sizing Factors for Biofiltration with Impermeable Liner

Table G.2-6 presents sizing factors for calculating the required surface area (A), surface volume (V1), and sub-surface volume (V2) for a biofiltration BMP with impermeable liner (formerly known as flow-through planter). The BMP consists of three layers:

- Ponding layer: 10-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- Growing medium: 18-inches of soil [bioretention soil media]
- Storage layer: 30-inches of gravel at 40 percent porosity [18 inches active storage above underdrain is required, additional dead storage depth below underdrain is optional and can vary]

This BMP includes an underdrain with a low flow orifice 18 inches (1.5 feet) below the bottom of the growing medium. This BMP includes an impermeable liner to prevent infiltration into underlying soils.



Biofiltration with impermeable liner BMP Example Illustration

Reference: "San Diego BMP Sizing Calculator Methodology," prepared by Brown and Caldwell, dated January 2012

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

How to use the sizing factors for flow control BMP Sizing:

Obtain sizing factors from Table G.2-6 based on the project's lower flow threshold fraction of Q_2 , hydrologic soil group, pre-development slope, and rain gauge (rainfall basin). Multiply the area tributary to the structural BMP (A, square feet) by the area weighted runoff factor (C, unitless) (see Table G.2-1) by the sizing factors to determine the required surface area (A, square feet), surface volume (V₁, cubic feet), and sub-surface volume (V₂, cubic feet). Select a low flow orifice for the underdrain that will discharge the lower flow threshold flow when there is 1.5 feet of head over the underdrain orifice. The civil engineer shall provide the necessary volume and surface area of the BMP and the underdrain and orifice detail on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

To use this BMP as a combined pollutant control and flow control BMP, determine the size using the sizing factors, then refer to Appendix B.5 and Appendix F to check whether the BMP meets performance standards for biofiltration for pollutant control. If necessary, adjust the surface area, depth of growing medium, or depth of storage layer as needed to meet pollutant control standards.

Table G.2-6: Sizing Factors for Hydromodification Flow Control Biofiltration BMPs (formerly known as Flow-Through Planters) Designed Using Sizing Factor Method

Sizing Factors for Hydromodification Flow Control Biofiltration with Impermeable Liner BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.5Q ₂	C	Flat	Lindbergh	0.115	0.0958	0.0690
0.5Q ₂	C	Moderate	Lindbergh	0.115	0.0958	0.0690
0.5Q ₂	C	Steep	Lindbergh	0.080	0.0667	0.0480
0.5Q ₂	D	Flat	Lindbergh	0.085	0.0708	0.0510
0.5Q ₂	D	Moderate	Lindbergh	0.085	0.0708	0.0510
0.5Q ₂	D	Steep	Lindbergh	0.065	0.0542	0.0390
0.5Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	A	Steep	Oceanside	N/A	N/A	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Impermeable Liner BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.5Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.5Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.5Q ₂	C	Flat	Oceanside	0.075	0.0625	0.0450
0.5Q ₂	C	Moderate	Oceanside	0.075	0.0625	0.0450
0.5Q ₂	C	Steep	Oceanside	0.065	0.0542	0.0390
0.5Q ₂	D	Flat	Oceanside	0.070	0.0583	0.0420
0.5Q ₂	D	Moderate	Oceanside	0.070	0.0583	0.0420
0.5Q ₂	D	Steep	Oceanside	0.050	0.0417	0.0300
0.5Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.5Q ₂	C	Flat	L Wohlford	0.070	0.0583	0.0420
0.5Q ₂	C	Moderate	L Wohlford	0.070	0.0583	0.0420
0.5Q ₂	C	Steep	L Wohlford	0.050	0.0417	0.0300
0.5Q ₂	D	Flat	L Wohlford	0.055	0.0458	0.0330
0.5Q ₂	D	Moderate	L Wohlford	0.055	0.0458	0.0330
0.5Q ₂	D	Steep	L Wohlford	0.045	0.0375	0.0270
0.3Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.3Q ₂	C	Flat	Lindbergh	0.130	0.1083	0.0780
0.3Q ₂	C	Moderate	Lindbergh	0.130	0.1083	0.0780
0.3Q ₂	C	Steep	Lindbergh	0.100	0.0833	0.0600
0.3Q ₂	D	Flat	Lindbergh	0.105	0.0875	0.0630
0.3Q ₂	D	Moderate	Lindbergh	0.105	0.0875	0.0630
0.3Q ₂	D	Steep	Lindbergh	0.075	0.0625	0.0450

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Impermeable Liner BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	A	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.3Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.3Q ₂	C	Flat	Oceanside	0.105	0.0875	0.0630
0.3Q ₂	C	Moderate	Oceanside	0.105	0.0875	0.0630
0.3Q ₂	C	Steep	Oceanside	0.085	0.0708	0.0510
0.3Q ₂	D	Flat	Oceanside	0.090	0.0750	0.0540
0.3Q ₂	D	Moderate	Oceanside	0.090	0.0750	0.0540
0.3Q ₂	D	Steep	Oceanside	0.070	0.0583	0.0420
0.3Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.3Q ₂	C	Flat	L Wohlford	0.085	0.0708	0.0510
0.3Q ₂	C	Moderate	L Wohlford	0.085	0.0708	0.0510
0.3Q ₂	C	Steep	L Wohlford	0.060	0.0500	0.0360
0.3Q ₂	D	Flat	L Wohlford	0.065	0.0542	0.0390
0.3Q ₂	D	Moderate	L Wohlford	0.065	0.0542	0.0390
0.3Q ₂	D	Steep	L Wohlford	0.050	0.0417	0.0300
0.1Q ₂	A	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	A	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	B	Flat	Lindbergh	N/A	N/A	N/A
0.1Q ₂	B	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q ₂	B	Steep	Lindbergh	N/A	N/A	N/A
0.1Q ₂	C	Flat	Lindbergh	0.250	0.2083	0.1500
0.1Q ₂	C	Moderate	Lindbergh	0.250	0.2083	0.1500
0.1Q ₂	C	Steep	Lindbergh	0.185	0.1542	0.1110

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Biofiltration with Impermeable Liner BMPs Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.1Q ₂	D	Flat	Lindbergh	0.200	0.1667	0.1200
0.1Q ₂	D	Moderate	Lindbergh	0.200	0.1667	0.1200
0.1Q ₂	D	Steep	Lindbergh	0.130	0.1083	0.0780
0.1Q ₂	A	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	A	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Flat	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Moderate	Oceanside	N/A	N/A	N/A
0.1Q ₂	B	Steep	Oceanside	N/A	N/A	N/A
0.1Q ₂	C	Flat	Oceanside	0.190	0.1583	0.1140
0.1Q ₂	C	Moderate	Oceanside	0.190	0.1583	0.1140
0.1Q ₂	C	Steep	Oceanside	0.140	0.1167	0.0840
0.1Q ₂	D	Flat	Oceanside	0.160	0.1333	0.0960
0.1Q ₂	D	Moderate	Oceanside	0.160	0.1333	0.0960
0.1Q ₂	D	Steep	Oceanside	0.105	0.0875	0.0630
0.1Q ₂	A	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	A	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Flat	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q ₂	B	Steep	L Wohlford	N/A	N/A	N/A
0.1Q ₂	C	Flat	L Wohlford	0.135	0.1125	0.0810
0.1Q ₂	C	Moderate	L Wohlford	0.135	0.1125	0.0810
0.1Q ₂	C	Steep	L Wohlford	0.105	0.0875	0.0630
0.1Q ₂	D	Flat	L Wohlford	0.110	0.0917	0.0660
0.1Q ₂	D	Moderate	L Wohlford	0.110	0.0917	0.0660
0.1Q ₂	D	Steep	L Wohlford	0.080	0.0667	0.0480

Q₂ = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Surface area sizing factor for flow control

V₁ = Surface volume sizing factor for flow control

V₂ = Subsurface volume sizing factor for flow control

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Definitions for "N/A"

- Soil groups A and B: N/A in all elements (A, V1, V2) for soil groups A and B means sizing factors were not developed for biofiltration (i.e., with an underdrain) for soil groups A and B. If no underdrain is proposed, refer to Appendix G.2.3, Sizing Factors for Bioretention. If an underdrain is proposed, use project-specific continuous simulation modeling.

G.2.6 Sizing Factors for "Cistern" BMP

Table G.2-7 presents sizing factors for calculating the required volume (V_1) for a cistern BMP. In this context, a "cistern" is a detention facility that stores runoff and releases it at a controlled rate. A cistern can be a component of a harvest and use system, however the sizing factor method will not account for any retention occurring in the system. The sizing factors were developed assuming runoff is released from the cistern. The sizing factors presented in this section are to meet the hydromodification management performance standard only. The cistern BMP is based on the following assumptions:

- Cistern configuration: The cistern is modeled as a 4-foot tall vessel. However, designers could use other configurations (different cistern heights), as long as the lower outlet orifice is sized to properly restrict outflows and the minimum required volume is provided.
- Cistern upper outlet: The upper outlet from the cistern would consist of a weir or other flow control structure with the overflow invert set at an elevation of $7/8$ of the water height associated with the required volume of the cistern – V_1 . For the assumed 4-foot water depth in the cistern associated with the sizing factor analysis, the overflow invert is assumed to be located at an elevation of 3.5 feet above the bottom of the cistern. The overflow weir would be sized to pass the peak design flow based on the tributary drainage area.

How to use the sizing factors:

Obtain sizing factors from Table G.2-7 based on the project's lower flow threshold fraction of Q_2 , hydrologic soil group, pre-development slope, and rain gauge (rainfall basin). Multiply the area tributary to the structural BMP (A , square feet) by the area weighted runoff factor (C , unitless) (see Table G.2-1) by the sizing factors to determine the required volume (V_1 , cubic feet). Select a low flow orifice that will discharge the lower flow threshold flow when there is 4 feet of head over the lower outlet orifice (or adjusted head as appropriate if the cistern configuration is not 4 feet tall). The civil engineer shall provide the necessary volume of the BMP and the lower outlet orifice detail on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

A cistern could be a component of a full retention, partial retention, or no retention BMP depending on how the outflow is disposed. However use of the sizing factor method for design of the cistern in a combined pollutant control and flow control system is not recommended. The sizing factor method for designing a cistern does not account for any retention or storage occurring in BMPs combined with the cistern (i.e., cistern sized using sizing factors may be larger than necessary because sizing factor method does not recognize volume losses occurring in other elements of a combined system). Furthermore when the cistern is designed using the sizing factor method, the cistern outflow must be set to the low flow threshold flow for the drainage area, which may be inconsistent with requirements for other elements of a combined system. To optimize a system in which a cistern provides temporary

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

storage for runoff to be either used onsite (harvest and use), infiltrated, or biofiltered, project-specific continuous simulation modeling is recommended. Refer to Sections 5.6 and 6.3.6.

Table G.2-7: Sizing Factors for Hydromodification Flow Control Cistern Facilities Designed Using Sizing Factor Method

Sizing Factors for Hydromodification Flow Control Cistern Facilities Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	A	Flat	Lindbergh	N/A	0.1200	N/A
0.5Q ₂	A	Moderate	Lindbergh	N/A	0.1000	N/A
0.5Q ₂	A	Steep	Lindbergh	N/A	0.1000	N/A
0.5Q ₂	B	Flat	Lindbergh	N/A	0.3900	N/A
0.5Q ₂	B	Moderate	Lindbergh	N/A	0.2000	N/A
0.5Q ₂	B	Steep	Lindbergh	N/A	0.1200	N/A
0.5Q ₂	C	Flat	Lindbergh	N/A	0.1200	N/A
0.5Q ₂	C	Moderate	Lindbergh	N/A	0.1200	N/A
0.5Q ₂	C	Steep	Lindbergh	N/A	0.1000	N/A
0.5Q ₂	D	Flat	Lindbergh	N/A	0.1000	N/A
0.5Q ₂	D	Moderate	Lindbergh	N/A	0.1000	N/A
0.5Q ₂	D	Steep	Lindbergh	N/A	0.0800	N/A
0.5Q ₂	A	Flat	Oceanside	N/A	0.1600	N/A
0.5Q ₂	A	Moderate	Oceanside	N/A	0.1400	N/A
0.5Q ₂	A	Steep	Oceanside	N/A	0.1200	N/A
0.5Q ₂	B	Flat	Oceanside	N/A	0.1900	N/A
0.5Q ₂	B	Moderate	Oceanside	N/A	0.1600	N/A
0.5Q ₂	B	Steep	Oceanside	N/A	0.1400	N/A
0.5Q ₂	C	Flat	Oceanside	N/A	0.1400	N/A
0.5Q ₂	C	Moderate	Oceanside	N/A	0.1400	N/A
0.5Q ₂	C	Steep	Oceanside	N/A	0.1200	N/A
0.5Q ₂	D	Flat	Oceanside	N/A	0.1200	N/A
0.5Q ₂	D	Moderate	Oceanside	N/A	0.1200	N/A
0.5Q ₂	D	Steep	Oceanside	N/A	0.1000	N/A
0.5Q ₂	A	Flat	L Wohlford	N/A	0.1800	N/A
0.5Q ₂	A	Moderate	L Wohlford	N/A	0.1400	N/A
0.5Q ₂	A	Steep	L Wohlford	N/A	0.0800	N/A
0.5Q ₂	B	Flat	L Wohlford	N/A	0.2100	N/A
0.5Q ₂	B	Moderate	L Wohlford	N/A	0.2000	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Cistern Facilities Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.5Q ₂	B	Steep	L Wohlford	N/A	0.1400	N/A
0.5Q ₂	C	Flat	L Wohlford	N/A	0.1400	N/A
0.5Q ₂	C	Moderate	L Wohlford	N/A	0.1400	N/A
0.5Q ₂	C	Steep	L Wohlford	N/A	0.1000	N/A
0.5Q ₂	D	Flat	L Wohlford	N/A	0.1000	N/A
0.5Q ₂	D	Moderate	L Wohlford	N/A	0.1000	N/A
0.5Q ₂	D	Steep	L Wohlford	N/A	0.0800	N/A
0.3Q ₂	A	Flat	Lindbergh	N/A	0.1200	N/A
0.3Q ₂	A	Moderate	Lindbergh	N/A	0.1000	N/A
0.3Q ₂	A	Steep	Lindbergh	N/A	0.1000	N/A
0.3Q ₂	B	Flat	Lindbergh	N/A	0.5900	N/A
0.3Q ₂	B	Moderate	Lindbergh	N/A	0.3600	N/A
0.3Q ₂	B	Steep	Lindbergh	N/A	0.1800	N/A
0.3Q ₂	C	Flat	Lindbergh	N/A	0.1800	N/A
0.3Q ₂	C	Moderate	Lindbergh	N/A	0.1800	N/A
0.3Q ₂	C	Steep	Lindbergh	N/A	0.1400	N/A
0.3Q ₂	D	Flat	Lindbergh	N/A	0.1400	N/A
0.3Q ₂	D	Moderate	Lindbergh	N/A	0.1400	N/A
0.3Q ₂	D	Steep	Lindbergh	N/A	0.0800	N/A
0.3Q ₂	A	Flat	Oceanside	N/A	0.1600	N/A
0.3Q ₂	A	Moderate	Oceanside	N/A	0.1400	N/A
0.3Q ₂	A	Steep	Oceanside	N/A	0.1200	N/A
0.3Q ₂	B	Flat	Oceanside	N/A	0.2200	N/A
0.3Q ₂	B	Moderate	Oceanside	N/A	0.1800	N/A
0.3Q ₂	B	Steep	Oceanside	N/A	0.1600	N/A
0.3Q ₂	C	Flat	Oceanside	N/A	0.1600	N/A
0.3Q ₂	C	Moderate	Oceanside	N/A	0.1600	N/A
0.3Q ₂	C	Steep	Oceanside	N/A	0.1400	N/A
0.3Q ₂	D	Flat	Oceanside	N/A	0.1400	N/A
0.3Q ₂	D	Moderate	Oceanside	N/A	0.1400	N/A
0.3Q ₂	D	Steep	Oceanside	N/A	0.1200	N/A
0.3Q ₂	A	Flat	L Wohlford	N/A	0.1800	N/A
0.3Q ₂	A	Moderate	L Wohlford	N/A	0.1400	N/A
0.3Q ₂	A	Steep	L Wohlford	N/A	0.0800	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Cistern Facilities Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.3Q ₂	B	Flat	L Wohlford	N/A	0.2600	N/A
0.3Q ₂	B	Moderate	L Wohlford	N/A	0.2400	N/A
0.3Q ₂	B	Steep	L Wohlford	N/A	0.1800	N/A
0.3Q ₂	C	Flat	L Wohlford	N/A	0.1800	N/A
0.3Q ₂	C	Moderate	L Wohlford	N/A	0.1800	N/A
0.3Q ₂	C	Steep	L Wohlford	N/A	0.1400	N/A
0.3Q ₂	D	Flat	L Wohlford	N/A	0.1400	N/A
0.3Q ₂	D	Moderate	L Wohlford	N/A	0.1400	N/A
0.3Q ₂	D	Steep	L Wohlford	N/A	0.1000	N/A
0.1Q ₂	A	Flat	Lindbergh	N/A	0.1200	N/A
0.1Q ₂	A	Moderate	Lindbergh	N/A	0.1000	N/A
0.1Q ₂	A	Steep	Lindbergh	N/A	0.1000	N/A
0.1Q ₂	B	Flat	Lindbergh	N/A	0.5400	N/A
0.1Q ₂	B	Moderate	Lindbergh	N/A	0.7800	N/A
0.1Q ₂	B	Steep	Lindbergh	N/A	0.3400	N/A
0.1Q ₂	C	Flat	Lindbergh	N/A	0.3600	N/A
0.1Q ₂	C	Moderate	Lindbergh	N/A	0.3600	N/A
0.1Q ₂	C	Steep	Lindbergh	N/A	0.2400	N/A
0.1Q ₂	D	Flat	Lindbergh	N/A	0.2600	N/A
0.1Q ₂	D	Moderate	Lindbergh	N/A	0.2600	N/A
0.1Q ₂	D	Steep	Lindbergh	N/A	0.1600	N/A
0.1Q ₂	A	Flat	Oceanside	N/A	0.1600	N/A
0.1Q ₂	A	Moderate	Oceanside	N/A	0.1400	N/A
0.1Q ₂	A	Steep	Oceanside	N/A	0.1200	N/A
0.1Q ₂	B	Flat	Oceanside	N/A	0.5100	N/A
0.1Q ₂	B	Moderate	Oceanside	N/A	0.3400	N/A
0.1Q ₂	B	Steep	Oceanside	N/A	0.2400	N/A
0.1Q ₂	C	Flat	Oceanside	N/A	0.2600	N/A
0.1Q ₂	C	Moderate	Oceanside	N/A	0.2600	N/A
0.1Q ₂	C	Steep	Oceanside	N/A	0.2000	N/A
0.1Q ₂	D	Flat	Oceanside	N/A	0.2000	N/A
0.1Q ₂	D	Moderate	Oceanside	N/A	0.2000	N/A
0.1Q ₂	D	Steep	Oceanside	N/A	0.1800	N/A
0.1Q ₂	A	Flat	L Wohlford	N/A	0.1800	N/A

Appendix G: Guidance for Continuous Simulation and Hydromodification Management Sizing Factors

Sizing Factors for Hydromodification Flow Control Cistern Facilities Designed Using Sizing Factor Method						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V ₁	V ₂
0.1Q ₂	A	Moderate	L Wohlford	N/A	0.1400	N/A
0.1Q ₂	A	Steep	L Wohlford	N/A	0.0800	N/A
0.1Q ₂	B	Flat	L Wohlford	N/A	0.4400	N/A
0.1Q ₂	B	Moderate	L Wohlford	N/A	0.4000	N/A
0.1Q ₂	B	Steep	L Wohlford	N/A	0.3200	N/A
0.1Q ₂	C	Flat	L Wohlford	N/A	0.3200	N/A
0.1Q ₂	C	Moderate	L Wohlford	N/A	0.3200	N/A
0.1Q ₂	C	Steep	L Wohlford	N/A	0.2200	N/A
0.1Q ₂	D	Flat	L Wohlford	N/A	0.2400	N/A
0.1Q ₂	D	Moderate	L Wohlford	N/A	0.2400	N/A
0.1Q ₂	D	Steep	L Wohlford	N/A	0.1800	N/A

Q₂ = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Bioretention surface area sizing factor (not applicable under this manual standards – use methods presented in Chapter 5 and Appendix B or Appendix F to size bioretention or biofiltration facility for pollutant control)

V₁ = Cistern volume sizing factor

Definitions for "N/A"

- Column V2: N/A in column V2 means there is no V2 element in the cistern BMP
- Column A: N/A in column A means there is no A element in the cistern BMP. Note sizing factors previously created for sizing a bioretention or biofiltration facility downstream of a cistern under the 2007 MS4 Permit are not applicable under the MS4 Permit.



B M P D E S I G N M A N U A L

**Guidance for Investigating
Potential Critical Coarse Sediment
Yield Areas**

Appendix H Guidance for Investigating Potential Critical Coarse Sediment Yield Areas

Introduction

Identification of potential critical coarse sediment yield areas for San Diego County has been prepared based on GLU analysis. Criteria for the GLU analysis were developed and documented in the "San Diego County Regional WMAA" (herein "Regional WMAA"). Regional-level mapping of potential critical coarse sediment yield areas was prepared using regional data sets and included in the Regional WMAA. The original Regional WMAA document can be found on the Project Clean Water website at the following address:

http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=75&Itemid=99

The regional-level mapping was distributed to WQIP preparers to incorporate into the WMAA attachment to the WQIP for all watersheds in San Diego County. The regional-level mapping is based on the following sources:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3 rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Areal Mapping Project, Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale

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The regional data set is a function of the inherent data resolution of the macro-level data sets and may not conform to all site conditions, or does not reflect changes to particular areas that have occurred since the underlying data was developed. This means slopes, geology, or land cover at the project site can be mischaracterized in the regional data set. This Appendix presents criteria for the GLU analysis, excerpted from the Regional WMAA, to be used when detailed project-level investigation of GLUs onsite is needed.

A project applicant should first check the map included in the WMAA for the watershed in which the project resides to determine if potential critical coarse sediment yield areas may exist within the project drainage boundaries (i.e., within or draining through the project). Generally, if the WMAA map does not indicate potential critical coarse sediment yield areas may exist within the project drainage boundaries, no further analysis is necessary. However, the Port has the discretion to require additional project-level investigation even when the WMAA map does not indicate the presence of potential critical coarse sediment yield areas within the project site.

If the project is shown to impact potential critical coarse sediment yield areas based on the WMAA map, or if the Port requires, project-level GLU analysis can be performed (see Section 6.2.1). Project-level GLU analysis will either confirm or invalidate the finding of the Regional WMAA maps. For project-level GLU analysis, the civil engineer shall determine slopes, geology, and land cover categories existing at the project site, and intersect this data to determine GLUs existing at the project site. The data provided in H.1 will assist the civil engineer to characterize the site.

When it has been determined based on the GLU analysis that potential critical coarse sediment yield areas are present within the project boundary, and it has been determined that downstream systems require protection (see Section 6.2.2), additional analysis may be performed that may refine the extents of actual critical coarse sediment yield areas to be protected onsite (see Section 6.2.3). Procedures for additional analysis are provided in H.2.

H.1 Criteria for GLU Analysis

There are four slope categories in the GLU analysis. Category numbers shown (1 to 4) were assigned for the purpose of GIS processing.

- 0% to 10% (1)
- 10% to 20% (2)
- 20% to 40% (3)
- >40% (4)

There are seven geology categories in the GLU analysis:

- Coarse bedrock (CB)
- Coarse sedimentary impermeable (CSI)
- Coarse sedimentary permeable (CSP)
- Fine bedrock (FB)
- Fine sedimentary impermeable (FSI)
- Fine sedimentary permeable (FSP)
- Other (O)

There are six land cover categories in the GLU analysis:

- Agriculture/grass
- Forest
- Developed
- Scrub/shrub
- Other
- Unknown

Project site slopes shall be classified into the categories based on project-level topography. Project site geology may be determined from geologic maps (may be the same as regional-level information) or classified in the field by a qualified geologist. Table H-1.1 provides information to classify geologic map units into each geology category. Project site land cover shall be determined from aerial photography and/or field visit. For reference, Table H-1.2 provides information to classify land cover categories from the SanGIS Ecology-Vegetation data set into land cover categories. The civil engineer shall not rely on the SanGIS Ecology-Vegetation data set to identify actual land cover at the project site (for project-level investigation land cover must be confirmed by aerial photo or field visit). Intersect the geologic categories, land cover categories, and slope categories within the project

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boundary to create GLUs. The GLUs listed in Table H-1.3 (also shown in Table 6-1) are considered to be potential critical coarse sediment yield areas. Note the GLU nomenclature is presented in the following format: Geology – Land Cover – Slope Category (e.g., "CB-Agricultural/Grass-3" for a GLU consisting of coarse bedrock geology, agricultural/grass land cover, and 20% to 40% slope).

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Table H.1-1: Geologic Grouping for Different Map Units

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Jcr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jhc	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jsp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ka	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kdl	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgbf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgh	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm1	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm2	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm3	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm4	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgu	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ki	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kis	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJem	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJld	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB

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Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Kjv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klb	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klh	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Km	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmgs	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpa	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kqbd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kvc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwsr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzq	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzs	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
sch	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kp	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ql	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
QTf	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ec	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
K	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Kccg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kcs	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

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Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Kl	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ku	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tp	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tpm	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tscu	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsd	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdcg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tst	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmv	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoc	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop1	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

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Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvop10	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop13	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop2	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop5	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop6	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qof	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP

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Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qt	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa1-2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa2-6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa5	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa7	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoc	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qc	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qu	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	San Diego 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyc	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
gb	Jennings; CA	Fine	Bedrock	Impermeable	FB
JTRm	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kc	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
KJvs	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kmv	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Ksp	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB

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Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kwmt	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Qv	Jennings; CA	Fine	Bedrock	Impermeable	FB
Tba	San Diego 30' x 60'	Fine	Bedrock	Impermeable	FB
Tda	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tvsr	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgdfg	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Ta	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tcs	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td+Tf	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tm	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tf	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tfr	El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
To	San Diego & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qpe	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Permeable	FSP
Mexico	San Diego 30' x 60'	NA	NA	Permeable	Other
Kuo	San Diego 30' x 60'	NA (Offshore)	NA	Permeable	Other
Teo	San Diego & Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Qmo	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
QTso	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
af	San Diego & Oceanside 30' x 60'	Variable, dependent on source material	Sedimentary		Other

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Table H.1-2: Land Cover Grouping for SanGIS Ecology-Vegetation Data Set

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
2	42100 Native Grassland		Agricultural/Grass
3	42110 Valley Needlegrass Grassland		Agricultural/Grass
4	42120 Valley Sacaton Grassland		Agricultural/Grass
5	42200 Non-Native Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agriculture/Grass
6	42300 Wildflower Field		Agriculture/Grass
7	42400 Foothill/Mountain Perennial Grassland		Agriculture/Grass
8	42470 Transmontane Dropseed Grassland		Agriculture/Grass
9	45000 Meadow and Seep		Agriculture/Grass
10	45100 Montane Meadow		Agriculture/Grass
11	45110 Wet Montane Meadow		Agriculture/Grass
12	45120 Dry Montane Meadows		Agriculture/Grass
13	45300 Alkali Meadows and Seeps		Agriculture/Grass
14	45320 Alkali Seep		Agriculture/Grass
15	45400 Freshwater Seep		Agriculture/Grass
16	46000 Alkali Playa Community		Agriculture/Grass
17	46100 Badlands/Mudhill Forbs		Agriculture/Grass
18	Non-Native Grassland		Agriculture/Grass
19	18000 General Agriculture	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Agriculture/Grass
20	18100 Orchards and Vineyards		Agriculture/Grass
21	18200 Intensive Agriculture		Agriculture/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches		Agriculture/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops		Agriculture/Grass
24	18310 Field/Pasture		Agriculture/Grass
25	18310 Pasture		Agriculture/Grass
26	18320 Row Crops		Agriculture/Grass
27	12000 Urban/Developed		Developed
28	12000 Urban/Developed		Developed
29	81100 Mixed Evergreen Forest	Forest	Forest
30	81300 Oak Forest		Forest
31	81310 Coast Live Oak Forest		Forest
32	81320 Canyon Live Oak Forest		Forest
33	81340 Black Oak Forest		Forest

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Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
34	83140 Torrey Pine Forest		Forest
35	83230 Southern Interior Cypress Forest		Forest
36	84000 Lower Montane Coniferous Forest		Forest
37	84100 Coast Range, Klamath and Peninsular Coniferous Forest		Forest
38	84140 Coulter Pine Forest	Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest		Forest
40	84230 Sierran Mixed Coniferous Forest		Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter		Forest
42	85100 Jeffrey Pine Forest		Forest
43	11100 Eucalyptus Woodland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Forest
44	60000 RIPARIAN AND BOTTOMLAND HABITAT	Riparian and Bottomland Habitat	Forest
45	61000 Riparian Forests		Forest
46	61300 Southern Riparian Forest		Forest
47	61310 Southern Coast Live Oak Riparian Forest		Forest
48	61320 Southern Arroyo Willow Riparian Forest		Forest
49	61330 Southern Cottonwood-willow Riparian Forest		Forest
50	61510 White Alder Riparian Forest		Forest
51	61810 Sonoran Cottonwood-willow Riparian Forest		Forest
52	61820 Mesquite Bosque		Forest
53	62000 Riparian Woodlands		Forest
54	62200 Desert Dry Wash Woodland		Forest
55	62300 Desert Fan Palm Oasis Woodland		Forest
56	62400 Southern Sycamore-alder Riparian Woodland		Forest
57	70000 WOODLAND	Woodland	Forest
58	71000 Cismontane Woodland		Forest

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Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
59	71100 Oak Woodland		Forest
60	71120 Black Oak Woodland		Forest
61	71160 Coast Live Oak Woodland		Forest
62	71161 Open Coast Live Oak Woodland		Forest
63	71162 Dense Coast Live Oak Woodland		Forest
64	71162 Dense Coast Love Oak Woodland		Forest
65	71180 Engelmann Oak Woodland	Woodland	Forest
66	71181 Open Engelmann Oak Woodland		Forest
67	71182 Dense Engelmann Oak Woodland		Forest
68	72300 Peninsular Pinon and Juniper Woodlands		Forest
69	72310 Peninsular Pinon Woodland		Forest
70	72320 Peninsular Juniper Woodland and Scrub		Forest
71	75100 Elephant Tree Woodland		Forest
72	77000 Mixed Oak Woodland		Forest
73	78000 Undifferentiated Open Woodland		Forest
74	79000 Undifferentiated Dense Woodland		Forest
75	Engelmann Oak Woodland		Forest
76	52120 Southern Coastal Salt Marsh	Bog and Marsh	Other
77	52300 Alkali Marsh		Other
78	52310 Cismontane Alkali Marsh		Other
79	52400 Freshwater Marsh		Other
80	52410 Coastal and Valley Freshwater Marsh		Other
81	52420 Transmontane Freshwater Marsh		Other
82	52440 Emergent Wetland		Other
83	44000 Vernal Pool	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Other
84	44320 San Diego Mesa Vernal Pool		Other
85	44322 San Diego Mesa Claypan Vernal Pool (southern mesas)		Other
86	13100 Open Water		Other

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Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
87	13110 Marine	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
88	13111 Subtidal		Other
89	13112 Intertidal		Other
90	13121 Deep Bay		Other
91	13122 Intermediate Bay		Other
92	13123 Shallow Bay		Other
93	13130 Estuarine		Other
94	13131 Subtidal		Other
95	13133 Brackishwater		Other
96	13140 Freshwater		Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
98	13300 Saltpan/Mudflats		Other
99	13400 Beach		Other
100	21230 Southern Foredunes	Dune Community	Scrub/Shrub
101	22100 Active Desert Dunes		Scrub/Shrub
102	22300 Stabilized and Partially- Stabilized Desert Sand Field		Scrub/Shrub
103	24000 Stabilized Alkaline Dunes		Scrub/Shrub
104	29000 ACACIA SCRUB		Scrub/Shrub
105	63000 Riparian Scrubs	Riparian and Bottomland Habitat	Scrub/Shrub
106	63300 Southern Riparian Scrub		Scrub/Shrub
107	63310 Mule Fat Scrub		Scrub/Shrub
108	63310 Mulefat Scrub		Scrub/Shrub
109	63320 Southern Willow Scrub		Scrub/Shrub
110	63321 Arundo donax Dominant/Southern Willow Scrub		Scrub/Shrub
111	63330 Southern Riparian Scrub		Scrub/Shrub
112	63400 Great Valley Scrub		Scrub/Shrub
113	63410 Great Valley Willow Scrub		Scrub/Shrub
114	63800 Colorado Riparian Scrub		Scrub/Shrub
115	63810 Tamarisk Scrub		Scrub/Shrub
116	63820 Arrowweed Scrub		Scrub/Shrub
117	31200 Southern Coastal Bluff Scrub	Scrub and Chaparral	Scrub/Shrub
118	32000 Coastal Scrub		Scrub/Shrub
119	32400 Maritime Succulent Scrub		Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub		Scrub/Shrub

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
121	32510 Coastal form		Scrub/Shrub
122	32520 Inland form (> 1,000 ft. elevation)		Scrub/Shrub
123	32700 Riversidian Sage Scrub		Scrub/Shrub
124	32710 Riversidian Upland Sage Scrub		Scrub/Shrub
125	32720 Alluvial Fan Scrub		Scrub/Shrub
126	33000 Sonoran Desert Scrub		Scrub/Shrub
127	33100 Sonoran Creosote Bush Scrub		Scrub/Shrub
128	33200 Sonoran Desert Mixed Scrub		Scrub/Shrub
129	33210 Sonoran Mixed Woody Scrub		Scrub/Shrub
130	33220 Sonoran Mixed Woody and Succulent Scrub	Scrub and Chaparral	Scrub/Shrub
131	33230 Sonoran Wash Scrub		Scrub/Shrub
132	33300 Colorado Desert Wash Scrub		Scrub/Shrub
133	33600 Encelia Scrub		Scrub/Shrub
134	34000 Mojavean Desert Scrub		Scrub/Shrub
135	34300 Blackbush Scrub		Scrub/Shrub
136	35000 Great Basin Scrub		Scrub/Shrub
137	35200 Sagebrush Scrub		Scrub/Shrub
138	35210 Big Sagebrush Scrub		Scrub/Shrub
139	35210 Sagebrush Scrub		Scrub/Shrub
140	36110 Desert Saltbush Scrub		Scrub/Shrub
141	36120 Desert Sink Scrub		Scrub/Shrub
142	37000 Chaparral		Scrub/Shrub
143	37120 Southern Mixed Chaparral		Scrub/Shrub
144	37120 Southern Mixed Chapparral		Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral		Scrub/Shrub
146	37121 Southern Mixed Chaparral		Scrub/Shrub
147	37122 Mafic Southern Mixed Chaparral		Scrub/Shrub
148	37130 Northern Mixed Chaparral		Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral		Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral		Scrub/Shrub
151	37200 Chamise Chaparral		Scrub/Shrub
152	37210 Granitic Chamise Chaparral		Scrub/Shrub
153	37220 Mafic Chamise Chaparral		Scrub/Shrub
154	37300 Red Shank Chaparral		Scrub/Shrub

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
155	37400 Semi-Desert Chaparral		Scrub/Shrub
156	37500 Montane Chaparral		Scrub/Shrub
157	37510 Mixed Montane Chaparral		Scrub/Shrub
158	37520 Montane Manzanita Chaparral		Scrub/Shrub
159	37530 Montane Ceanothus Chaparral		Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral		Scrub/Shrub
161	37800 Upper Sonoran Ceanothus Chaparral		Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral		Scrub/Shrub
163	37900 Scrub Oak Chaparral		Scrub/Shrub
164	37A00 Interior Live Oak Chaparral		Scrub/Shrub
165	37C30 Southern Maritime Chaparral	Scrub and Chaparral	Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub		Scrub/Shrub
167	37K00 Flat-topped Buckwheat		Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub		Scrub/Shrub
169	Diegan Coastal Sage Scrub		Scrub/Shrub
170	Granitic Northern Mixed Chaparral		Scrub/Shrub
171	Southern Mixed Chaparral		Scrub/Shrub
172	11000 Non-Native Vegetation	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Unknown
173	11000 Non-Native VegetationVegetation		Unknown
174	11200 Disturbed Wetland		Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

Table H.1-3: Potential Critical Coarse Sediment Yield Areas

GLU	Geology	Land Cover	Slope (%)
CB-Agricultural/Grass-3	Coarse Bedrock	Agricultural/Grass	20% - 40%
CB-Agricultural/Grass-4	Coarse Bedrock	Agricultural/Grass	>40%
CB-Forest-2	Coarse Bedrock	Forest	10 – 20%
CB-Forest-3	Coarse Bedrock	Forest	20% - 40%
CB-Forest-4	Coarse Bedrock	Forest	>40%
CB-Scrub/Shrub-4	Coarse Bedrock	Scrub/Shrub	>40%
CB-Unknown-4	Coarse Bedrock	Unknown	>40%
CSI-Agricultural/Grass-2	Coarse Sedimentary Impermeable	Agricultural/Grass	10 – 20%
CSI-Agricultural/Grass-3	Coarse Sedimentary Impermeable	Agricultural/Grass	20% - 40%
CSI-Agricultural/Grass-4	Coarse Sedimentary Impermeable	Agricultural/Grass	>40%
CSP-Agricultural/Grass-4	Coarse Sedimentary Permeable	Agricultural/Grass	>40%
CSP-Forest-3	Coarse Sedimentary Permeable	Forest	20% - 40%
CSP-Forest-4	Coarse Sedimentary Permeable	Forest	>40%
CSP-Scrub/Shrub-4	Coarse Sedimentary Permeable	Scrub/Shrub	>40%

H.2 Optional Additional Analysis When Potential Critical Coarse Sediment Yield Areas are Present Onsite

(Adapted from "Step 1" of Section 2.3.i of "Santa Margarita Region HMP," dated May 2014)

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

As stated in Chapter 6.2.3 of this manual, when it has been determined based on a GLU analysis that potential critical coarse sediment yield areas are present within the project boundary, and it has been determined that downstream systems require protection, additional analysis may be performed that may refine the extents of actual critical coarse sediment yield areas to be protected onsite. The following text, adapted from Chapter 2 of the Santa Margarita Region HMP dated May 2014, describes the process.

Step 1: Determine whether the Portion of the Project Site is a Significant Source of Bed Sediment Supply to the Channel Receiving Runoff

A triad approach will be completed to determine whether the project site is a Significant Source of Bed Sediment Supply to the channel receiving runoff and includes the following components:

- A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the receiving channel and the onsite channel;
- B. Determination of the capability of the channels on the project site to deliver the site Bed Sediment (if present) to the receiving channel; and
- C. Present and potential future condition of the receiving channel.

A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the channel receiving runoff and the onsite channels

A geotechnical and sieve analysis is the first piece of information to be used in a triad approach to determine if the project site is a Significant Source of Bed Sediment Supply to the assessment channel. An investigation must be completed of the assessment channel to complete a sieve analysis of the Bed Sediment. Two samples will be taken of the assessment channel using the “reach” approach (TS13A, 2007 [United States Army Corps of Engineers. 2007. Guidelines for Sampling Bed Material, Technical Supplement 13A, Part 654 of National Engineering Handbook, New England District. August]). Samples in each of the two locations should be taken using the surface and subsurface bulk sample technique (TS13A, 2007) for a total of four samples. Pebble counts may be required for some channels.

A similar sampling assessment should be conducted on the project site. First-order and greater channels that may be impacted by the PDP (drainage area changed, stabilized, lined or replaced with underground conduits) will be analyzed in each subwatershed. First-order channels are identified as the unbranched channels that drain from headwater areas and develop in the uppermost topographic depressions, where two or more contour crenulations (notches or indentations) align and point upslope (National Engineering Handbook, 2007). First-order channels may, in fact, be field ditches, gullies, or ephemeral gullies (National Engineering Handbook, 2007). One channel per subwatershed that may be impacted on the project site must be assessed. A subwatershed is defined as tributary to a single discharge point at the project site boundary.

The sieve analysis should report the coarsest 90% (by weight) of the sediment for comparison between the site and the assessment channel. The User should render an opinion if the Bed Sediment found

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

on the site is of similar gradation to the Bed Sediment found in the receiving channel. The opinion will be based on the following information:

- Sieve analysis results
- Soil erodibility (K) factor
- Topographic relief of the project area
- Lithology of the soils on the project site

The User should rate the similarity of onsite Bed Sediment and Bed Sediment collected in the receiving channel as high, medium, or low.

This site soil assessment serves as the first piece of information for the triad approach.

B. Determination of the capability of the onsite channels to deliver Bed Sediment Supply (if present) to the channel receiving runoff from the project site.

The second piece of information is to qualitatively assess the sediment delivery potential of the channels on the project site to deliver the Bed Sediment Supply to the channel receiving runoff from the project site, or the Bed Sediment delivery potential or ratio. There are few documented procedures to estimate the Bed Sediment delivery ratio (see: Williams, J. R., 1977: Sediment delivery ratios determined with sediment and runoff models. IAHS Publication (122): 168-179, as an example); it is affected by a number of factors, including the sediment source, proximity to the receiving channel, onsite channel density, project sub-watershed area, slope, length, land use and land cover, and rainfall intensity. The User will qualitatively assess the Bed Sediment delivery potential and rate the potential as high, medium, or low.

C. Present and potential future condition of the channel receiving runoff from the project site.

The final piece of information is the present and potential future condition of the channel receiving runoff from the project site. The User should assess the receiving channel for the following:

- Bank stability – Receiving channels with unstable banks may be more sensitive to changes in Bed Sediment Load.
- Degree of incision – Receiving channels with moderate to high incision may be more sensitive to changes in Bed Sediment Load.
- Bed Sediment gradation – Receiving channels with more coarse Bed Sediment (such as gravel) are better able to buffer change in Bed Sediment Load as compared to beds with finer gradation of Bed Sediment (sand).
- Transport vs. supply limited channels. Receiving channels that are transport limited may be better able to buffer changes in Bed Sediment Load as compared to channels that are supply limited.

Appendix H: Guidance for Investigation Potential Critical Coarse Sediment Yield Areas

The User will qualitatively assess the channel receiving runoff from the project site using the gathered observations and rate the potential for adverse response based on a change in Bed Sediment Load as high, medium, or low.

[Interpreting the results of A, B, and C]

The User should use the triad assessment approach, weighting each of the components based on professional judgment to determine if the project site provides a Significant Source of Bed Sediment Supply to the receiving channel, and the impact the PDP would have on the receiving channel. The final assessment and recommendation must be documented in the HMP portion of the [SWQMP].

The recommendation may be any of the following:

- Site is a Significant Source of Bed Sediment Supply – all channels on the project site must be preserved or by-passed within the site plan.
- Site is a source of Bed Sediment Supply – some of the channels on the project site must be preserved (with identified channels noted).
- Site is not a Significant Source of Bed Sediment Supply.

The final recommendation will be guided by the triad assessment. Projects with predominantly “high” values for each of the three assessment areas would indicate preservation of channels on the project site. Sites with predominantly “medium” values may warrant preservation of some of the channels on the project site, and sites with generally “low” values would not require site design considerations for Bed Sediment Load.



B M P D E S I G N M A N U A L

Forms and Checklists

Appendix I Forms and Checklists

- 1) For projects that will start construction prior to the effective date of Order No. R9-2013-0001, project applicants should use the current Port Storm Water Requirements Applicability Checklist. The current checklist for tenant projects is available at:

<https://www.portofsandiego.org/environment/stormwater/stormwater-development.html>

For capital projects, please contact the Port Environmental and Land Use Management Department for a copy of the current applicability checklist.

- 2) For projects that will start construction after the effective date of Order No. R9-2013-0001, projects should use the forms included with Appendix I to document whether the project is a standard or priority development project and to document selection of applicable Source Control and Site Design (Both Standard and PDPs) and Storm Water Pollutant Control BMPs (PDPs only). In addition, Section 2 of the Port Storm Water Requirements Applicability Checklist should be used to determine Construction Phase BMP requirements for the Project.

The Port Storm Water Requirements Applicability Checklist is in the process of being tailored to meet the procedures and requirements of the BMP Design Manual and the forms in Appendix I will be updated / amended once the forms are tailored.

The following Forms/Checklists/Worksheets were developed for use by the project applicant to document the storm water management design:

- I-3A: Site Information Checklist for Standard Projects
- I-3B: Site Information Checklist for PDPs
- I-4: Source Control BMP Checklist for All Development Projects
- I-5: Site Design BMP Checklist for All Development Projects
- I-6: Summary of PDP Structural BMPs
- I-7: Harvest and Use Feasibility Screening Checklist
- I-8: Categorization of Infiltration Feasibility Condition
- I-9: Factor of Safety and Design Infiltration Rate
- I-10: Determination of Downstream Systems Requirements for Preservation of Coarse Sediment Supply
- I-1: Applicability of Permanent, Post-Construction Storm Water BMP Requirements
- I-2: Project Type Determination Checklist (Standard Project or PDP)

Form I-1 and Form I-2 were included in previous versions of this manual, and used to determine stormwater requirements. The stormwater requirements applicability checklist, available online, has replaced forms I-1 and I-2, and takes precedence over aforementioned forms. The applicability checklist can be found on the Port's stormwater management website: <https://www.portofsandiego.org/stormwater-management>

Site Information Checklist For Standard Projects		Form I-3A (Standard Projects)
Project Summary Information		
Project Name		
Project Address		
Assessor's Parcel Number(s)		
Permit Application Number		
Project Watershed (Hydrologic Unit)	Select One: <input type="checkbox"/> Santa Margarita 902 <input type="checkbox"/> San Luis Rey 903 <input type="checkbox"/> Carlsbad 904 <input type="checkbox"/> San Dieguito 905 <input type="checkbox"/> Penasquitos 906 <input type="checkbox"/> San Diego 907 <input type="checkbox"/> Pueblo San Diego 908 <input type="checkbox"/> Sweetwater 909 <input type="checkbox"/> Otay 910 <input type="checkbox"/> Tijuana 911	
Parcel Area (total area of Assessor's Parcel(s) associated with the project)	_____ Acres (_____ Square Feet)	
Area to be disturbed by the project (Project Area)	_____ Acres (_____ Square Feet)	
Project Proposed Impervious Area (subset of Project Area)	_____ Acres (_____ Square Feet)	
Project Proposed Pervious Area (subset of Project Area)	_____ Acres (_____ Square Feet)	
Note: Proposed Impervious Area + Proposed Pervious Area = Area to be Disturbed by the Project. This may be less than the Parcel Area.		

Description of Existing Site Condition and Drainage Patterns

Current Status of the Site (select all that apply)

- ☐ Existing development
- ☐ Previously graded but not built out
- ☐ Agricultural or other non-impervious use
- ☐ Vacant, undeveloped/natural

Description / Additional Information

Existing Land Cover Includes (select all that apply)

- ☐ Vegetative Cover
- ☐ Non-Vegetated Pervious Areas
- ☐ Impervious Areas

Description / Additional Information

Underlying Soil belongs to Hydrologic Soil Group (select all that apply):

- ☐ NRCS Type A
- ☐ NRCS Type B
- ☐ NRCS Type C
- ☐ NRCS Type D

Existing Natural Hydrologic Features (select all that apply)

- ☐ Watercourses
- ☐ Seeps
- ☐ Springs
- ☐ Wetlands
- ☐ None

Description / Additional Information

Description of Existing Site Drainage [How is storm water runoff conveyed from the site? At a minimum, this description should answer (1) whether existing drainage conveyance is natural or urban; (2) describe existing constructed storm water conveyance systems, if applicable; and (3) is runoff from offsite conveyed through the site? If so, describe.]

Description of Proposed Site Development and Drainage Patterns

Project Description / Proposed Land Use and/or Activities

List proposed impervious features of the project (e.g., buildings, roadways, parking lots, courtyards, athletic courts, other impervious features)

List proposed pervious features of the project (e.g., landscape areas)

Does the project include grading and changes to site topography?

☐ Yes

☐ No

Description / Additional Information

Does the project include changes to site drainage (e.g., installation of new storm water conveyance systems)?

☐ Yes

☐ No

Description / Additional Information

Identify whether any of the following features, activities, and/or pollutant source areas will be present (select all that apply)

- ☐ Onsite storm drain inlets
- ☐ Interior floor drains and elevator shaft sump pumps
- ☐ Interior parking garages
- ☐ Need for future indoor & structural pest control
- ☐ Landscape/outdoor pesticide use
- ☐ Pools, spas, ponds, decorative fountains, and other water features
- ☐ Food service
- ☐ Refuse areas
- ☐ Industrial processes
- ☐ Outdoor storage of equipment or materials
- ☐ Vehicle and equipment cleaning
- ☐ Vehicle/equipment repair and maintenance
- ☐ Fuel dispensing areas
- ☐ Loading docks
- ☐ Fire sprinkler test water
- ☐ Miscellaneous drain or wash water
- ☐ Plazas, sidewalks, and parking lots

Site Information Checklist For PDPs		Form I-3B (PDPs)
Project Summary Information		
Project Name		
Project Address		
Assessor's Parcel Number(s)		
Permit Application Number		
Project Watershed (Hydrologic Unit)	Select One: <input type="checkbox"/> Santa Margarita 902 <input type="checkbox"/> San Luis Rey 903 <input type="checkbox"/> Carlsbad 904 <input type="checkbox"/> San Dieguito 905 <input type="checkbox"/> Penasquitos 906 <input type="checkbox"/> San Diego 907 <input type="checkbox"/> Pueblo San Diego 908 <input type="checkbox"/> Sweetwater 909 <input type="checkbox"/> Otay 910 <input type="checkbox"/> Tijuana 911	
Parcel Area (total area of Assessor's Parcel(s) associated with the project)	_____ Acres (_____ Square Feet)	
Area to be disturbed by the project (Project Area)	_____ Acres (_____ Square Feet)	
Project Proposed Impervious Area (subset of Project Area)	_____ Acres (_____ Square Feet)	
Project Proposed Pervious Area (subset of Project Area)	_____ Acres (_____ Square Feet)	
Note: Proposed Impervious Area + Proposed Pervious Area = Area to be Disturbed by the Project. This may be less than the Parcel Area.		

Description of Existing Site Condition and Drainage Patterns

Current Status of the Site (select all that apply):

- ☐ Existing development
- ☐ Previously graded but not built out
- ☐ Agricultural or other non-impervious use
- ☐ Vacant, undeveloped/natural

Description / Additional Information:

Existing Land Cover Includes (select all that apply):

- ☐ Vegetative Cover
- ☐ Non-Vegetated Pervious Areas
- ☐ Impervious Areas

Description / Additional Information:

Underlying Soil belongs to Hydrologic Soil Group (select all that apply):

- ☐ NRCS Type A
- ☐ NRCS Type B
- ☐ NRCS Type C
- ☐ NRCS Type D

Approximate Depth to Groundwater:

- ☐ Groundwater Depth < 5 feet
- ☐ 5 feet < Groundwater Depth < 10 feet
- ☐ 10 feet < Groundwater Depth < 20 feet
- ☐ Groundwater Depth > 20 feet

Existing Natural Hydrologic Features (select all that apply):

- ☐ Watercourses
- ☐ Seeps
- ☐ Springs
- ☐ Wetlands
- ☐ None

Description / Additional Information:

Description of Existing Site Topography and Drainage [How is storm water runoff conveyed from the site? At a minimum, this description should answer (1) whether existing drainage conveyance is natural or urban; (2) describe existing constructed storm water conveyance systems, if applicable; and (3) is runoff from offsite conveyed through the site? If so, describe]:

Description of Proposed Site Development and Drainage Patterns

Project Description / Proposed Land Use and/or Activities:

List/describe proposed impervious features of the project (e.g., buildings, roadways, parking lots, courtyards, athletic courts, other impervious features):

List/describe proposed pervious features of the project (e.g., landscape areas):

Does the project include grading and changes to site topography?

☐ Yes

☐ No

Description / Additional Information:

Does the project include changes to site drainage (e.g., installation of new storm water conveyance systems)?

☐ Yes

☐ No

Description / Additional Information:

Identify whether any of the following features, activities, and/or pollutant source areas will be present (select all that apply):

- ☐ Onsite storm drain inlets
- ☐ Interior floor drains and elevator shaft sump pumps
- ☐ Interior parking garages
- ☐ Need for future indoor & structural pest control
- ☐ Landscape/outdoor pesticide use
- ☐ Pools, spas, ponds, decorative fountains, and other water features
- ☐ Food service
- ☐ Refuse areas
- ☐ Industrial processes
- ☐ Outdoor storage of equipment or materials
- ☐ Vehicle and equipment cleaning
- ☐ Vehicle/equipment repair and maintenance
- ☐ Fuel dispensing areas
- ☐ Loading docks
- ☐ Fire sprinkler test water
- ☐ Miscellaneous drain or wash water
- ☐ Plazas, sidewalks, and parking lots

Identification of Receiving Water Pollutants of Concern

Describe path of storm water from the project site to the Pacific Ocean (or bay, lagoon, lake or reservoir, as applicable):

List any 303(d) impaired water bodies within the path of storm water from the project site to the Pacific Ocean (or bay, lagoon, lake or reservoir, as applicable), identify the pollutant(s)/stressor(s) causing impairment, and identify any TMDLs for the impaired water bodies:

303(d) Impaired Water Body	Pollutant(s)/Stressor(s)	TMDLs

Identification of Project Site Pollutants*

***Identification of project site pollutants is only required if flow-thru treatment BMPs are implemented onsite in lieu of retention or biofiltration BMPs (note the project must also participate in an alternative compliance program unless prior lawful approval to meet earlier PDP requirements is demonstrated)**

Identify pollutants anticipated from the project site based on all proposed use(s) of the site (see manual Appendix B.6):

Pollutant	Not Applicable to the Project Site	Anticipated from the Project Site	Also a Receiving Water Pollutant of Concern
Sediment			
Nutrients			
Heavy Metals			
Organic Compounds			
Trash & Debris			
Oxygen Demanding Substances			
Oil & Grease			
Bacteria & Viruses			
Pesticides			

Hydromodification Management Requirements

Do hydromodification management requirements apply (see Section 1.6 of the manual)?

- ☐ Yes, hydromodification management flow control structural BMPs required.
- ☐ No, the project will discharge runoff directly to existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.
- ☐ No, the project will discharge runoff directly to conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.
- ☐ No, the project will discharge runoff directly to an area identified as appropriate for an exemption by the WMAA for the watershed in which the project resides.

Description / Additional Information (to be provided if a 'No' answer has been selected above):

Critical Coarse Sediment Yield Areas*

***This Section only required if hydromodification management requirements apply**

Based on the maps provided within the WMAA, do potential critical coarse sediment yield areas exist within the project drainage boundaries?

- ☐ Yes
- ☐ No, no critical coarse sediment yield areas to be protected based on WMAA maps

If yes, have any of the optional analyses presented in Section 6.2 of the manual been performed?

- ☐ 6.2.1 Verification of GLUs Onsite
- ☐ 6.2.2 Downstream Systems Sensitivity to Coarse Sediment
- ☐ 6.2.3 Optional Additional Analysis of Potential Critical Coarse Sediment Yield Areas Onsite
- ☐ No optional analyses performed, the project will avoid critical coarse sediment yield areas identified based on WMAA maps

If optional analyses were performed, what is the final result?

- ☐ No critical coarse sediment yield areas to be protected based on verification of GLUs onsite.
- ☐ Critical coarse sediment yield areas exist but additional analysis has determined that protection is not required. Documentation attached in Attachment 8 of the SWQMP.
- ☐ Critical coarse sediment yield areas exist and require protection. The project will implement management measures described in Sections 6.2.4 and 6.2.5 as applicable, and the areas are identified on the SWQMP Exhibit.

Discussion / Additional Information:

Flow Control for Post-Project Runoff****This Section only required if hydromodification management requirements apply**

List and describe point(s) of compliance (POCs) for flow control for hydromodification management (see Section 6.3.1). For each POC, provide a POC identification name or number correlating to the project's HMP Exhibit and a receiving channel identification name or number correlating to the project's HMP Exhibit.

Has a geomorphic assessment been performed for the receiving channel(s)?

- ☐ No, the low flow threshold is 0.1Q2 (default low flow threshold)
- ☐ Yes, the result is the low flow threshold is 0.1Q2
- ☐ Yes, the result is the low flow threshold is 0.3Q2
- ☐ Yes, the result is the low flow threshold is 0.5Q2

If a geomorphic assessment has been performed, provide title, date, and preparer:

Discussion / Additional Information: (optional)

Other Site Requirements and Constraints

When applicable, list other site requirements or constraints that will influence storm water management design, such as zoning requirements including setbacks and open space, or local codes governing minimum street width, sidewalk construction, allowable pavement types, and drainage requirements.

Optional Additional Information or Continuation of Previous Sections As Needed

This space provided for additional information or continuation of information from previous sections as needed.

Source Control BMP Checklist for All Development Projects (Standard Projects and PDPs)		Form I-4	
Project Identification			
Project Name			
Permit Application Number			
Source Control BMPs			
All development projects must implement source control BMPs SC-1 through SC-6 where applicable and feasible. See Chapter 4 and Appendix E of the manual for information to implement source control BMPs shown in this checklist.			
Answer each category below pursuant to the following.			
<ul style="list-style-type: none"> • "Yes" means the project will implement the source control BMP as described in Chapter 4 and/or Appendix E of the manual. Discussion / justification is not required. • "No" means the BMP is applicable to the project but it is not feasible to implement. Discussion / justification must be provided. • "N/A" means the BMP is not applicable at the project site because the project does not include the feature that is addressed by the BMP (e.g., the project has no outdoor materials storage areas). Discussion / justification may be provided. 			
Source Control Requirement		Applied?	
SC-1 Prevention of Illicit Discharges into the MS4		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SC-1 not implemented:			
SC-2 Storm Drain Stenciling or Signage		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SC-2 not implemented:			
SC-3 Protect Outdoor Materials Storage Areas from Rainfall, Run-On, Runoff, and Wind Dispersal		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SC-3 not implemented:			
SC-4 Protect Materials Stored in Outdoor Work Areas from Rainfall, Run-On, Runoff, and Wind Dispersal		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SC-4 not implemented:			

Form I-4 Page 2 of 2			
Source Control Requirement	Applied?		
SC-5 Protect Trash Storage Areas from Rainfall, Run-On, Runoff, and Wind Dispersal	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> N/A
Discussion / justification if SC-5 not implemented:			
SC-6 Additional BMPs Based on Potential Sources of Runoff Pollutants (must answer for each source listed below) <ul style="list-style-type: none"> <input type="checkbox"/> Onsite storm drain inlets <input type="checkbox"/> Interior floor drains and elevator shaft sump pumps <input type="checkbox"/> Interior parking garages <input type="checkbox"/> Need for future indoor & structural pest control <input type="checkbox"/> Landscape/outdoor pesticide use <input type="checkbox"/> Pools, spas, ponds, decorative fountains, and other water features <input type="checkbox"/> Food service <input type="checkbox"/> Refuse areas <input type="checkbox"/> Industrial processes <input type="checkbox"/> Outdoor storage of equipment or materials <input type="checkbox"/> Vehicle and equipment cleaning <input type="checkbox"/> Vehicle/equipment repair and maintenance <input type="checkbox"/> Fuel dispensing areas <input type="checkbox"/> Loading docks <input type="checkbox"/> Fire sprinkler test water <input type="checkbox"/> Miscellaneous drain or wash water <input type="checkbox"/> Plazas, sidewalks, and parking lots 	<input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No <input type="checkbox"/> No	<input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A <input type="checkbox"/> N/A
Discussion / justification if SC-6 not implemented. Clearly identify which sources of runoff pollutants are discussed. Justification must be provided for <u>all</u> "No" answers shown above.			

Site Design BMP Checklist for All Development Projects (Standard Projects and PDPs)		Form I-5	
Project Identification			
Project Name			
Permit Application Number			
Site Design BMPs			
All development projects must implement site design BMPs SD-1 through SD-8 where applicable and feasible. See Chapter 4 and Appendix E of the manual for information to implement site design BMPs shown in this checklist.			
Answer each category below pursuant to the following.			
<ul style="list-style-type: none"> • "Yes" means the project will implement the site design BMP as described in Chapter 4 and/or Appendix E of the manual. Discussion / justification is not required. • "No" means the BMP is applicable to the project but it is not feasible to implement. Discussion / justification must be provided. • "N/A" means the BMP is not applicable at the project site because the project does not include the feature that is addressed by the BMP (e.g., the project site has no existing natural areas to conserve). Discussion / justification may be provided. 			
Site Design Requirement		Applied?	
SD-1 Maintain Natural Drainage Pathways and Hydrologic Features		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SD-1 not implemented:			
SD-2 Conserve Natural Areas, Soils, and Vegetation		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SD-2 not implemented:			
SD-3 Minimize Impervious Area		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SD-3 not implemented:			
SD-4 Minimize Soil Compaction		<input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> N/A
Discussion / justification if SD-4 not implemented:			

Form I-5 Page 2 of 2			
Site Design Requirement	Applied?		
SD-5 Impervious Area Dispersion	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> N/A
Discussion / justification if SD-5 not implemented:			
SD-6 Runoff Collection	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> N/A
Discussion / justification if SD-6 not implemented:			
SD-7 Landscaping with Native or Drought Tolerant Species	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> N/A
Discussion / justification if SD-7 not implemented:			
SD-8 Harvesting and Using Precipitation	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> N/A
Discussion / justification if SD-8 not implemented:			

Summary of PDP Structural BMPs	Form I-6 (PDPs)
Project Identification	
Project Name	
Permit Application Number	
PDP Structural BMPs	
<p>All PDPs must implement structural BMPs for storm water pollutant control (see Chapter 5 of the manual). Selection of PDP structural BMPs for storm water pollutant control must be based on the selection process described in Chapter 5. PDPs subject to hydromodification management requirements must also implement structural BMPs for flow control for hydromodification management (see Chapter 6 of the manual). Both storm water pollutant control and flow control for hydromodification management can be achieved within the same structural BMP(s).</p> <p>PDP structural BMPs must be verified by the local jurisdiction at the completion of construction. This may include requiring the project owner or project owner's representative to certify construction of the structural BMPs (see Section 1.12 of the manual). PDP structural BMPs must be maintained into perpetuity, and the local jurisdiction must confirm the maintenance (see Section 7 of the manual).</p> <p>Use this form to provide narrative description of the general strategy for structural BMP implementation at the project site in the box below. Then complete the PDP structural BMP summary information sheet (page 3 of this form) for each structural BMP within the project (copy the BMP summary information page as many times as needed to provide summary information for each individual structural BMP).</p> <p>Describe the general strategy for structural BMP implementation at the site. This information must describe how the steps for selecting and designing storm water pollutant control BMPs presented in Section 5.1 of the manual were followed, and the results (type of BMPs selected). For projects requiring hydromodification flow control BMPs, indicate whether pollutant control and flow control BMPs are integrated or separate.</p> <p>(Continue on page 2 as necessary.)</p>	

**(Page reserved for continuation of description of general strategy for structural BMP
implementation at the site)**

(Continued from page 1)

Form I-6 Page 3 of X (Copy as many as needed)	
Structural BMP Summary Information (Copy this page as needed to provide information for each individual proposed structural BMP)	
Structural BMP ID No.	
Construction Plan Sheet No.	
Type of structural BMP: <input type="checkbox"/> Retention by harvest and use (HU-1) <input type="checkbox"/> Retention by infiltration basin (INF-1) <input type="checkbox"/> Retention by bioretention (INF-2) <input type="checkbox"/> Retention by permeable pavement (INF-3) <input type="checkbox"/> Partial retention by biofiltration with partial retention (PR-1) <input type="checkbox"/> Biofiltration (BF-1) <input type="checkbox"/> Flow-thru treatment control with prior lawful approval to meet earlier PDP requirements (provide BMP type/description in discussion section below) <input type="checkbox"/> Flow-thru treatment control included as pre-treatment/forebay for an onsite retention or biofiltration BMP (provide BMP type/description and indicate which onsite retention or biofiltration BMP it serves in discussion section below) <input type="checkbox"/> Flow-thru treatment control with alternative compliance (provide BMP type/description in discussion section below) <input type="checkbox"/> Detention pond or vault for hydromodification management <input type="checkbox"/> Other (describe in discussion section below)	
Purpose: <input type="checkbox"/> Pollutant control only <input type="checkbox"/> Hydromodification control only <input type="checkbox"/> Combined pollutant control and hydromodification control <input type="checkbox"/> Pre-treatment/forebay for another structural BMP <input type="checkbox"/> Other (describe in discussion section below)	
Who will certify construction of this BMP? Provide name and contact information for the party responsible to sign BMP verification forms if required by the Port (See Section 1.12 of the manual)	
Who will be the final owner of this BMP?	
Who will maintain this BMP into perpetuity?	
What is the funding mechanism for maintenance?	
Discussion (as needed):	

Harvest and Use Feasibility Checklist		Form I-7
<p>1. Is there a demand for harvested water (check all that apply) at the project site that is reliably present during the wet season?</p> <p><input type="checkbox"/> Toilet and urinal flushing</p> <p><input type="checkbox"/> Landscape irrigation</p> <p><input type="checkbox"/> Other: _____</p>		
<p>2. If there is a demand; estimate the anticipated average wet season demand over a period of 36 hours. Guidance for planning level demand calculations for toilet/urinal flushing and landscape irrigation is provided in Section B.3.2.</p> <p>[Provide a summary of calculations here]</p>		
<p>3. Calculate the DCV using worksheet B-2.1.</p> <p>DCV = _____ (cubic feet)</p>		
<p>3a. Is the 36 hour demand greater than or equal to the DCV?</p> <p><input type="checkbox"/> Yes / <input type="checkbox"/> No ➡</p> <p>⇓</p>	<p>3b. Is the 36 hour demand greater than 0.25DCV but less than the full DCV?</p> <p><input type="checkbox"/> Yes / <input type="checkbox"/> No ➡</p> <p>⇓</p>	<p>3c. Is the 36 hour demand less than 0.25DCV?</p> <p><input type="checkbox"/> Yes</p> <p>⇓</p>
<p>Harvest and use appears to be feasible. Conduct more detailed evaluation and sizing calculations to confirm that DCV can be used at an adequate rate to meet drawdown criteria.</p>	<p>Harvest and use may be feasible. Conduct more detailed evaluation and sizing calculations to determine feasibility. Harvest and use may only be able to be used for a portion of the site, or (optionally) the storage may need to be upsized to meet long term capture targets while draining in longer than 36 hours.</p>	<p>Harvest and use is considered to be infeasible.</p>
<p>Is harvest and use feasible based on further evaluation?</p> <p><input type="checkbox"/> Yes, refer to Appendix E to select and size harvest and use BMPs.</p> <p><input type="checkbox"/> No, select alternate BMPs.</p>		

Form I-8 Page 2 of 4

Criteria	Screening Question	Yes	No
3	Can infiltration greater than 0.5 inches per hour be allowed without increasing risk of groundwater contamination (shallow water table, storm water pollutants or other factors) that cannot be mitigated to an acceptable level? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
4	Can infiltration greater than 0.5 inches per hour be allowed without causing potential water balance issues such as change of seasonality of ephemeral streams or increased discharge of contaminated groundwater to surface waters? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
Provide basis:			
Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
Part 1 Result *	<p>If all answers to rows 1 - 4 are “Yes” a full infiltration design is potentially feasible. The feasibility screening category is Full Infiltration</p> <p>If any answer from row 1-4 is “No”, infiltration may be possible to some extent but would not generally be feasible or desirable to achieve a “full infiltration” design. Proceed to Part 2</p>		

*To be completed using gathered site information and best professional judgment considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by Agency/Jurisdictions to substantiate findings

Form I-8 Page 3 of 4

Part 2 – Partial Infiltration vs. No Infiltration Feasibility Screening Criteria

Would infiltration of water in any appreciable amount be physically feasible without any negative consequences that cannot be reasonably mitigated?

Criteria	Screening Question	Yes	No
5	Do soil and geologic conditions allow for infiltration in any appreciable rate or volume? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.2 and Appendix D.		

<p>Provide basis:</p>
<p>Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.</p>

6	<p>Can Infiltration in any appreciable quantity be allowed without increasing risk of geotechnical hazards (slope stability, groundwater mounding, utilities, or other factors) that cannot be mitigated to an acceptable level? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.2.</p>		
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Provide basis:

Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.

Form I-8 Page 4 of 4

Criteria	Screening Question	Yes	No
7	Can Infiltration in any appreciable quantity be allowed without posing significant risk for groundwater related concerns (shallow water table, storm water pollutants or other factors)? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
<p>Provide basis:</p> <p>Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.</p>			
8	Can infiltration be allowed without violating downstream water rights? The response to this Screening Question shall be based on a comprehensive evaluation of the factors presented in Appendix C.3.		
<p>Provide basis:</p> <p>Summarize findings of studies; provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability and why it was not feasible to mitigate low infiltration rates.</p>			
Part 2 Result*	<p>If all answers from row 5-8 are yes then partial infiltration design is potentially feasible. The feasibility screening category is Partial Infiltration.</p> <p>If any answer from row 5-8 is no, then infiltration of any volume is considered to be infeasible within the drainage area. The feasibility screening category is No Infiltration.</p>		

*To be completed using gathered site information and best professional judgment considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by Agency/Jurisdictions to substantiate findings

Factor of Safety and Design Infiltration Rate Worksheet				Form I-9	
Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) $p = w \times v$
A	Suitability Assessment	Soil assessment methods	0.25		
		Predominant soil texture	0.25		
		Site soil variability	0.25		
		Depth to groundwater / impervious layer	0.25		
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			
B	Design	Level of pretreatment/ expected sediment loads	0.5		
		Redundancy/resiliency	0.25		
		Compaction during construction	0.25		
		Design Safety Factor, $S_B = \Sigma p$			
Combined Safety Factor, $S_{total} = S_A \times S_B$					
Observed Infiltration Rate, inch/hr, $K_{observed}$ (corrected for test-specific bias)					
Design Infiltration Rate, in/hr, $K_{design} = K_{observed} / S_{total}$					
Supporting Data					
Briefly describe infiltration test and provide reference to test forms:					

Downstream Systems Requirements for Preservation of Coarse Sediment Supply		Form I-10	
When it has been determined that potential critical coarse sediment yield areas exist within the project site, the next step is to determine whether downstream systems would be sensitive to reduction of coarse sediment yield from the project site. Use this form to document the evaluation of downstream systems requirements for preservation of coarse sediment supply.			
Project Name:			
Project Tracking Number / Permit Application Number:			
1	Will the project discharge runoff to a hardened MS4 system (pipe or lined channel) or an un-lined channel?	<input type="checkbox"/> Hardened MS4 system	Go to 2
		<input type="checkbox"/> Un-lined channel	Go to 4
2	Will the hardened MS4 system convey sediment (e.g., a concrete-lined channel with steep slope and cleansing velocity) or sink sediment (e.g., flat slopes, constrictions, treatment BMPs, or ponds with restricted outlets within the system will trap sediment and not allow conveyance of coarse sediment from the project site to an un-lined system).	<input type="checkbox"/> Convey	Go to 3
		<input type="checkbox"/> Sink	Go to 7
3	What kind of receiving water will the hardened MS4 system convey the sediment to?	<input type="checkbox"/> Un-lined channel	Go to 4
		<input type="checkbox"/> Lake <input type="checkbox"/> Reservoir <input type="checkbox"/> Bay	Go to 7
		<input type="checkbox"/> Lagoon <input type="checkbox"/> Ocean	Go to 6
4	Is the un-lined channel impacted by deposition of sediment? This condition must be documented by the local agency.	<input type="checkbox"/> Yes	Go to 7
		<input type="checkbox"/> No	Go to 5

Form I-10 Page 2 of 2

5	End – Preserve coarse sediment supply to protect un-lined channels from accelerated erosion due to reduction of coarse sediment yield from the project site unless further investigation determines the sediment is not critical to the receiving stream. Sediment that is critical to receiving streams is the sediment that is a significant source of bed material to the receiving stream (bed sediment supply) (see Section 6.2.3 and Appendix H.2 of the manual).
6	End – Provide management measures for preservation of coarse sediment supply (protect beach sand supply).
7	End – Downstream system does not warrant preservation of coarse sediment supply, no measures for protection of critical coarse sediment yield areas onsite are necessary. Use the space below to describe the basis for this finding for the project.

Appendix J Tidal Influence Study

**BMP TIDAL ANALYSIS
FOR
TENTH AVENUE MARINE TERMINAL**

Job Number 17765-H

August 4, 2017

RICK
RICK ENGINEERING COMPANY
ENGINEERING COMPANY
RICK ENGINEERING CO

**BMP TIDAL ANALYSIS
FOR
TENTH AVENUE MARINE TERMINAL**

Job Number: 17765-H



Brendan Hastie
R.C.E #65809
Exp. 09/17

Prepared For:

San Diego Unified Port District
3165 Pacific Highway
San Diego, California 92101

Prepared By:

Rick Engineering Company
Water Resources Division
5620 Friars Road
San Diego, California 92110-2596
(619) 291-0707

August 4, 2017

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APPENDICES:

Appendix A – Relevant Tide Elevations (San Diego Regional Standard Drawing M-12)

Appendix B – Continuous Simulation Model, Summary of Annual Rainfall

Appendix C – Copy of Plan Sheets Relevant to Structural BMP

1.0 INTRODUCTION

This study was performed for the San Diego Unified Port District (District) to evaluate the performance of flow-based water quality best management practices (BMPs) proposed for implementation along the waterfront at elevations where tide levels may influence hydraulic function, in support of the structural BMP design for the Tenth Avenue Marine Terminal (TAMT) Tiger Grant Project. The study effort included a review and statistical analysis of historical rain and tidal data, preparation and execution of storm water models, evaluation of results, and the preparation of this report.

This report presents a summary of the data collected, methodologies, and results related to the following tasks:

1. A comparison of historical tidal and rainfall data to show the distribution of rainfall associated with tide levels.
2. An analysis of average treatment volumes, in terms of percentage, associated with various BMP design capacities, in terms of rainfall intensity, set at various elevations relative to the Mean Lower Low Water (MLLW) datum.
3. Evaluation of the water quality treatment capacity of the BMP design shown on the TAMT Tiger Grant Project (100 percent design submittal).
4. Evaluation of the water quality treatment capacity of the BMP with the potential design modification of raising the upstream diversion weir to 6.5 feet MLLW.

1.1 Study Vertical Datum

The Mean Lower Low Water (MLLW) was selected as the vertical datum for this study. For projects that may be tidally influenced, it is critical that a consistent vertical datum be used when comparing key project elevations to key tidal elevations. Key elevations associated with projects that are proposing flow based BMPs may include the invert elevation of the BMP outlet and the BMP maximum operating water surface elevation. San Diego Region Standard Drawing (SDRSD) M-12 provides a summary of the various tide elevation for the MLLW datum as well as other vertical datums. Key tidal elevations, based on SDRSD M-12, are shown in Table 1-1.

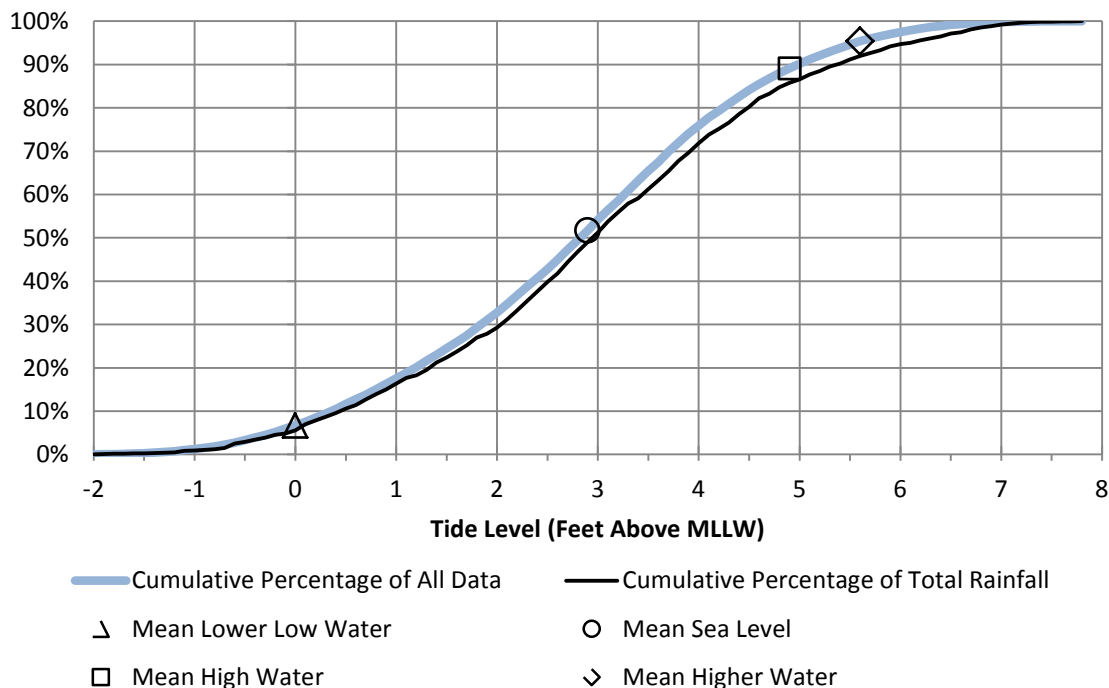
Table 1-1. Mean Lower Low Water Datum

Description	Elevation (feet MLLW)
Highest Tide	7.79
Mean Higher Water	5.61
Mean High Water	4.89
Mean Sea Level	2.88
Mean Lower Low Water	0
Lowest Tide	-2.18

2.0 HISTORICAL TIDAL AND RAINFALL COMPARISON

A statistical comparison of tidal data to rainfall data was performed in order to show the distribution of tide levels and the corresponding rainfall amounts. Rainfall data was obtained from the County of San Diego's Onerain Website (<https://sandiego.onerain.com/home.php>) for the Fashion Valley Gage for the period of July 1, 1998 through June 10, 2017. Data of higher resolution than hourly Gage is not readily available for Lindbergh Field, and thus the next closest gage with incremental data (i.e., actual time to the minute recorded with each gage bucket tip) was selected. Hourly Tidal data was obtained for the same period for Broadway Pier from the National Oceanic and Atmospheric Website (<https://tidesandcurrents.noaa.gov>). The timeframe of 19 years was selected based on the Metonic cycle of 19 years, in which the Earth, moon, and sun's relative positions repeat. For each rainfall record value the tidal level, rounded to the nearest tenth of a foot, was estimated using the method of linear interpretation between the hourly tidal data points. The results of this analysis are provided in Figure 1. The thick blue represents all data, irrespective of rainfall, whereas the black line corresponds to amount of rainfall, as a percentage of total rainfall that occurred at or below the corresponding tide level indicated by the x-axis.

Figure 2-1. Comparison of Rainfall Versus Tide Levels



The results indicate that the rainfall distribution generally follows the same distribution as tide levels. Based on this analysis, above and below the Mean Sea Level the curve is approximately linear for about a foot. The Mean High Water corresponds approximately with the 85 percent precipitation (i.e., 85 percent of precipitation occurs when tide is at or below Mean High Water), and the Mean Higher Water corresponds with slightly more than the 90 percent precipitation.

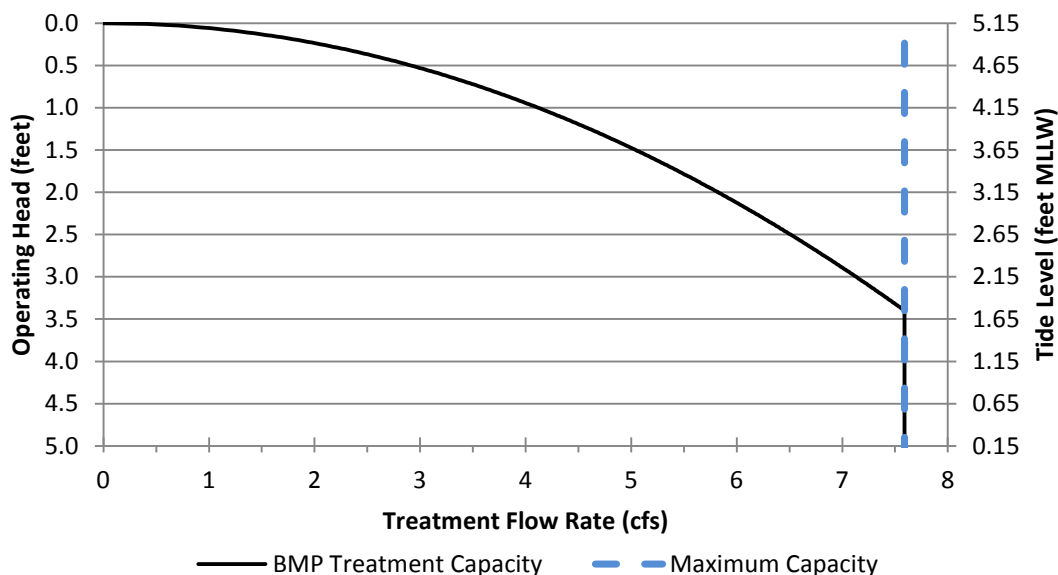
3.0 GENERAL ANALYSIS OF TIDALLY INFLUENCED BMP PERFORMANCE

An analysis was performed to estimate the performance of tidally influenced BMPs. Appendix F of the District's *BMP Design Manual*, dated February 2016, details two options for determining the pollutant treatment performance of flow-based BMPs that includes (Option 1) using a 0.2 inch per hour uniform intensity or (Option 2) conducting a continuous simulation analysis to compute the treatment flow rate (i.e., BMP size) required to capture and treat 80 percent of the average annual runoff. Both Options 1 and 2 require that a 1.5 factor be applied to the flow rate if BMPs do not have a total volume to capture 75 percent of the Design Capture Volume (DCV). Flow based BMPs do not typically meet the 75 percent of DCV requirement and thus must apply the 1.5 factor. The Option 2 analysis was performed as part of this study for several scenarios, each having a different treatment flow rate in terms of constant rainfall intensity (i.e., rainfall intensity was varied for each scenario). For each treatment flow rate scenario, several secondary scenarios were evaluated by varying the BMP height above the MLLW elevation. For each secondary scenario for the average annual runoff treatment value was determined.

A continuous simulation model was prepared to analyze the storm water runoff, tide level, BMP capacity (considering tide level), and average annual storm water runoff treated. The US Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) software was utilized. The SWMM software allows the user to provide incremental rainfall data and site specific information, such as soil parameters and subcatchment lengths, widths, and slopes. These data allow the program to simulate the storm event rainfall and the hydrologic processes across the site in order to calculate storm event runoff values. A rainfall data set was collected, as described in Section 2.0, and incorporated into the model. A SWMM analysis was performed for each scenario (i.e., BMP treatment capacity remained unchanged between scenarios and drainage area was varied to achieve different BMP capacities in terms of uniform rainfall intensity). Using a constant BMP capacity while varying other parameters (e.g., area) allows for a single BMP, such as the BMP currently proposed at TAMT, to be incorporated into each scenario. The SWMM analyses provided output data that included the total storm water runoff flow rates in 5-minute time steps for the period of July 1, 2003 through June 10, 2017 (a simulation of approximately 14 years). The timeframe for continuous simulation modeling was selected based on the availability of good quality, higher resolution rain gage data. Extending beyond 14 years, the data has periods of hourly reading. The 14-year time frame does include both wet, dry, and near average years, and thus is considered to provide an adequately representation of the average annual rainfall. Key SWMM parameters were selected in accordance with guidance from the District's *BMP Design Manual*, dated February 2016.

A typical flow-based BMP was incorporated into the continuous simulation model. The selected BMP has a maximum operating head of 3.4 feet. That is, with storm water runoff within the BMP at a depth of 3.4 feet above the BMP outlet invert, the BMP is designed to be at peak capacity. The flow rate is regulated through an orifice located at each outlet. When the tide level is above the outlet elevation, the difference in water surface elevations, or head, across the orifice is reduced resulting in less flow rate through the BMP. When the tide level is above the maximum operating water surface of the BMP, corresponding to a depth of 3.4 feet above the BMP flowline, the flow rate through the BMP is reduced to zero. Figure 2-1 shows a graphical representation of the relationship between the operating head and treatment capacity of the typical flow-based BMP incorporated into the continuous simulation modeling. For this example, the BMP outlet invert is assumed to be at 1.75 feet MLLW, and thus the maximum treatment flow rate capacity of 7.59 cfs occurs for tide levels at or below 1.75 feet MLLW. For this example, tide levels of 5.15 feet MLLW or above result in zero head and thus zero treatment flow rate.

Figure 3-1. Head versus Treatment Capacity for Typical Flow-Based BMP



The data obtained from the SWMM analyses were exported to Microsoft Excel post-processing worksheets and were evaluated with tidal data and BMP treatment parameters in order to calculate the average annual runoff capture and treatment volumes. Tidal data was collected, as described in Section 2.0, and incorporated into the post-processing worksheet calculations. The post-processing worksheets included 5-minute time step calculations to compare the tide level to the BMP maximum operation level, determine the BMP treatment capacity associated with the tide level, and determine the volume of runoff treated and bypassed. The post-processing worksheets were prepared to allow the user to change the height of the BMP relative to the MLLW elevation thereby providing

calculations and results for each secondary scenario (i.e., for each assumed BMP elevation). The results of the general analysis of tidally influenced BMP performance are summarized in the Table 3-1.

Table 3-1. Summary of the General Analysis of Tidally Influenced BMP Performance

BMP Outlet Elevation (ft MLLW)	Max. BMP Operating Level (ft MLLW)	*Unfactored BMP Rainfall Intensity Treatment Capacity (inches per hour)							
		0.15	0.2	0.25	0.3	0.4	0.5	0.75	1
0	3.4	29.0%	32.0%	34.4%	37.1%	39.8%	41.8%	45.2%	47.5%
0.5	3.9	36.6%	40.2%	43.1%	46.3%	49.5%	51.9%	56.1%	58.7%
1	4.4	43.9%	48.1%	51.4%	55.1%	58.8%	61.5%	66.1%	68.9%
1.5	4.9	50.5%	55.2%	58.8%	58.7%	67.0%	69.9%	74.6%	77.4%
2	5.4	56.0%	61.1%	65.0%	69.4%	70.3%	76.6%	81.2%	83.8%
2.5	5.9	60.5%	65.8%	70.0%	76.7%	78.8%	81.6%	86.0%	88.4%
3	6.4	64.2%	69.7%	74.1%	78.7%	82.9%	83.6%	89.8%	92.1%
3.5	6.9	66.9%	72.6%	77.0%	81.6%	85.7%	88.4%	92.4%	94.6%
4	7.4	68.8%	74.6%	79.0%	82.5%	87.6%	90.1%	94.1%	96.3%
4.5	7.9	70.0%	75.8%	80.2%	83.5%	88.5%	91.0%	94.8%	97.0%
5	8.4	70.3%	76.5%	80.8%	84.6%	89.1%	91.5%	95.1%	97.2%
5.5	8.9	71.1%	76.9%	81.2%	85.3%	89.3%	91.7%	95.2%	97.3%
6	9.4	71.3%	77.1%	81.4%	85.6%	89.5%	91.7%	95.3%	97.3%
6.5	9.9	71.5%	77.2%	81.6%	85.8%	89.5%	91.8%	95.3%	97.3%
7	10.4	71.5%	77.3%	81.6%	85.9%	89.6%	91.8%	95.3%	97.4%
7.5	10.9	71.5%	77.3%	81.6%	85.9%	89.6%	91.8%	95.3%	97.4%
8	11.4	71.5%	77.3%	81.6%	85.9%	89.6%	91.8%	95.3%	97.4%

*Design capacities shown are unfactored. If using this table for design purposes, the final capacity of proposed BMPs shall be based on the intensity listed here multiplied by 1.5.

The results shown in Table 3-1 indicate that as tidally influenced BMPs are proposed at lower elevations, the capacities of these BMPs must be increased in order to capture and treat 80 percent of the average annual runoff. The thick line represents the approximate delineation between the ranges of acceptable and unacceptable BMP design capacities. BMPs with outlet elevations at or below 4.5 feet MLLW have a decrease in average annual treatment capacities. BMPs with outlets at 5.0 feet MLLW or above have no significant decrease in average annual treatment capacities (i.e., act like non-tidally influenced BMPs). At the other end of spectrum, BMPs with outlet elevations below approximately 2.5 feet MLLW may not be feasible for typical site layouts.

It is noted that the District's BMP Design Manual, dated February 2016, allows for the use of 0.2 inches per hour to determine the unfactored BMP treatment capacity (Option 1 analysis), whereas the results of the Option 2 analysis indicates that a design rainfall intensity of approximately 0.23 inches per hour is required to capture and treat 80 percent of the average annual runoff (assuming 100 percent impervious cover in the drainage areas to the BMPs). Modeling that incorporates pervious areas may result in less runoff and thus result in BMPs requiring less capacity (i.e., capacity closer to and possibly lower than the design intensity of 0.2 inches per hour).

Both Options 1 and 2 detailed in Section F.2.2 of the District's BMP Design Manual require that the determined BMP capacity be factored by 1.5 (i.e., increased in size by a factor of 1.5), and both options are valid for the design of BMPs that are not significantly influenced by tide levels. For BMPs that are influenced by tide levels, and that have the same general characteristics as the example flow-based BMP analyzed, the following general guidelines may be implemented:

- The performance of BMPs with outlet elevations at or above 5.0 feet MLLW are not significantly affected, and thus either the Option 1 or 2 analysis may be performed in support of BMP design.
- For BMPs with an outlet elevation below 5.0 feet MLLW, the Option 2 analysis should be used to demonstrate that proposed BMPs meet the applicable pollutant control obligations.

4.0 SPECIFIC TIDAL ANALYSIS FOR TAMT PROJECT

A detailed analysis was performed to evaluate the performance of the BMP proposed as part of the TAMT Tiger Project. The analysis was based on data extracted from the 100 percent submittal drawings obtained on July 6, 2017. The potential design modification of raising the upstream weir elevation to 6.5 feet MLLW was discussed at coordination meetings and this change was also incorporated into analysis. The models and post-processing calculations, described in Section 3.0, were enhanced to incorporate project specific drainage area and BMP parameters. In particular, the hydraulic function of the BMP and downstream system was evaluated to identify potential system limitations or restrictions, which were incorporated into the post-processing worksheet calculations. Additionally, the required 1.5 factor was incorporated into the post-processing worksheet calculations.

The following summarizes key characteristics of the proposed structural BMP:

100% Design Submittal

- BMP outlet elevation of 1.75 feet MLLW.
- BMP maximum operation depth of 3.4 feet (elevation of 5.15 feet MLLW).
- Upstream bypass weir elevation of 5.23 feet MLLW.
- BMP system maximum treatment capacity of 7.59 cfs.

As Discussed at Coordination Meetings

- BMP outlet elevation of 1.75 feet MLLW.
- BMP maximum operation depth of 4.58 feet (elevation of 6.33 feet MLLW).
- Upstream bypass weir elevation of 6.5 feet MLLW.
- BMP system maximum treatment capacity of 7.59 cfs.

Hydraulic calculations of the storm drain system downstream of the proposed BMP were performed using Water Surface Pressure Gradient for Windows (WSPGW) modeling software. The results of these calculations indicate that the peak flow rate of 7.59 cubic feet per second through the BMP results in a downstream water surface elevation, at the BMP outlet, of approximately 2.85 feet MLLW during periods when the system is not influenced by tide levels (i.e., when tide levels are below 1.75 feet MLLW). This means that as designed, at a water surface elevation of 5.15 feet MLLW in the treatment chamber of the BMP, the system would have an operating head of 2.3 feet not 3.4 feet, and this would result in a reduced flow through the system (see Figure 3-1 in Section 3.0) (or with a water surface elevation of 6.33 feet MLLW in the treatment chamber of the BMP, the system would have an operating head of 3.48 feet not 4.58 feet). A reduced flow would in turn would result in a lower downstream water surface elevation, and performing the necessary iterations indicates that as currently designed the BMP has a peak pollutant control capacity 6.89 cubic feet per second, which results in a downstream water surface elevation of approximately 2.73 feet MLLW. The hydraulic calculations also

indicate that when the system bypasses flows of approximately 30 cubic feet per second or more, the resulting water surface elevations downstream of the BMP are above 5.15 feet MLLW, and thus no flow is treated through the BMP when this occurs. Both of these hydraulic limitations were incorporated into the post-processing worksheet calculations.

A total of four scenarios were analyzed in order to evaluate BMP performance and to incorporate and evaluate design considerations. The first two scenarios evaluated the BMP effectiveness considering a reduced drainage area of 8.8 acres, which corresponds to the area where site improvements are proposed (i.e., area required to be treated). Scenario 1 assumed the BMP is designed as shown on the 100 percent design drawings. Scenario 2 assumed modifications that included raising the upstream diversion weir to 6.5 feet MLLW and increasing the diameter of BMP orifices in order to achieve the optimal treatment capacity flow rate of 7.59 cubic feet considering a downstream water surface elevation of 2.85 feet MLLW.

Scenarios 3 and 4 assumed similar BMP configurations as Scenarios 1 and 2, respectively. However, Scenarios 3 and 4 assumed that the drainage area is a total of 40.3 acres as shown on the 100 percent submittal documents. Scenario 3 results indicate how the system will function in the current design (i.e., BMP outlet at 1.75 feet MLLW and orifice diameter based on 3.4 feet operating head). Scenario 4 results indicate how the system will function if the upstream weir is raised to 6.5 feet MLLW and if the diameters of the BMP orifices are modified to maximize treatment flow rate provided. The summary of the analysis performed for each scenario is shown in Table 4-1. The “Equivalent Area Treated” column provides the correlation between the total volumes treated for each scenario and the total volume required to be treated, which is 80 percent of the runoff from the 8.8 acres, multiplied by 8.8 acres (i.e., correlated to the area of the project that the project is obligated to treat through a pollutant control BMP). The “Net Additional Area Treated” column provides the additional equivalent area, beyond the 8.8 acres required by the project, that the project is estimated to treat on an average annually basis. Please note that the results presented in Table 4-1 include the 1.5 scaling factor that is required by BMP Design Manual criteria.

Table 4-1. Summary of TMA BMP Performance Analysis

Scenario	Modeled Drainage Area (acres)	Upstream Weir Elevation (ft MLLW)	Orifice Diameters (inches)	Average Annual Runoff Treated*	Average Annual Runoff Treated (cf)	Equivalent Area Treated (acres)	Net Additional Area Treated (acres)
1	8.8	5.23	2.67	74.7%	210,487	8.2	-0.6
2	8.8	6.5	2.65	86.7%	244,334	9.5	0.7
3	40.3	5.23	2.67	*43.6%	558,119	21.8	13.0
4	40.3	6.5	2.65	*54.6%	699,115	27.3	18.5

*Please note that average annual runoff treated values shown in this table were computed utilizing a reduced BMP treatment capacity (i.e., reduced by 1 / 1.5). The proposed BMP was designed to treat approximately 80% of the average annual runoff without the consideration of tidal influence or the 1.5 scaling factor. When performing the simulation to consider tidal influence but without the applying the 1.5 scaling reduction, such as if considering the Industrial General Permit treatment volumes treated, the overall average annual runoff treated values are 58.5% and 70.3% for Scenarios 3 and 4, respectively.

The refinement of raising the upstream diversion weir elevation, if implemented, shall be coordinated with BMP manufacturer. This refinement may be more complicated than merely proposing a raised weir elevation as it may require that the BMP manufacturer ensure that depths above 3.4 feet will not simply overflow into the discharge chamber (i.e., bypass the BMP at the downstream BMP wall). Additionally, this sort of refinement may require modification to the media configuration, such as making the media area taller or placing a barrier over the media to prevent short circuiting. Additionally, future refinements to the proposed BMP, beyond those mentioned here, if proposed should be evaluated using the described methodologies and continuous simulation model prepared for this study.

5.0 SUMMARY

Data collection, compilation, and various analyses were performed in order to evaluate the performance of tidally influenced BMPs. Based on the SDRSD M-12, the Highest Tide elevation is 7.79 feet MLLW, the Mean Higher Water elevation is 5.61 feet MLLW, the Mean High Water elevation is 4.89 feet MLLW, the Mean Sea Level is 2.88 feet MLLW, and MLLW is the datum with an elevation of zero feet MLLW. This study included a general analysis of BMP performance, which indicates typical BMPs with outlet elevations at 5.0 feet MLLW or above have no significant decrease in average annual treatment capacities (i.e., act like non-tidally influenced BMPs). BMPs with outlet elevations below approximately 2.5 feet MLLW may not be feasible for implementation for typical site layouts. BMPs with outlet elevations below 5.0 feet MLLW should require continuous simulation modeling to demonstrate that the unfactored BMP capacity will be adequate to capture and treat 80 percent of the average annual runoff (i.e., determine the flow rate capacity required to treat 80 percent of the average annual runoff and then multiple that value by the 1.5 scaling factor). BMP Tidal Analysis key findings for flow-based BMPs include the following:

- BMP outlet elevation ≥ 7.8 feet MLLW: no special requirements, no flap valve.
- BMP outlet elevation ≤ 7.8 feet and ≥ 5.0 feet MLLW: flap valve required, no other special design or analysis required.
- BMP outlet elevation < 5.0 feet MLLW: flap valve required, *BMP Design Manual* Appendix F Option 2 analysis required to demonstrate project will capture and treat 80 percent of the average annual runoff.

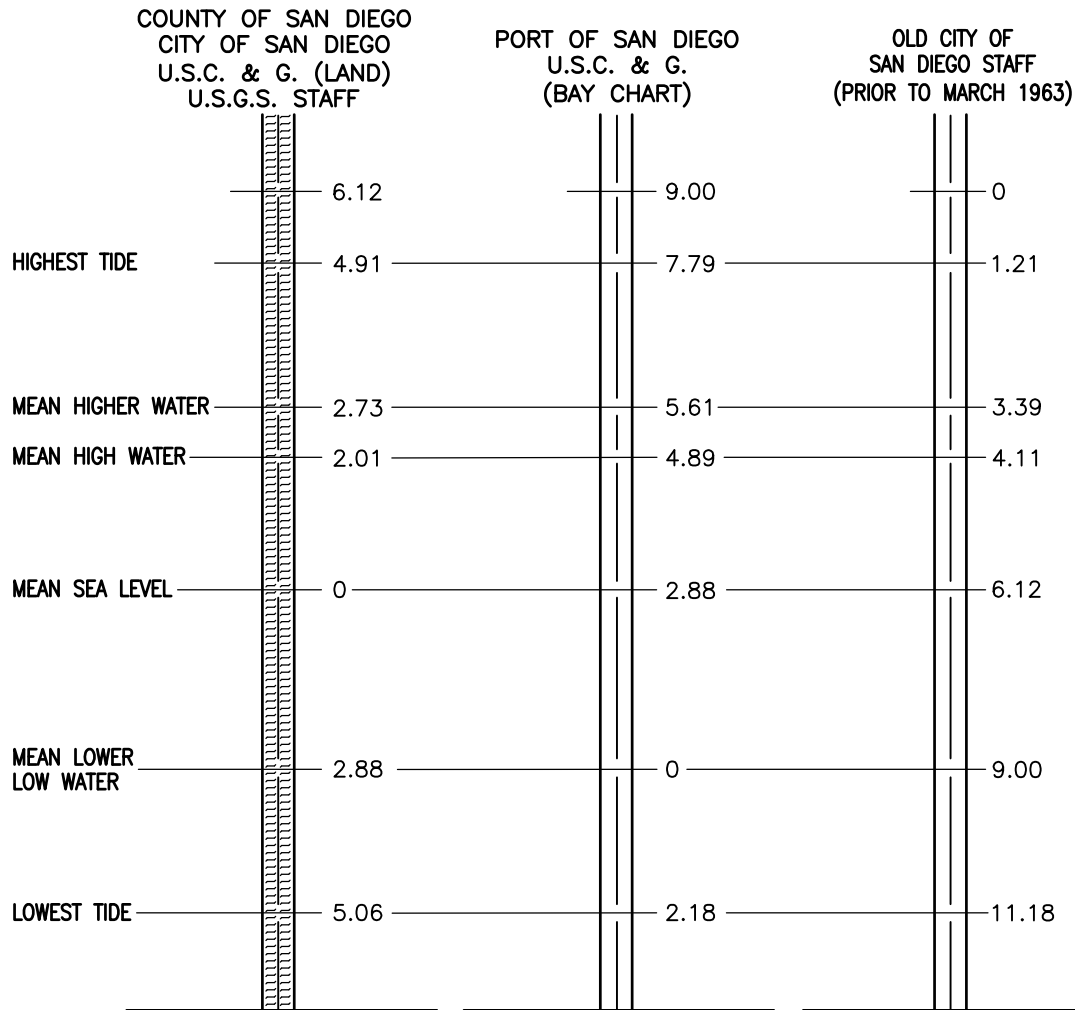
A project-specific continuous simulation modeling analysis was prepared to evaluate the BMP performance of the proposed TAMT Tiger Demolition Project. The results of the analysis indicate that the proposed BMP will capture and treat an average annual runoff volume in excess of the annual runoff volume associated with the project area of 8.8 acres. The site location, project scope, and BMP system combine to create a very unique situation, and the approach to quantify pollutant control capture and treatment for this type of unique situation is not clearly described in current guidance documents, such as the District's *BMP Design Manual*. The approach and results described in this study seem to meet the intent of the current regulatory permit, which is understood as priority development projects (PDPs) must reduce project pollutant loading in storm water runoff from project areas by at least 80 percent. Based on the analysis described hereon, the TAMT Tiger Project exceeds this requirement by capturing and treating runoff from an area that is larger than what is required. The analysis results are summarized in Table 4-1 in Section 4.0.

The potential design modification of raising the upstream diversion weir to 6.5 feet MLLW was evaluated. According to the assumptions and analysis described in this study, the modification would result in the BMP system having the capacity to treat well over the 80 percent of the average annual runoff specific to 8.8 acres associated with project site. The increased pollutant removal provided by the modification provides additional confidence in meeting current regulatory requirements. Furthermore, by voluntarily directing runoff from the entire drainage area of 40.3 acres, the project will provide significantly better water quality, and thus generate additional earned credits for pollutant control in support of the District's Alternative Compliance Program (ACP).

APPENDIX A

San Diego Regional Standard Drawing

M-12 – Datums



LEGEND

U.S.C. & G. = United States Coast and Geodetic Survey.
 U.S.G.S. = United States Geological Survey.
 MEAN HIGH WATER = Mean of all high water in San Diego Bay.
 MEAN HIGHER WATER = Mean of all higher water in San Diego Bay.
 Bay charts and topography up to the mean high tide based on zero at the mean lower low water.

SOURCE

Data based on U.S.C. & G. "Sea level Datum of 1929".

Revision	By	Approved	Date	SAN DIEGO REGIONAL STANDARD DRAWING	RECOMMENDED BY THE SAN DIEGO REGIONAL STANDARDS COMMITTEE
TEXT	BUSS		2/11		
REVISED		D. Gerschoffer	9/15	DATUMS	<i>M. Stanton</i> 12/17/2015
					Chairperson R.C.E. 19246 Date
					DRAWING NUMBER
					M-12

APPENDIX B

Continuous Simulation Model

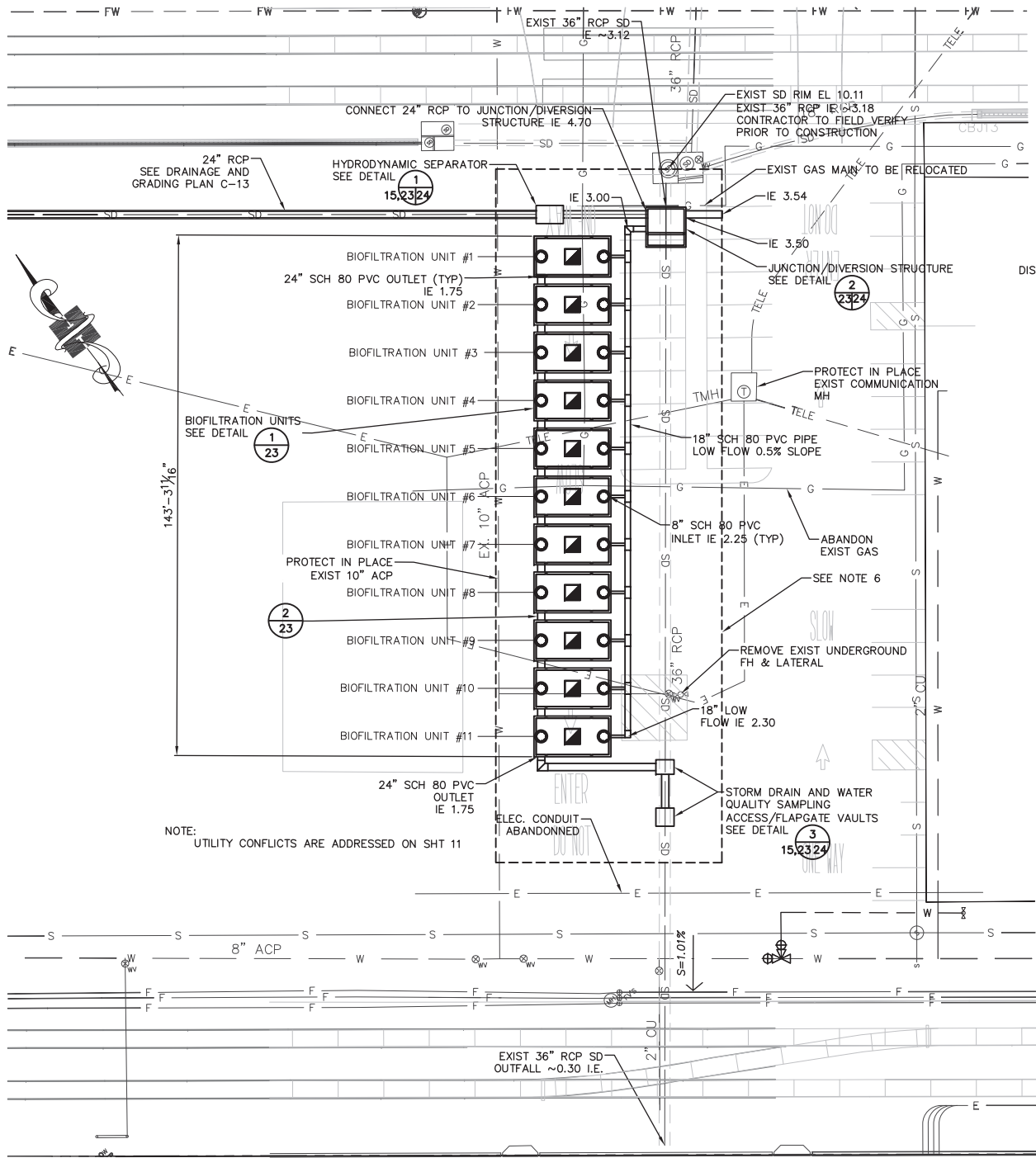
Summary of Annual Rainfall

Fashion Valley Rain Gage Data, Summary of Annual Rainfall for Model Period

Rainfall Year	Rain (inches)
2003 - 2004	6.16
2004 - 2005	25.51
2005 - 2006	7.04
2006 - 2007	4.72
2007 - 2008	10.16
2008 - 2009	8.04
2009 - 2010	12.31
2010 - 2011	15.34
2011 - 2012	8.75
2012 - 2013	7.79
2013 - 2014	4.85
2014 - 2015	8.19
2015 - 2016	11.80
2016 - 2017	14.87
Average =	10.39

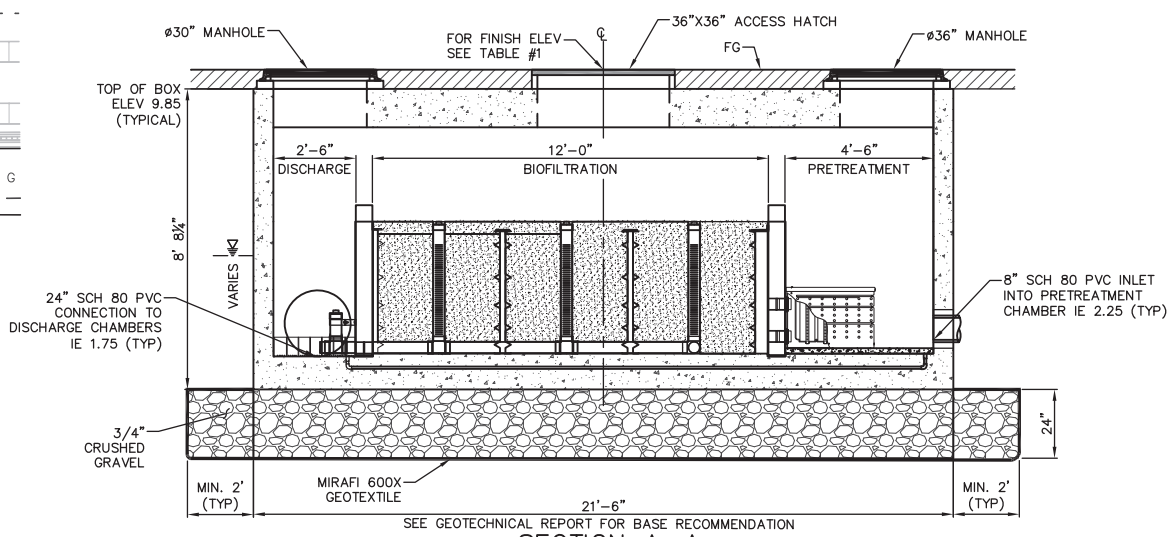
APPENDIX C

Copy of Plan Sheets Relevant to Structural BMP



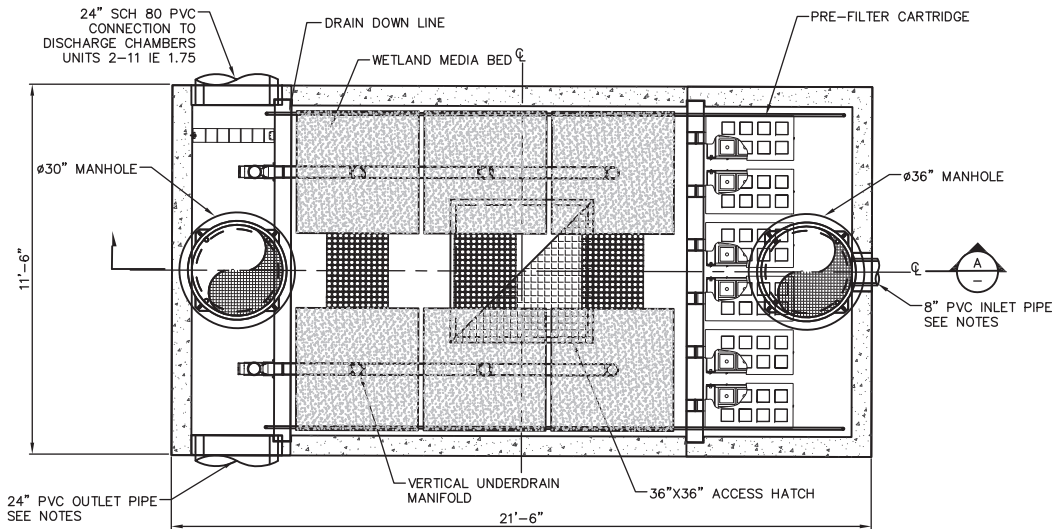
NOTE:

1. IN ORDER TO MINIMIZE IMPACT TO PORT OPERATIONS, THE CONSTRUCTION OF BIOFILTRATION UNITS AND STORM DRAIN SYSTEM AT THIS LOCATION, MUST NOT OCCUR CONCURRENT WITH DEMOLITION AND PAVEMENT ACTIVITIES AT TRANSIT SHED NO. 1. AS A MINIMUM, CONTRACTOR MUST COMPLETE THE PAVEMENT WORK ON BAYS A AND B BEFORE STARTING CONSTRUCTION ACTIVITIES AT THE BIOFILTRATION SITE. COORDINATE WORK WITH THE ENGINEER. ALSO, A WORKPLAN IS REQUIRED FOR CONSTRUCTION OF THE BIOFILTRATION UNITS AND STORM DRAIN SYSTEM SHOWN ABOVE. SEE SPECIFICATIONS FOR MORE DETAILS.
2. DIMENSIONS PROVIDED ARE DIAGRAMMATIC AND APPROXIMATE. SEE SPECIFICATIONS FOR THE SPECIFIED PERFORMANCE AND REQUIREMENTS OF THE BIOFILTRATION UNITS. DIMENSIONS AND LAYOUT DETAILS PER THE MANUFACTURER.
3. CONTRACTOR IS REQUIRED TO DESIGN AND CONSTRUCT THE STORM DRAIN STRUCTURES ON THIS SHEET FOR H2O LOADING.
4. CONTRACTOR TO SUBMIT DESIGN CALCULATIONS (BY A CIVIL OR STRUCTURAL ENGINEER REGISTERED IN THE STATE OF CALIFORNIA) TO THE ENGINEER FOR APPROVAL.
5. SEE GEOTECHNICAL REPORT BY NINYO AND MOORE FOR BASE RECOMMENDATIONS FOR BIOFILTRATION UNITS. ALTERNATIVE BASE RECOMMENDATION IS PROVIDED FOR STABILIZING THE BIOFILTRATION UNITS.
6. PROVIDE RED DIAGONAL STRIPING A MINIMUM OF 10' FROM STORM DRAIN SYSTEM VAULTS AS SHOWN. STRIPES AT EVERY 10' OC, WIDTH OF STRIPE 12". PROVIDE THE FOLLOWING TEXT: "NO GOTTWALD CRANE IN THIS AREA" ALONG BOTH LENGTHS OF STRIPE BOUNDARY. LETTERING SHALL BE A MINIMUM OF 1' HEIGHT.



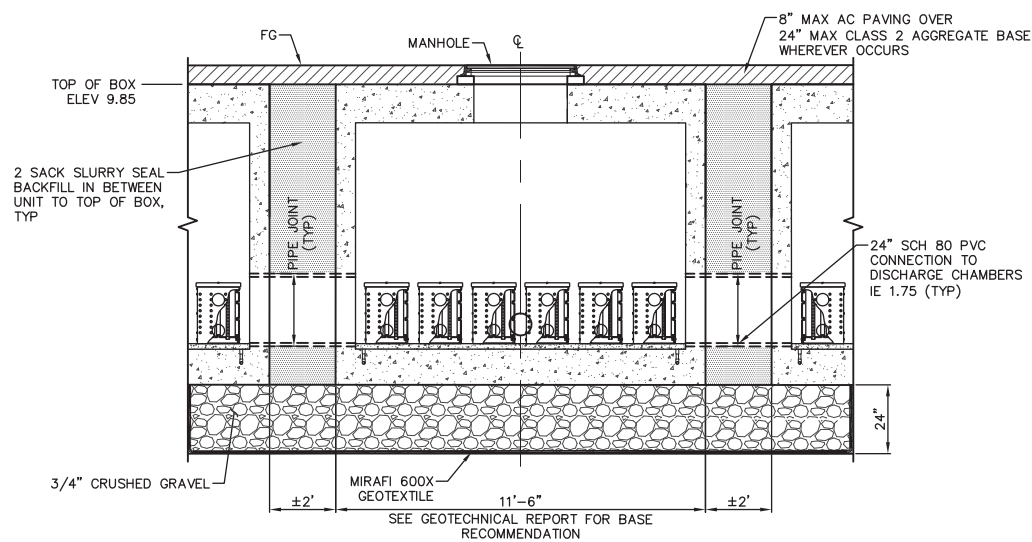
SECTION A-A

SCALE: NTS



BIOFILTRATION UNIT DETAIL

SCALE: NTS



TYPICAL ELEVATION BETWEEN BIOFILTRATION UNIT PRETREATMENT CHAMBER

SCALE: NTS

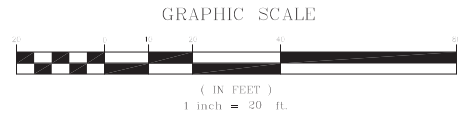
INSTALLATION NOTES

1. CONTRACTOR TO PROVIDE ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED TO OFFLOAD AND INSTALL THE SYSTEM AND APPURTENANCES IN ACCORDANCE WITH THIS DRAWING AND THE MANUFACTURERS SPECIFICATIONS.
2. UNIT MUST BE INSTALLED ON LEVEL BASE.
3. ALL PIPES MUST BE FLUSH WITH INSIDE SURFACE OF CONCRETE. (PIPES CANNOT INTRUDE BEYOND FLUSH). INVERT OF OUTFLOW PIPE MUST BE FLUSH WITH DISCHARGE CHAMBER FLOOR. ALL GAPS AROUND PIPES SHALL BE SEALED WATER TIGHT WITH A NON-SHRINK GROUT PER MANUFACTURERS STANDARD CONNECTION DETAIL AND SHALL MEET OR EXCEED REGIONAL PIPE CONNECTION STANDARDS.
4. CONTRACTOR TO SUPPLY AND INSTALL ALL EXTERNAL CONNECTING PIPES.
5. CONTRACTOR RESPONSIBLE FOR INSTALLATION OF ALL RISERS, MANHOLES, AND HATCHES. CONTRACTOR TO GROUT ALL MANHOLES AND HATCHES TO MATCH FINISHED SURFACE.
6. SEE DETAIL 4 ON SHT 22 FOR PIPE PENETRATION TO CONCRETE STRUCTURES.
7. SAW CUT PAVEMENT FOR EXCAVATION TO CONSTRUCT BIOFILTRATION STRUCTURES. PAVEMENT SECTION BETWEEN THE BIOFILTRATION UNITS AND THE EDGE OF THE EXCAVATION PIT SHALL BE PER DETAIL 1 ON SHT 20, MATCHING BAY C PAVEMENT SECTION.

TABLE #1

BIOFILTRATION UNIT #	FINISH GRADE SURFACE ELEVATION	FLOW (CFS)
1	10.60	0.69
2	10.70	0.69
3	10.80	0.69
4	10.90	0.69
5	11.00	0.69
6	11.10	0.69
7	11.20	0.69
8	11.30	0.69
9	11.50	0.69
10	11.50	0.69
11	11.60	0.69

NOTE: TOP OF BOX ELEVATION IS 9.85 (TYP)
FINISH GRADE SURFACE ELEVATIONS ARE APPROXIMATE. MATCH EXISTING GRADE



HARRIS & ASSOCIATES
600 B Street, Suite 2000
San Diego, CA 92101
(619) 236-1778 • (619) 236-1179

SPEC NO. 2017-03	WBS NO. CP-0016-1
PROJECT ENGINEER MARK MCINTIRE	
CONTRACTOR	
CONSTRUCTION STARTED	
CONSTRUCTION COMPLETED	
COST	
INSPECTOR	

REVISIONS

DATE

APPROVED

San Diego Unified Port District
San Diego, California



DESIGNED	JAY
DRAWN	OU
CHECKED	GKM

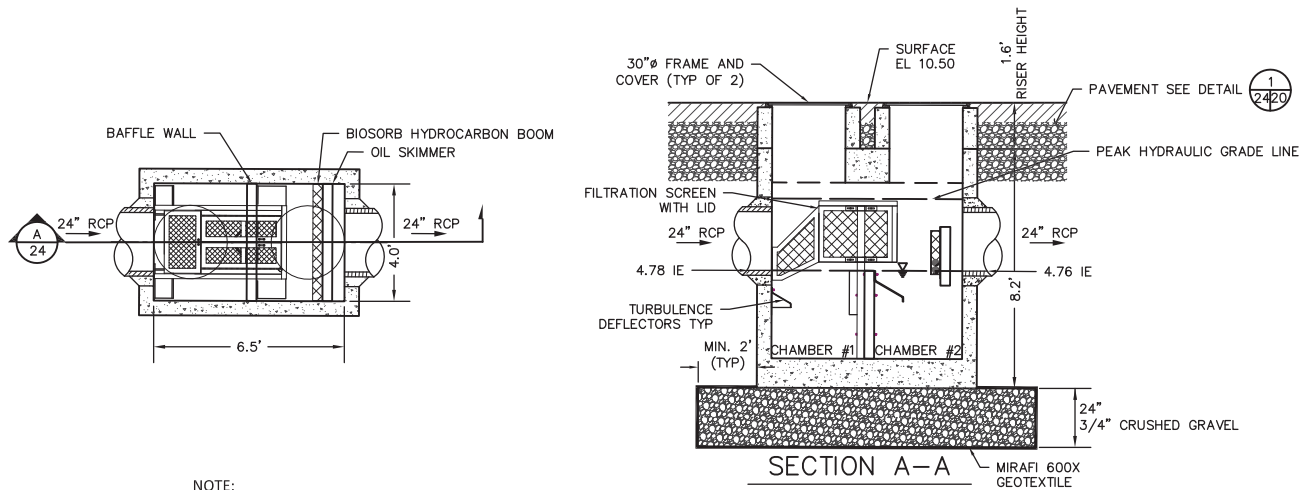
APPROVAL	RECOMMENDED
APPROVED	

SAN DIEGO, CALIFORNIA

DEMOLITION AND SITE IMPROVEMENTS OF TRANSIT SHED 1 AT TENTH AVENUE MARINE TERMINAL

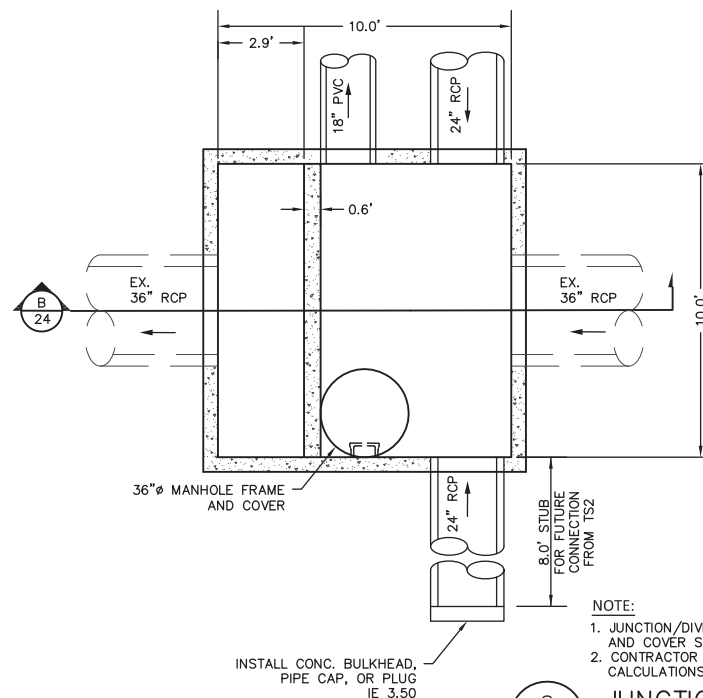
STORM WATER TS1 BMP SITE MAP & DETAILS

C20	* DATUM = MEAN LOWER LOW WATER
DATE 3/30/2017	
SHEET 23 of 88	
DRAWING NO. TA-2017-01	REV.



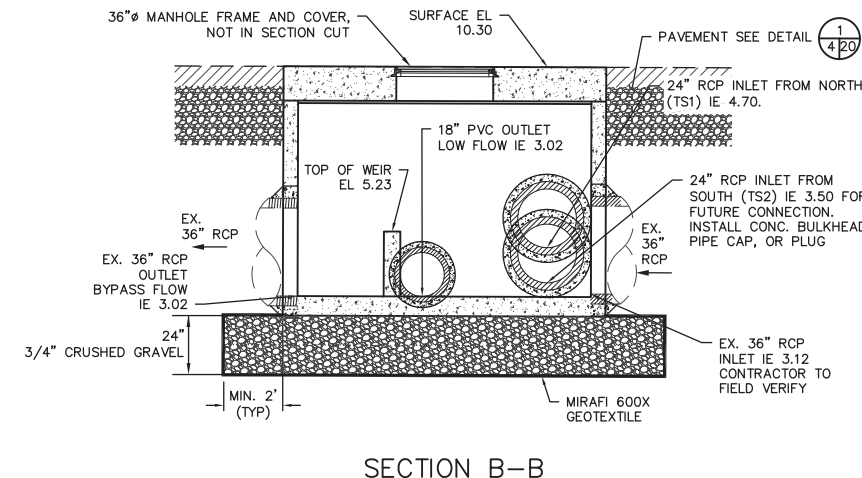
NOTE:
1. HYDRODYNAMIC SEPARATOR STRUCTURE, MANHOLE RISER, MANHOLE FRAME, AND COVER SHALL BE RATED FOR H2O LOADING.
2. CONTRACTOR TO PROVIDE DESIGN AND STRUCTURAL CALCULATIONS. SEE GENERAL NOTE 4.

1 HYDRODYNAMIC SEPARATOR
15,2324 SCALE: NTS

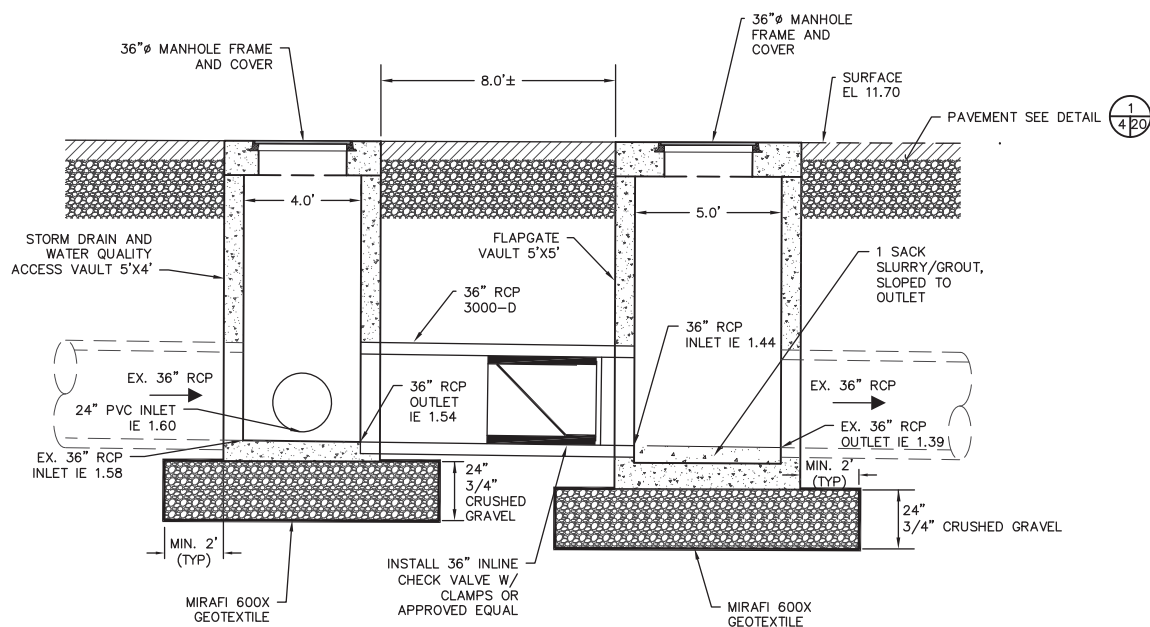


NOTE:
1. JUNCTION/DIVERSION STRUCTURE, MANHOLE RISER, MANHOLE FRAME, AND COVER SHALL BE RATED FOR H2O LOADING.
2. CONTRACTOR TO PROVIDE DESIGN AND STRUCTURAL CALCULATIONS. SEE GENERAL NOTE 4.

2 JUNCTION/DIVERSION STRUCTURE
15,2324 SCALE: NTS



SECTION C-C
SCALE: NTS

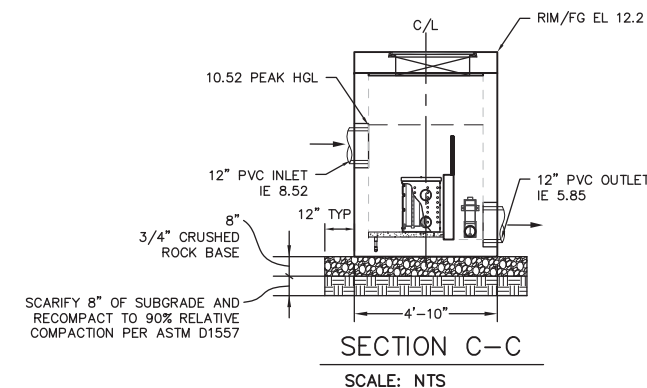


NOTE:
1. STORM DRAIN AND WATER QUALITY ACCESS / FLAPGATE VAULTS, MANHOLE RISER, MANHOLE FRAME, AND COVER SHALL BE RATED FOR H2O LOADING.
2. CONTRACTOR TO PROVIDE DESIGN AND STRUCTURAL CALCULATIONS. SEE GENERAL NOTE 4.

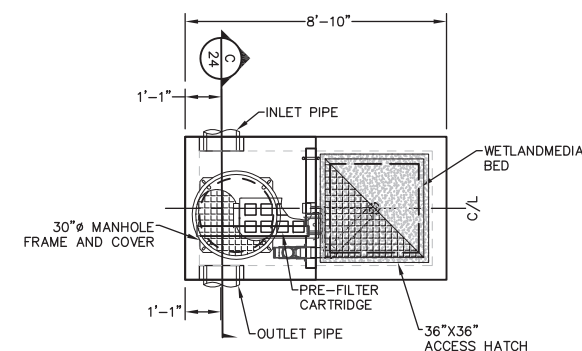
3 STORM DRAIN AND WATER QUALITY ACCESS / FLAPGATE VAULTS
15,2324 SCALE: NTS

GENERAL NOTES:

- IN ORDER TO MINIMIZE IMPACT TO PORT OPERATIONS, THE CONSTRUCTION OF BIOFILTRATION UNITS AND STORM DRAIN SYSTEM AT THIS LOCATION, MUST NOT OCCUR CONCURRENT WITH DEMOLITION AND PAVEMENT ACTIVITIES AT TRANSIT SHED NO. 1. AS A MINIMUM, CONTRACTOR MUST COMPLETE THE PAVEMENT WORK ON BAYS A AND B BEFORE STARTING CONSTRUCTION ACTIVITIES AT THE BIOFILTRATION SITE. COORDINATE WORK WITH THE ENGINEER. ALSO, A WORKPLAN IS REQUIRED FOR CONSTRUCTION OF THE BIOFILTRATION UNITS AND STORM DRAIN SYSTEM SHOWN ABOVE. SEE SPECIFICATIONS FOR MORE DETAILS.
- DIMENSIONS PROVIDED ARE DIAGRAMMATIC AND APPROXIMATE. SEE SPECIFICATIONS FOR THE SPECIFIED PERFORMANCE AND REQUIREMENTS OF THE BIOFILTRATION UNITS. DIMENSIONS AND LAYOUT DETAILS PER THE MANUFACTURER.
- CONTRACTOR IS REQUIRED TO DESIGN AND CONSTRUCT STORM DRAIN STRUCTURES ON THIS SHEET FOR H2O LOADING.
- CONTRACTOR TO SUBMIT DESIGN CALCULATIONS (BY A REGISTERED CIVIL OR STRUCTURAL ENGINEER REGISTERED IN THE STATE OF CALIFORNIA) TO THE ENGINEER FOR APPROVAL.
- SEE GEOTECHNICAL REPORT BY NINYO AND MOORE FOR BASE RECOMMENDATIONS FOR BIOFILTRATION UNITS. ALTERNATIVE BASE RECOMMENDATION IS PROVIDED FOR STABILIZING THE BIOFILTRATION UNITS.



SECTION E-E
SCALE: NTS



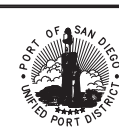
NOTE:
1. THIS BIOFILTRATION UNIT SHALL BE RATED FOR H2O LOADING, INCLUDING VAULT, FRAME AND COVER, RISER AND HATCH.
2. SEE GENERAL NOTE 4 THIS SHEET.
3. FLOW RATE THROUGHOUT THIS BIOFILTRATION UNIT IS 0.11 CFS

4 BIOFILTRATION UNIT FOR MODULAR OFFICE SITE
1924 SCALE: NTS

UNAPPROVED COPY OF SAN DIEGO UNIFIED PORT DISTRICT - 15,2324-0001-0001 - STORM WATER BMP DETAILS (05-20-17 8:11:29AM)

SPEC NO. 2017-03	WBS NO. CP-0016-1				
REFERENCES					
PROJECT ENGINEER MARK MCINTIRE					
CONTRACTOR					
CONSTRUCTION STARTED					
CONSTRUCTION COMPLETED					
COST					
INSPECTOR					
REVISIONS					
DATE					
APPROVED					

San Diego Unified Port District
San Diego • California



DESIGNED	JAY	APPROVAL	RECOMMENDED
DRAWN		APPROVED	
CHECKED			
GKM			

SAN DIEGO, CALIFORNIA	
DEMOLITION AND SITE IMPROVEMENTS OF TRANSIT SHED 1 AT TENTH AVENUE MARINE TERMINAL	
STORM WATER BMP DETAILS	

HARRIS & ASSOCIATES
600 B Street, Suite 2000
San Diego, CA 92101
(619) 236-1778 • (619) 236-1179



C21	
MEAN LOWER LOW WATER	
DATE 3/30/2017	
SHEET 24 of 88	
DRAWING NO. TA-2017-01	REV.

PDP Exemption Guidance

Appendix K PDP Exemption Guidance

There are two categories of PDP exemptions, each with its own requirements for runoff treatment.

- Walkways Exemption: New or retrofit paved sidewalks, bicycle lanes, or trails that meet certain criteria (Appendix K.1)
- Green Street Exemption: Retrofitting or redevelopment of existing paved alleys, streets or roads that meet certain criteria (Appendix K.2)

Technical guidance related to both exemption categories are provided in this appendix.

K.1 Walkways Exemption

The Walkways Exemption is defined in Section 1.4.3. This section provides technical guidance related to this exemption category, including sidewalks, bicycle lanes or paths that are:

1. Designed and constructed to direct stormwater runoff to adjacent vegetated areas, or other non-erodible permeable areas (Appendix K.1.1); OR
2. Designed and constructed to be hydraulically disconnected from paved streets or roads (Appendix K.1.2); OR
3. Designed and constructed with permeable pavements or surfaces (Appendix K.1.3).

Where a project or portion of a project meets the criteria for the Walkways Exemption, then pollutant control and hydromodification controls are not required. Additionally, this area should not be included in tabulation of the created, added, or replaced impervious surface.

Form K-1 is used to document how a project meets the requirements of the Walkways Exemption. A PDF version of Form K-1 can be found on the Port of San Diego Stormwater Management website: <https://www.portofsandiego.org/stormwater-management>

K.1.1 Guidance for Directing Stormwater into Vegetated or Non-Erodible Permeable Areas

Routing stormwater onto vegetated and non-erodible permeable areas can provide an opportunity for infiltration and/or evaporation to occur, particularly in smaller storms. However, the effectiveness of this approach is dependent on the loading ratio (i.e., how much area is routed onto a given permeable area) and whether the surface is resistant to erosion (i.e. shear stress). If loading ratios are too high

and/or permeable surfaces are too unstable, this approach can create additional problems relative to erosion and sedimentation.

For the purpose of meeting the criteria of this exemption, one of two options, or equivalent, may be used:

1. Satisfy the specifications outlined within the impervious dispersion factsheet (SD-B in Appendix E), OR
2. Route water into an open-graded gravel area with a gravel diameter greater than or equal to 1-inch diameter, or other surface with similar permeability and resistance to shear stress (Figure K.1-1). For this option, the loading ratio must be less or equal to 5:1 and the contributing path length of the impervious surface must have a maximum length of 20 feet. The sidewalk or other paved pathway must be designed with the standard cross slope.

Intent: A vegetated or non-erodible pervious surface must allow water to permeate into the subsurface layers and not be susceptible to erosion at the maximum hydraulic load rates and velocities expected to occur under large storm events, such as the 10-year storm event.

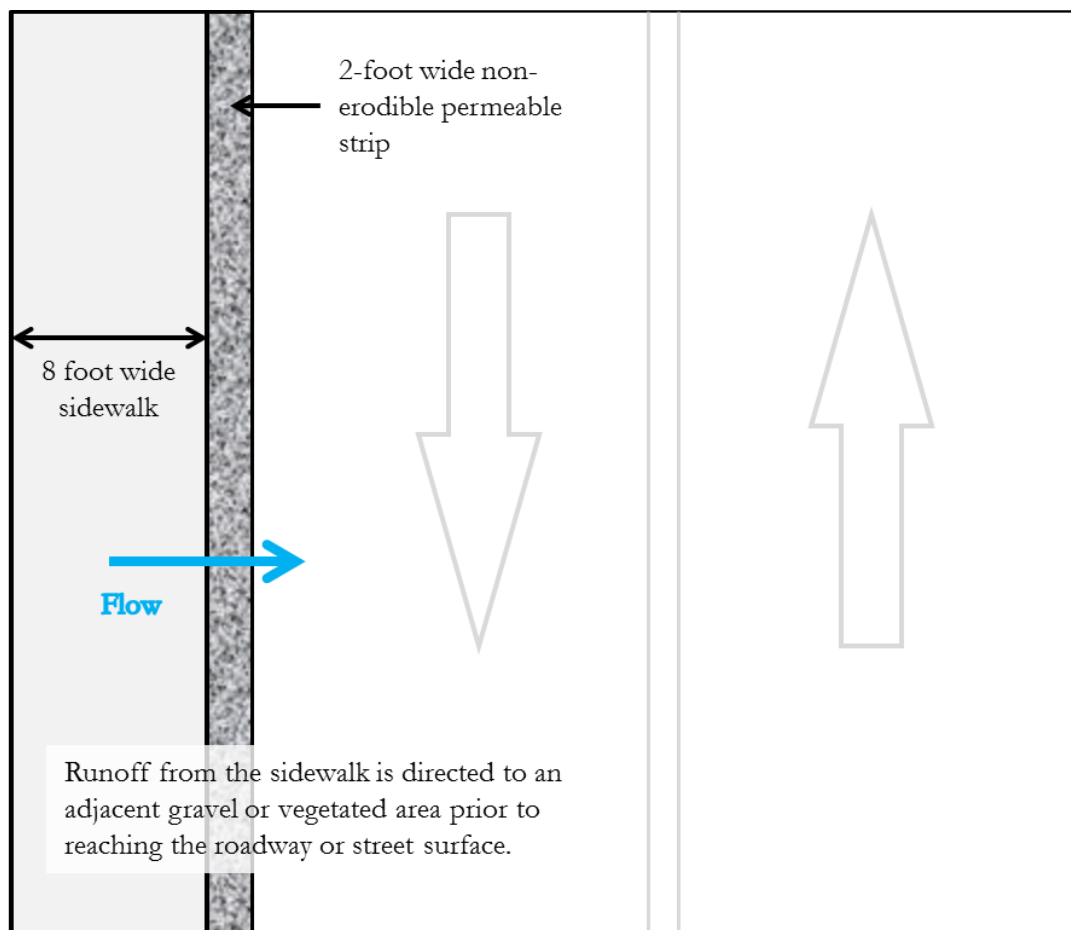


Figure K.1-1 : Schematic of an all gravel non-erodible permeable area configuration (not to scale)

K.1.2 Guidance for Hydraulic Disconnection

Hydraulic disconnection involves separating the stormwater collected from the sidewalk, bicycle lane, and/or trail surface from the runoff collected from an adjacent paved street or roadway. If the surface runoff from the sidewalk, bicycle lane, and/or trail surfaces does not comeingle with street runoff on the ground surface and does not enter the same inlet as the street or roadway runoff, then this area can be considered exempt from PDP requirements. Figure K.1-2 and Figure K.1-3 provide examples of how this exemption could be achieved. Water is allowed to comeingle once it is in the storm drain pipe.

Intent: This exemption seeks to isolate the runoff generated from sidewalks, bicycle lanes, and trails that tend to be cleaner (i.e., less floatables and lower contaminant concentrations) as compared to their street and roadway counterparts. The exemption allows surface runoff from these surfaces to discharge untreated, as long as it does not comeingle with street or roadway surface water. In a case when the sidewalk, bicycle lane, or trail is expected to generate runoff with similar contaminant profiles as the adjacent street or roadway, the Stormwater Construction and Redevelopment Program Manager may determine that it is not appropriate to grant this exemption.

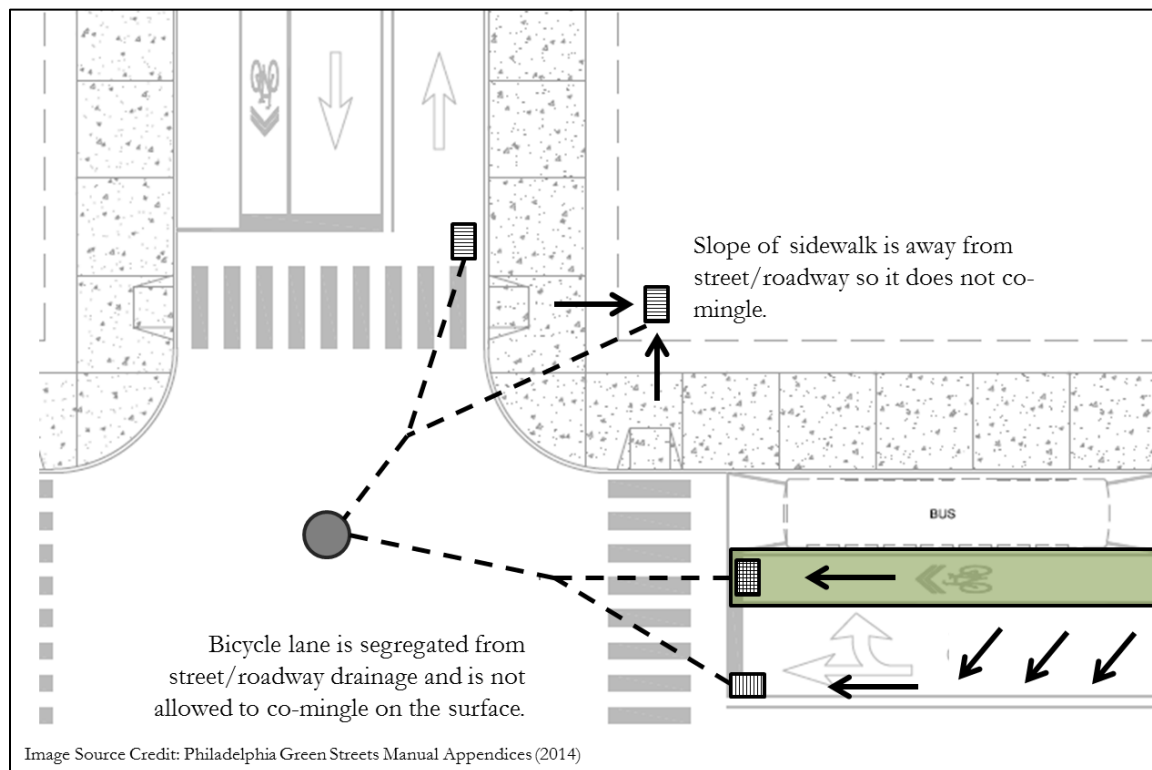


Figure K.1-2 : Schematic showing hydraulic disconnection of sidewalks and bicycle lanes in a typical intersection.

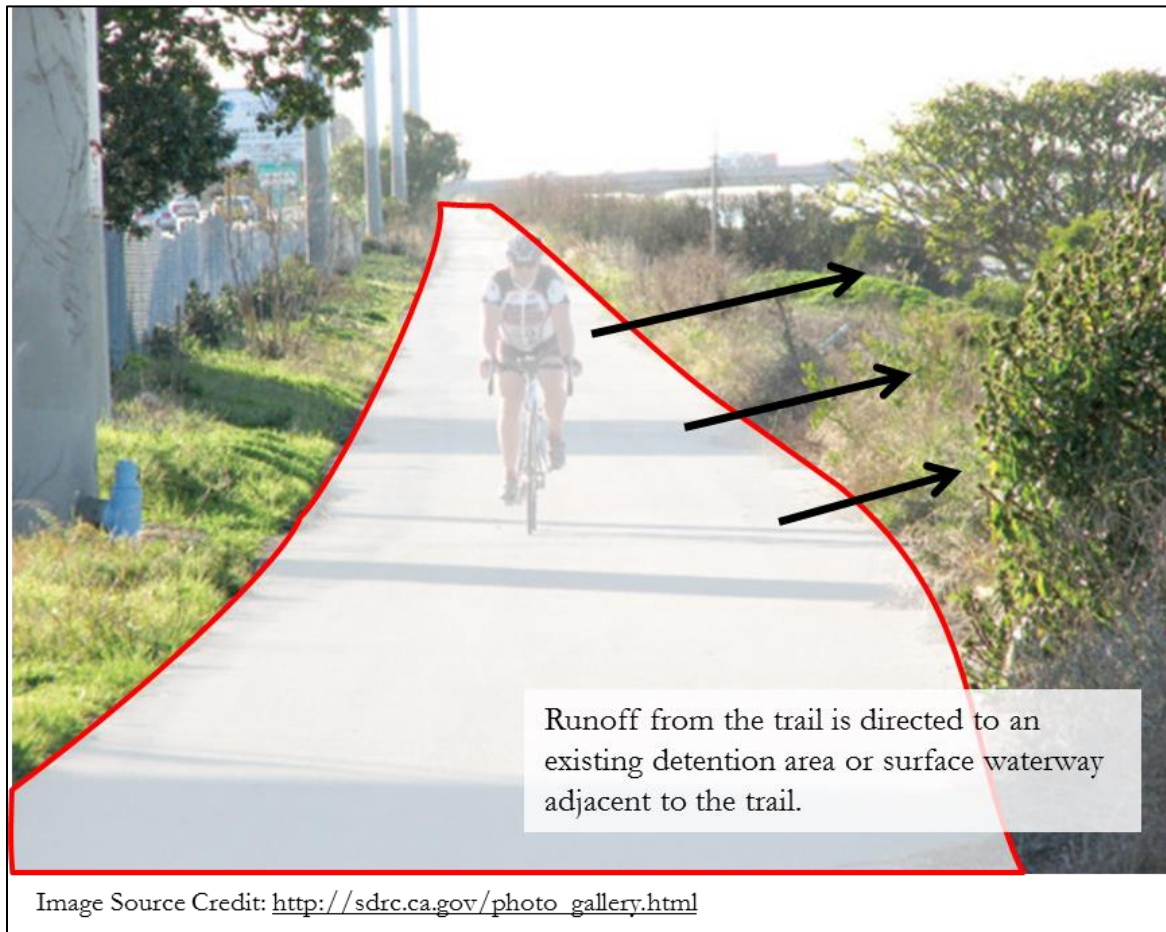


Figure K.1-3 : Schematic of a trail where the runoff does not comingle with street or road runoff

K.1.3 Permeable Pavements/Surfaces Guidance

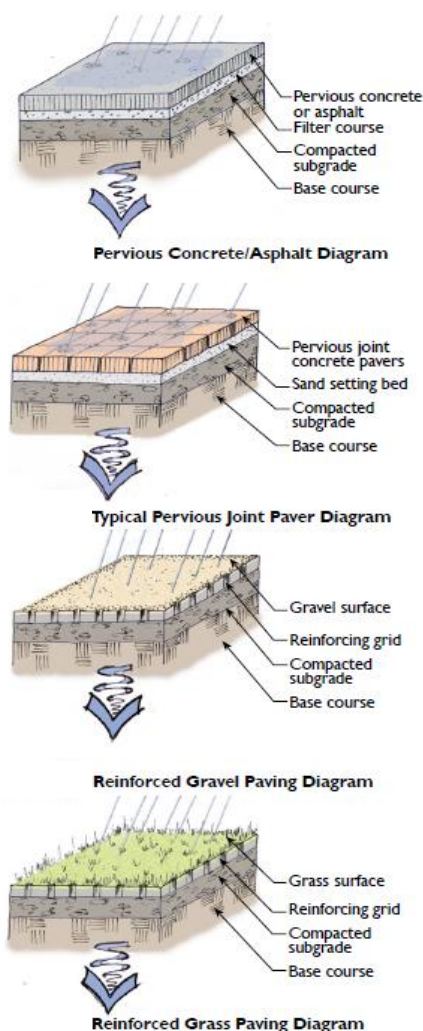
Permeable pavements or surfaces allow rainwater to pass through the surface and soak into the underlying ground. These help in reducing the amount of stormwater runoff generated. These surfaces should not be used where infiltration of stormwater runoff causes geotechnical or groundwater concerns, including in areas with shallow groundwater (refer to Appendix C). However, it should be noted that where permeable surfaces receive only direct rainfall, the total water loading per area is not typically higher than other pervious areas of the site and should generally pose limited risk associated with stormwater infiltration. No exemption is granted if the permeable pavement is lined with an impermeable liner. The following provides general guidelines for implementation of permeable pavements/surfaces:

Pervious Asphalt and Concrete: Pervious asphalt and concrete production is similar to that of standard asphalt and concrete. The main difference is that the fines are left out of the aggregate added to the mixture. This results in small holes within the paving that allows water to drain through the surface. Unlike traditional asphalt surfaces, pervious asphalt surfaces are not sealed. Regular maintenance of pervious asphalt and concrete is required for the long-term viability of the paving system.

Pervious Joint Pavers: Any type of paver can create a pervious surface if there are spaces between them and those spaces are filled with sand or other porous aggregate. Many interlocking concrete unit pavers are designed specifically for stormwater management applications. They allow water to pass through joint gaps that are filled with sand or gravel and infiltrate into a thick gravel subgrade. It is important to note that selected pervious joint pavers along pedestrian walkways must be ADA-compliant and not cause tripping hazards. Regular vacuum cleaning of the paver joints will help prevent clogging and extend the longevity of the system.

Reinforced Gravel Paving: A gravel paving system uses small, angular gravel without the fines and a structure that helps provide support to create a rigid surface. Gravel can be a viable alternative to a traditional paved surface in areas of low use that still require a rigid surface.

Reinforced Grass Paving: In the right situations, grass paving, or other hybrids between paving and planting, can be used to



Source Credit: San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook (adapted)

provide structural support while also allowing for some plant growth and stormwater infiltration. These systems may be appropriate in areas of low use and where soil, drainage, sunlight, and other conditions are conducive to plant growth.

K.2 Green Streets Exemption

As provided by MS4 Permit Provision E.3.b.(3), certain projects may be exempted from being defined as PDPs provided that they are designed and constructed in accordance with USEPA Green Streets Guidance.¹¹ The USEPA Green Streets Guidance provides direction on types of BMPs to be included in projects, but it does not provide direction on numeric sizing of BMPs or some other practical implementation aspects of designing green street projects. This appendix provides additional direction for the design of green street projects so that project proponents may incorporate features consistent with the USEPA Green Streets Guidance in accordance with the maximum extent practicable (MEP) standard.

This appendix is applicable only to projects that meet the criteria in Section 1.4.3 of the Port of San Diego BMP Design Manual. These projects are referred to in this appendix as “applicable Green Streets projects.” Generally the entire project must qualify as a green street in order to use the Green Street Exemption. When a private PDP is conditioned to complete improvements in the public right-of-way (e.g., street or sidewalk improvements), the public improvements may be considered a separate project that is eligible to use the Green Street Exemption provided that the public improvements meet the criteria in Section 1.4.3. The private improvements would need to meet PDP standards.

K.2.1 Site Assessment Considerations

Site assessment, including conceptual site layout, for applicable Green Streets projects includes many of the same considerations as described in Sections 3 and 5 of the Port BMP Design Manual. In addition to those factors, specific elements which should be given special consideration in the site assessment process for applicable Green Streets include the following:

- **Ownership of land adjacent to right of ways.** The opportunity to provide storm water treatment may depend on the ownership of land adjacent to the right-of-way. Acquisition of additional right-of-way and/or access easements may be more feasible if land bordering the project is owned by relatively few land owners.
- **Location of existing utilities.** The location of existing storm drainage utilities can influence the opportunities for Green Streets infrastructure. For example, storm water planters can be designed to overflow along the curb-line to an existing storm drain inlet, thereby avoiding the infrastructure costs associated with an additional inlet. The location of other utilities will

¹¹ USEPA, 2008. “Managing Wet Weather with Green Infrastructure – Municipal Handbook: Green Streets”. http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_municipalhandbook_green_streets.pdf

influence the ability to plumb BMPs to storm drains, therefore, may limit the allowable placement of BMPs to only those areas where a clear pathway to the storm drain exists.

- **Grade differential between road surface and storm drain system.** Some BMPs require more head from inlet to outlet than others; therefore, allowable head drop may be an important consideration in BMP selection. Storm drain elevations may be constrained by a variety of factors in a roadway project (utility crossings, outfall elevations, sites located over or on water, etc.) that cannot be overcome and may override storm water management considerations.
- **Longitudinal slope.** The suite of LID BMPs which may be installed on steeper road sections is more limited. Specifically, permeable pavement and swales are more suitable for gentle grades. Other BMPs may be more readily terraced to be used on steeper slopes.
- **Potential access opportunities.** A significant concern with installation of BMPs in major rights-of-way is the ability to access the BMPs safely for maintenance considering traffic hazards. The site assessment should identify vehicle travel lanes and areas of specific safety hazards for maintenance crews, and subsequent steps of the SWQMP preparation process should attempt to avoid placing BMPs in these areas.
- **Suitability for infiltration and geotechnical considerations.** Infiltration may be considered for applicable Green Streets projects provided that infeasibility screening criteria are observed, with specific attention to protection of groundwater quality as discussed in Appendices C and E and to the structural integrity of adjacent road bed. Impermeable liners and/or root barriers may need to be included in the design of LID BMPs to protect surrounding utilities and infrastructure.
- **Street Category.** As listed in Table K-1, suitability of different BMPs for green street design varies depending on the category of street. For example, infiltration BMPs are generally not suitable for high traffic roadways.
- **Traffic Safety and Emergency Vehicle Access.** LID BMPs for green street design should not be selected and sited where they would compromise traffic safety or emergency access.

K.2.2 BMP Selection and Site Design for Applicable Green Streets Projects

The fundamental tenets of the approach described by the USEPA Green Streets Guidance include:

- Selecting LID BMPs to the opportunities of the site and to attempt to address pollutants of concern and HCOCs,
- Developing innovative storm water management configurations integrating “green” with “grey” infrastructure,
- Sizing BMPs opportunistically to provide storm water pollution reduction to the MEP, accounting for the many competing considerations in rights of way.

Applicable Green Streets projects should apply the following LID site design measures to the MEP and as specified in the local permitting agency's codes, where feasible:

- Minimize street width to the appropriate minimum width for maintaining traffic flow and public safety.
- Add tree canopy by planting or preserving trees/shrubs.

Applicable Green Streets projects should select BMPs consistent with the USEPA Green Streets Guidance. Table K-1 provides an inventory of LID BMPs which may be appropriate for applicable Green Streets projects. The performance criteria for applicable Green Streets projects do not require retention BMPs to be considered to the MEP before considering biotreatment and treatment control BMPs. A formal process of BMP prioritization and selection is not required for applicable Green Streets projects. However, if retention BMPs are selected, geotechnical and groundwater information must be provided to confirm that the BMPs are feasible. See geotechnical and groundwater investigation requirements in Appendix C and BMP fact sheets in Appendix E for additional details.

BMPs should be prioritized based on a comparison of drainage area characteristics to the opportunity criteria listed in Table K-1. The USEPA Green Streets Guidance describes how some of these BMPs may be used in combination to achieve optimal benefits in runoff reduction and water quality improvement. Specific examples and applications for residential streets, commercial streets, arterials streets, and alleys are provided in the USEPA guidance.

The drainage patterns of the project should be developed so that drainage can be routed to areas with BMP opportunities before entering storm drains. For example, if a median strip is present, a reverse crown should be considered, where allowed, so that storm water can drain to a storm water treatment feature in the median. Likewise, standard peak-flow curb inlets should be located downstream of areas with potential for storm water planters so that water can first flow into the planter, and then overflow to the downstream inlet if capacity of the planter is exceeded. It is more difficult to apply green infrastructure after water has entered the storm drain.

Conceptual drainage plans for redevelopment projects should identify tributary areas outside of the project site generates runoff that comingles with on-site runoff. The project is not required to treat off-site runoff; however treatment of comingled off-site runoff may be used to off-set the inability to treat areas within the project for which significant constraints prevent the ability to provide treatment.

Table K-1: Potential BMPs for Applicable Green Streets Projects

BMP Type ¹	Fact Sheet(s) ¹	Opportunity Criteria for Applicable Green Streets Projects
Tree wells, Canopy Interception	SD-1	<ul style="list-style-type: none"> • Access roads, residential streets, local roads and minor arterials • Drainage infrastructure, sea walls/break waters • Effective for projects with any slope • Trees may be prohibited along high speed roads for safety reasons or must be setback behind the clear zone or protected with guard rails and barriers
Permeable Pavement	SD-D (Site Design), INF- 3 (Sized for Pollution Control)	<ul style="list-style-type: none"> • Parking and sidewalk areas of residential streets, and local roads • Should not receive significant run-on from major roads • Should not receive significant run-on from areas anticipated to have high sediment loads in runoff (e.g., sparsely vegetated steep slopes). • Should not be subject to heavy truck/ equipment traffic • Light vehicle access roads • Vacuum street sweepers typically required for maintenance
Infiltration Basin or Trench ²	INF-1 ²	<ul style="list-style-type: none"> • Constrained ROWs • Can require small footprint where soils are suitable • Low to moderate traffic roadways • Not suitable for high traffic roadways • Requires robust pretreatment • May be designed with decorative rock surface layer that requires no landscaping or irrigation
Bioretention Curb Extensions / Storm Water Planters	INF-2 (Bioretention), PR-1 (Biofiltration with Partial Retention), BF-1 (Biofiltration)	<ul style="list-style-type: none"> • Access roads, residential streets, and local roads with parallel or angle parking and sidewalks • Can be designed to overflow back to curblane and to standard inlet • Shape is not important and can be integrated wherever unused space exists • Can be installed on relatively steep grades with terracing • Curb extensions are beneficial where traffic calming is a desired project objective • Parkways or medians are potential locations for storm water planters, provided adequate space is available • Features typically require landscaping and irrigation

Table K-1: Potential BMPs for Applicable Green Streets Projects

BMP Type ¹	Fact Sheet(s) ¹	Opportunity Criteria for Applicable Green Streets Projects
Vegetated Swales	FT-1	<ul style="list-style-type: none">• Roadways with low to moderate slope• Residential streets with minimal driveway access• Minor to major arterials with medians or mandatory sidewalk set-back• Access roads• Swales running parallel to storm drain can have intermittent discharge points to reduce required flow capacity• Use of media in place of native soil is suggested where it will improve pollutant removal, where feasible• Features require landscaping and irrigation
Proprietary Biotreatment ³	BF-3; FT-5 (guidance provided by manufacturer)	<ul style="list-style-type: none">• Constrained ROWs• Typically have small footprint to tributary area ratio• Simple installation and maintenance• Can be installed on roadways of any slope• Can be designed to overflow back to curb line and to standard inlet

Notes:

1. Other BMPs not listed in this table, or BMPs in this table designed in accordance with other green street or LID design manuals, may also be approved at the discretion of the Port.
2. Fact sheet INF-1 provides direction for the design of infiltration basins. For more information on the design of infiltration trenches, see CASQA fact sheet TC-10 (<https://www.casqa.org/sites/default/files/BMPHandbooks/TC-10.pdf>).
3. This category includes proprietary BMPs that have a similar appearance to or treatment mechanism as tree wells or storm water planters. Proprietary BMPs that use soil media to filter runoff but do not include plants may be used. However, this category does not include proprietary BMPs that do not use vegetation or soil media to provide treatment, such as underground cartridge filter systems.

K.2.3 BMP Sizing for Applicable Green Streets Projects

The following steps are used to size BMPs for applicable Green Streets projects:

1. Delineate drainage management areas (DMA) tributary to BMP locations.
2. Based on project area characteristics, including those listed in Section K.1 above, select one or more BMPs that may be feasible for the proposed project.
 - a. Tree wells (SD-1) and permeable pavement (SD-D) may be used as site design measures to reduce the amount of runoff to be treated by other BMPs.

3. Look up the recommended sizing method for the BMP(s) selected in each DMA based on the appropriate BMP fact sheet(s) from Appendix E, and calculate the target capacity for each BMP as directed in Appendix B, and/or F, as needed. Although the use of green street elements also typically results in flow control benefits, sizing calculations are based on providing storm water pollutant control only.
 - a. For most BMPs, the target capacity is the design capture volume (DCV). Applicable Green Streets projects that incorporate biofiltration should be sized at 1.5 times the DCV, consistent with PDP sizing requirements.
 - b. Flow-thru BMPs must be sized using the flow-thru BMP sizing method described in Appendix B.
4. Design BMPs per the guidance provided in the BMP fact sheets (Appendix E).
5. Attempt to provide the target capacity calculated based on the appropriate sizing criteria for each selected BMP.
 - a. Often it may be difficult to locate BMPs onsite (within the project area) in a manner that treats runoff from the entire project area. In these cases, it is acceptable to use onsite BMPs to treat run-on from offsite area of similar land use to the project such that the entire target capacity, as calculated in Step 3, is treated. This approach is consistent with MS4 Permit requirements because it results in implementing BMPs listed in the USEPA Green Streets Guidance as part of the project.
6. If the target capacity cannot be fully provided, document the constraints that override the application of BMPs, and proceed through the steps listed below, documenting additional constraints where necessary. Applicable Green Streets projects are not required to meet alternative compliance options if storm water management controls described in this section, or equivalent, are installed in a manner consistent with the MEP standard.
 - a. Use offsite BMPs to treat the portion of the target capacity that cannot be treated onsite. The offsite BMPs must receive runoff from offsite area of similar land use to the project and should be located as close to the project site as possible, as described in item 5.a above.

OR

If “a” is not feasible, proceed to item “b” below.

- b. Provide onsite and/or offsite BMPs listed in Table K-1 sized to provide treatment for the largest portion of the target capacity that can be reasonably provided given constraints.

In some cases the required amount of treatment needed to meet the Green Streets standard may be less than the DCV associated with the entire tributary area to a BMP location. In these cases, the BMP must also be designed to avoid flooding and scour when considering the entire tributary area, and the designer must provide appropriate supporting calculations to demonstrate that any BMP sized for an area smaller than the entire upstream tributary area will not result in flooding or scour and that BMP

effectiveness will not be compromised.

For example, a BMP may be required to treat 15,000 square feet within the right-of-way but be installed at location that receives runoff from both that 15,000 square feet plus an additional 25,000 square feet of development outside the right-of-way. In this type of scenario, the BMP treatment capacity may be designed only for the 15,000 square feet of project area in the tributary area. The designer would also need to show that when considering the runoff from the entire drainage area of 40,000 square feet, the BMP does not cause flooding for high peak flows (as required by flood control sizing standards), scour does not occur within the BMP, and higher flow rates, volumes, or velocities associated with the entire tributary area to the BMP do not result in decreased BMP effectiveness for the design treatment flow rate or volume.

Glossary of Key Terms

50% Rule	Refers to an MS4 Permit standard for redevelopment PDPs (PDPs on previously developed sites) that defines whether the redevelopment PDP must meet storm water management requirements for the entire development or only for the newly created or replaced impervious surface. Refer to Section 1.7 .
Aggregate	Hard, durable material of mineral origin typically consisting of gravel, crushed stone, crushed quarry or mine rock. Gradation varies depending on application within a BMP as bedding, filter course, or storage.
Aggregate Storage Layer	Layer within a BMP that serves to provide a conduit for conveyance, detention storage, infiltration storage, saturated storage, or a combination thereof.
Alternative Compliance Programs	A program that allows PDPs to participate in an offsite mitigation project in lieu of implementing the onsite structural BMP performance requirements required under the MS4 Permit. Refer to Section 1.8 for more information on alternative compliance programs.
Bed Sediment	The part of the sediment load in channel flow that moves along the bed by sliding or saltation, and part of the suspended sediment load, that principally constitutes the channel bed.
Bedding	Aggregate used to establish a foundation for structures such as pipes, manholes, and pavement.
Biodegradation	Decomposition of pollutants by biological means.
Biofiltration BMPs	Biofiltration BMPs are shallow basins filled with treatment media and drainage rock that treat storm water runoff by capturing and detaining inflows prior to controlled release through minimal incidental infiltration, evapotranspiration, or discharge via underdrain or surface outlet structure. Treatment is achieved through filtration, sedimentation, sorption, biochemical processes and/or vegetative uptake. These BMPs must be sized to:[a] Treat 1.5 times the DCV not reliably retained onsite, OR[b] Treat the DCV not reliably retained

onsite with a flow-thru design that has a total volume, including pore spaces and pre-filter detention volume, sized to hold at least 0.75 times the portion of the DCV not reliably retained onsite. (See **Section 5.5.3** and **Appendix B.5** for illustration and additional information).

Biofiltration Treatment Treatment from a BMP meeting the biofiltration standard.

Biofiltration with Partial Retention BMPs Biofiltration with partial retention BMPs are shallow basins filled with treatment media and drainage rock that manage storm water runoff through infiltration, evapotranspiration, and biofiltration. Partial retention is characterized by a subsurface stone infiltration storage zone in the bottom of the BMP below the elevation of the discharge from the underdrains. The discharge of biofiltered water from the underdrain occurs when the water level in the infiltration storage zone exceeds the elevation of the underdrain outlet. (See **Section 5.5.2.1** for illustration and additional information).

Bioretention BMPs Vegetated surface water systems that filter water through vegetation and soil, or engineered media prior to infiltrating into native soils. Bioretention BMPs in this manual retain the entire DCV prior to overflow to the downstream conveyance system. (See **Section 5.5.1.2** for illustration and additional information).

BMP A procedure or device designed to minimize the quantity of runoff pollutants and / or volumes that flow to downstream receiving water bodies. Refer to **Section 2.2.2.1**.

BMP Sizing Calculator An on-line tool that was developed under the 2007 MS4 Permit to facilitate the sizing factor method for designing flow control BMPs for hydromodification management. The BMP Sizing Calculator has been discontinued as of June 30, 2014.

Cistern A vessel for storing water. In this manual, a cistern is typically a rain barrel, tank, vault, or other artificial reservoir.

Coarse Sediment Yield Area A GLU with coarse-grained geologic material (material that is expected to produce greater than 50% sand when weathered). See the following terms modifying coarse sediment yield area: critical, potential critical.

Compact Biofiltration BMP	A biofiltration BMP, either proprietary or non-proprietary in origin, that is designed to provide storm water pollutant control within a smaller footprint than a typical biofiltration BMP, usually through use of specialized media that is able to efficiently treat high storm water inflow rates.
Conditions of Approval	Requirements a jurisdiction may adopt for a project in connection with a discretionary action (e.g., issuance of a use permit). COAs may include features to be incorporated into the final plans for the project and may also specify uses, activities, and operational measures that must be observed over the life of the project.
Contemporary Design Standards	This term refers to design standards that are reasonably consistent with the current state of practice and are based on desired outcomes that are reasonably consistent with the context of the MS4 Permit and Model BMP Design Manual. For example, a detention basin that is designed solely to mitigate peak flow rates would not be considered a contemporary water quality BMP design because it is not consistent with the goal of water quality improvement. Current state of the practice recognizes that a drawdown time of 24 to 72 hour is typically needed to promote settling. For practical purposes, design standards can be considered “contemporary” if they have been published within the last 10 years, preferably in California or Washington State, and are specifically intended for storm water quality management.
Continuous Simulation Modeling	A method of hydrological analysis in which a set of rainfall data (typically hourly for 30 years or more) is used as input, and a continuous runoff hydrograph is calculated over the same time period. Continuous simulation models track dynamic soil and storage conditions during and between storm events. The output is then analyzed statistically for the purposes of comparing runoff patterns under different conditions (for example, pre- and post-development-project).
Copermittees	See Jurisdiction.
Critical Channel Flow (Qc)	The channel flow that produces the critical shear stress that initiates bed movement or that erodes the toe of channel banks. When measuring Qc, it should be based on the weakest boundary material – either bed or bank.

Critical Coarse Sediment Yield Areas	A GLU with coarse-grained geologic material and high relative sediment production, where the sediment produced is critical to the receiving stream (a source of bed material to the receiving stream). See also: potential critical coarse sediment yield area.
Critical Shear Stress	The shear stress that initiates channel bed movement or that erodes the toe of channel banks. See also critical channel flow.
DCV	A volume of storm water runoff produced from the 85th percentile, 24-hour storm event. See Section 2.2.2.2 .
De Minimis DMA	De minimis DMAs are very small areas that are not considered to be significant contributors of pollutants, and are considered not practicable to drain to a BMP. See Section 5.2.2 .
Depth	The distance from the top, or surface, to the bottom of a BMP component.
Detention	Temporarily holding back storm water runoff via a designed outlet (e.g., underdrain, orifice) to provide flow rate and duration control.
Detention Storage	Storage that provides detention as the outflow mechanism.
Development Footprint	The limits of all grading and ground disturbance, including landscaping, associated with a project.
Development Project	Construction, rehabilitation, redevelopment, or reconstruction of any capital or tenant projects. Includes both new development and redevelopment. Also includes whole of the action as defined by CEQA. See Section 1.3 .
Direct Discharge	The connection of project site runoff to an exempt receiving water body, which could include an exempt river reach, reservoir or lagoon. To qualify as a direct discharge, the discharge elevation from the project site outfall must be at or below either the normal operating water surface elevation or the reservoir spillway elevation, and properly designed energy dissipation must be provided. “Direct discharge” may be more specifically defined by each municipality.

Direct Infiltration	Infiltration via methods or devices, such as dry wells or infiltration trenches, designed to bypass the mantle of surface soils that is unsaturated and more organically active and transmit runoff directly to deeper subsurface soils.
DMA	See Section 3.3.3 .
Drawdown Time	The time required for a storm water detention or infiltration facility to drain and return to the dry-weather condition. For detention facilities, drawdown time is a function of basin volume and outlet orifice size. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate.
Enclosed Embayments (Enclosed Bays)	Enclosed bays are indentations along the coast that enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between the headlands or outermost bay works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. Enclosed bays do not include inland surface waters or ocean waters. In San Diego: Mission Bay and San Diego Bay.
Environmentally Sensitive Areas (ESAs)	Areas that include but are not limited to all Clean Water Act Section 303(d) impaired water bodies; areas designated as Areas of Special Biological Significance by the State Water Board and San Diego Water Board; State Water Quality Protected Areas; water bodies designated with the RARE beneficial use by the State Water Board and San Diego Water Board; and any other equivalent environmentally sensitive areas which have been identified by the Copermittees.
Filter Course	Aggregate used to prevent particle migration between two different materials when storm water runoff passes through.
Filter Fabric	A permeable textile material, also termed a non-woven geotextile, that prevents particle migration between two different materials when storm water runoff passes through.
Filtration	Controlled seepage of storm water runoff through media, vegetation, or aggregate to reduce pollutants via physical separation.
Flow Control	Control of runoff rates and durations as required by the HMP.

Flow Control BMP	A structural BMP designed to provide control of post-project runoff flow rates and durations for the purpose of hydromodification management.
Flow-thru Treatment	Treatment from a BMP meeting the flow-thru treatment control standard.
Flow-Thru Treatment BMPs	Flow-thru treatment control BMPs are structural, engineered facilities that are designed to remove pollutants from storm water runoff using treatment processes that do not incorporate significant biological methods. Flow-thru BMPs include vegetated swales, media filters, sand filters, and dry extended detention basins. (See Section 5.5.4 for illustration and additional information).
Forebay	An initial storage area at the entrance to a structural BMP designed to trap and settle out solid pollutants such as sediment in a concentrated location, to provide pre-treatment within the structural BMP and facilitate removal of solid pollutants during maintenance operations.
Full Infiltration	Infiltration of a storm water runoff volume equal to the DCV.
Geomorphic Assessment	A quantification or measure of the changing properties of a stream channel.
Geomorphically Significant Flows	Flows that have the potential to cause, or accelerate, stream channel erosion or other adverse impacts to beneficial stream uses. The range of geomorphically significant flows was determined as part of the development of the March 2011 Final HMP, and has not changed under the 2013 MS4 Permit. However, under the 2013 MS4 Permit, Q2 and Q10 must be based on the pre-development condition rather than the pre-project condition, meaning that no pre-project impervious area may be considered in the computation of pre-development Q2 and Q10.
GLUs	Classifications that provide an estimate of sediment yield based upon three factors: geology, hillslope, and land cover. GLUs are developed based on the methodology presented in the SCCWRP Technical Report 605 titled “Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge” (SCCWRP, 2010).

Gross Pollutants	In storm water, generally litter (trash), organic debris (leaves, branches, seeds, twigs, grass clippings), and coarse sediments (inorganic breakdown products from soils, pavement, or building materials).
Harvest and Use BMP	Harvest and use (aka rainwater harvesting) BMPs capture and store storm water runoff for later use. These BMPs are engineered to store a specified volume of water and have no design surface discharge until this volume is exceeded. (See Section 5.5.1.1 for illustration and additional information).
HMP	A plan implemented by the Copermittees so that post-project runoff shall not exceed estimated pre-development rates and/or durations by more than 10%, where increased runoff would result in increased potential for erosion or other adverse impacts to beneficial uses. The March 2011 Final HMP and the updated MS4 Permit are the basis of the flow control requirements of this manual.
Hungry Water	Also known as "sediment-starved" water, "hungry" water refers to channel flow that is hungry for sediment from the channel bed or banks because it currently contains less bed material sediment than it is capable of conveying. The "hungry water" phenomenon occurs when the natural sediment load decreases and the erosive force of the runoff increases as a natural counterbalance, as described by Lane's Equation.
Hydraulic Head	Energy represented as a difference in elevation, typically as the difference between the inlet and outlet water surface elevation for a BMP.
Hydraulic Residence Time	The length of time between inflow and outflow that runoff remains in a BMP.
Hydrologic Soil Group	Classification of soils by the Natural Resources Conservation Service (NRCS) into A, B, C, and D groups according to infiltration capacity.

Hydromodification	<p>The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, installation of dams and water impoundments, and excessive stream-bank and shoreline erosion are also considered hydromodification, due to their disruption of natural watershed hydrologic processes.</p>
Hydromodification Management BMP	<p>A structural BMP for the purpose of hydromodification management, either for protection of critical coarse sediment yield areas or for flow control. See also flow control BMP.</p>
Impervious Surface	<p>Any material that prevents or substantially reduces infiltration of water into the soil.</p>
Infeasible	<p>As applied to BMPs, refers to condition in which a BMP approach is not practicable based on technical constraints specific to the site, including by not limited to physical constraints, risks of impacts to environmental resources, risks of harm to human health, or risk of loss or damage to property. Feasibility criteria are provided in this manual.</p>
Infiltration	<p>In the context of LID, infiltration is defined as the percolation of water into the ground. Infiltration is often expressed as a rate (inches per hour), which is determined through an infiltration test. In the context of non-storm water, infiltration is water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from, inflow [40 CFR 35.2005(20)].</p>
Infiltration BMP	<p>Infiltration BMPs are structural measures that capture, store and infiltrate storm water runoff. These BMPs are engineered to store a specified volume of water and have no design surface discharge (underdrain or outlet structure) until this volume is exceeded. These types of BMPs may also support evapotranspiration processes, but are characterized by having their most dominant volume losses due to infiltration. (See Section 5.5.1.2 for illustration and additional information).</p>

Jurisdiction	The term “jurisdiction” is used in this manual to refer to individual copermittees who have independent responsibility for implementing the requirements of the MS4 Permit.
LID	A storm water management and land development strategy that emphasizes conservation and the use of onsite natural features integrated with engineered, small-scale hydrologic controls to more closely reflect pre-development hydrologic functions. See Site Design .
Lower Flow Threshold	The lower limit of the range of flows to be controlled for hydromodification management. The lower flow threshold is the flow at which erosion of sediment from the stream bed or banks begins to occur. See also critical channel flow. For the San Diego region, the lower flow threshold shall be a fraction (0.1, 0.3, or 0.5) of the pre-development 2-year flow rate based on continuous simulation modeling (0.1Q2, 0.3Q2, or 0.5Q2).
Media	Storm water runoff pollutant treatment material, typically included as a permeable constructed bed or container (cartridge) within a BMP.
MEP	Refer to the definition in the MS4 Permit. [Appendix C, Definitions, Page C-6]
National Pollutant Discharge Elimination System	The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 318, 402, and 405 of the Clean Water Act.
New Development	Land disturbing activities; structural development, including construction or installation of a building or structure, the creation of impervious surfaces; and land subdivision.
O&M	Requirements in the MS4 Permit to inspect structural BMPs and verify the implementation of operational practices and preventative and corrective maintenance in perpetuity.
Partial Infiltration	Infiltration of a storm water runoff volume less than the DCV.
Partial Retention	Partial retention category is defined by structural measures that incorporate both infiltration (in the lower treatment zone) and biofiltration (in the upper treatment zone).

PDPs	As defined by the MS4 Permit provision E.3.b, land development projects that fall under the planning and building authority of the Copermittee for which the Copermittee must impose specific requirements in addition to those required of Standard Projects. Refer to Section 1.4 to determine if your project is a PDP.
PDPs with only Pollutant Control Requirements	PDPs that need to meet Source Control, Site Design and Pollutant Control Requirements (but are exempt from Hydromodification Management Requirements).
PDPs with Pollutant Control and Hydromodification Management Requirements	PDPs that need to meet Source Control, Site Design, Pollutant Control and Hydromodification Management Requirements.
Point of Compliance	1. For channel screening and determination of low flow threshold: the point at which collected storm water from a development is delivered from a constructed or modified drainage system into a natural or un-lined channel. POC for channel screening may be located onsite or offsite, depending on where runoff from the project meets a natural or un-lined channel. 2. For flow control: the point at which pre-development and post-development flow rates and durations will be compared. POC for flow control is typically onsite. A project may have a different POC for channel screening vs. POC for flow control if runoff from the project site is conveyed in hardened systems from the project site boundary to the natural or un-lined channel.
Pollutant Control	Control of pollutants via physical, chemical or biological processes
Pollution Prevention	Pollution prevention is defined as practices and processes that reduce or eliminate the generation of pollutants, in contrast to source control BMPs, treatment control BMPs, or disposal.
Post-Project Hydrology Flows, Volumes	The peak runoff flows and runoff volume anticipated after the project has been constructed taking into account all permeable and impermeable surfaces, soil and vegetation types and conditions after landscaping is complete, detention or retention basins or other water storage elements incorporated into the site design, and any other site features that would affect runoff volumes and peak flows.

Potential Critical Coarse Sediment Yield Area	A GLU with coarse-grained geologic material and high relative sediment production, as defined in the Regional WMAA. The Regional WMAA identified GLUs as potential critical coarse sediment yield areas based on slope, geology, and land cover. GLU analysis does not determine whether the sediment produced is critical to the receiving stream (a source of bed material to the receiving stream) therefore the areas are designated as potential.
Pre-Development Runoff Conditions	Approximate flow rates and durations that exist or existed onsite before land development occurs. For new development projects, this equates to runoff conditions immediately before any new project disturbance or grading. For redevelopment projects, this equates to runoff conditions from the project footprint assuming infiltration characteristics of the underlying soil, and existing grade. Runoff coefficients of concrete or asphalt must not be used. A redevelopment PDP must use available information pertaining to existing underlying soil type and onsite existing grade to estimate pre-development runoff conditions.
Pre-Project Condition	The condition prior to any project work or the existing condition. Note that pre-project condition and pre-development condition will not be the same for redevelopment projects.
Pretreatment	Removal of gross solids, including organic debris and coarse sediment, from runoff to minimize clogging and increase the effectiveness of BMPs.
Project Area	All areas proposed by an applicant to be altered or developed, plus any additional areas that drain on to areas to be altered or developed. Also see Section 1.3 .
Project Submittal	Documents submitted to a jurisdiction or Copermittee in connection with an application for development approval and demonstrating compliance with MS4 Permit requirements for the project. Specific requirements vary from municipality to municipality.
Proprietary BMP	BMP designed and marketed by private business for treatment of storm water. Check with Port prior to proposing to use a proprietary BMP.
Receiving Waters	See Waters of the United States .

Redevelopment	The creation and/or replacement of impervious surface on an already developed site. Examples include the expansion of a building footprint, road widening, and the addition to or replacement of a structure. Replacement of impervious surfaces includes any activity where impervious material(s) are removed, exposing underlying soil during construction. Redevelopment does not include routine maintenance activities, such as trenching and resurfacing associated with utility work; pavement grinding; resurfacing existing roadways, sidewalks, pedestrian ramps, or bike lanes on existing roads; and routine replacement of damaged pavement, such as pothole repair.
Retrofitting	Storm water management practice put into place after development has occurred in watersheds where the practices previously did not exist or are ineffective. Retrofitting of developed areas is intended to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Retrofitting developed areas may include, but is not limited to replacing roofs with green roofs, disconnecting downspouts or impervious surfaces to drain to pervious surfaces, replacing impervious surfaces with pervious surfaces, installing rain barrels, installing rain gardens, and trash area enclosures.
Regional Water Quality Control Board (San Diego Water Board)	California Water Boards are responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within their jurisdiction. There are nine California Water Boards.
Retention (Retention BMPs)	A category of BMP that does not have any service outlets that discharge to surface water or to a conveyance system that drains to surface waters for the design event (i.e. 85 th percentile 24-hour). Mechanisms used for storm water retention include infiltration, evapotranspiration, and use of retained water for non-potable or potable purposes.
Saturated Storage	Storage that provides a permanent volume of water at the bottom of the BMP as an anaerobic zone to promote denitrification and/or thermal pollution control. Also known as internal water storage or a saturation zone.
Self-mitigating Areas	A natural, landscaped, or turf area that does not generate significant pollutants and drains directly offsite or to the public storm drain system without being treated by a structural BMP. See Section 5.2.1 .

Self-retaining DMA via Qualifying Site Design BMPs	An area designed to retain runoff to fully eliminate storm water runoff from the 85 th percentile 24 hours storm event; See Section 5.2.3 .
SIC	A Federal government system for classifying industries by 4-digit code. It is being supplanted by the North American Industrial Classification System but SIC codes are still referenced by the Regional Water Board in identifying development sites subject to regulation under the National Pollutant Discharge Elimination System permit. Information and an SIC search function are available at https://www.osha.gov/pls/imis/sicsearch.html
Significant Redevelopment	Redevelopment that meets the definition of a “PDP” in this manual. See Section 1.4 .
Site Design	A storm water management and land development strategy that emphasizes conservation of natural features and the use of onsite natural features integrated with engineered, small-scale hydrologic controls to more closely reflect pre-development hydrologic functions.
Sizing Factor Method	A method for designing flow control BMPs for hydromodification management using sizing factors developed from unit area continuous simulation models.
Sorption	Physical and/or chemical process where pollutants are taken out of runoff through attachment to another substance.
Source Control	Land use or site planning practices, or structures that aim to prevent runoff pollution by reducing the potential for contamination at the source of pollution. Source control BMPs minimizes the contact between pollutants and storm water runoff. Examples include roof structures over trash or material storage areas, and berms around fuel dispensing areas. Source control BMPs are described within this manual.
Standard Project	Any development project that is not defined as a PDP by the MS4 Permit.

**Storm Water
Conveyance System**

A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or designated and approved management agency under section 208 of the Clean Water Act that discharges to waters of the United States; (ii) Designated or used for collecting or conveying storm water; (iii) Which is not a combined sewer; (iv) Which is not part of the Publicly Owned Treatment Works as defined at 40 CFR 122.26.

**Storm Water Pollutant
Control BMP**

A category of storm water management requirements that includes treatment of storm water to remove pollutants by measures such as retention, biofiltration, and/or flow-thru treatment control, as specified in this manual. Also called a Pollutant Control BMP.

Structural BMP

Throughout the manual, the term "structural BMP" is a general term that encompasses the pollutant control BMPs and hydromodification BMPs required for PDPs under the MS4 Permit. A structural BMP may be a pollutant control BMP, a hydromodification management BMP, or an integrated pollutant control and hydromodification management BMP. Structural BMPs as defined in the MS4 Permit are: a subset of BMPs which detains, retains, filters, removes, or prevents the release of pollutants to surface waters from development projects in perpetuity, after construction of a project is completed.

Subgrade

In-situ soil that lies underneath a BMP.

Tributary Area

The total surface area of land or hardscape that contributes runoff to the BMP; including any offsite or onsite areas that comingles with project runoff and drains to the BMP. Refer to **Section 3.3.3** for additional guidance Also termed the drainage area or catchment area.

**Unified BMP Design
Approach**

This term refers to the standardized process for site and watershed investigation, BMP selection, BMP sizing, and BMP design that is outlined and described in this manual with associated appendices and templates. This approach is considered to be “unified” because it represents a pathway for compliance with MS4 Permit requirements that is anticipated to be reasonably consistent across the local jurisdictions in San Diego County. In contrast, applicants may choose to take an alternative approach where they demonstrate to the satisfaction of the Port, in their submittal, compliance with applicable performance standards without necessarily following the process identified in this manual.

Upper Flow Threshold

The upper limit of the range of flows to be controlled for hydromodification management. For the San Diego region, the upper flow threshold shall be the pre-development 10-year flow rate (Q10) based on continuous simulation modeling.

Vactor

Refers to a sewer or storm drain cleaning truck equipped to remove materials from sewer or storm drain pipes or structures, including some storm water BMPs.

Vector

An animal or insect capable of transmitting the causative agent of human disease. An example of a vector in San Diego County that is of concern in storm water management is a mosquito.

**Water Quality
Improvement Plan**

Copermittees are required to develop a Water Quality Improvement Plan for each Watershed Management Area in the San Diego Region. The purpose of the Water Quality Improvement Plans is to guide the Copermittees’ jurisdictional runoff management programs towards achieving the outcome of improved water quality in MS4 discharges and receiving waters. WQIPs requirements are defined in the MS4 Permit provision B.

Waters of the United States

Surface bodies of water, including naturally occurring wetlands, streams (perennial, intermittent, and ephemeral (exhibiting bed, bank, and ordinary high water mark)), creeks, rivers, reservoirs, lakes, lagoons, estuaries, harbors, bays and the Pacific Ocean which directly or indirectly receive discharges from storm water conveyance systems. The Port shall determine the definition for wetlands and the limits thereof for the purposes of this definition, which shall be as protective as the Federal definition utilized by the United States Army Corps of Engineers and the United States Environmental Protection Agency. Constructed wetlands are not considered wetlands under this definition, unless the wetlands were constructed as mitigation for habitat loss. Other constructed BMPs are not considered receiving waters under this definition, unless the BMP was originally constructed within the boundaries of the receiving waters. Also see MS4 permit definition.

Watershed Management Area

The ten areas defined by the San Diego Water Board in Regional MS4 Permit provision B.1, Table B-1. Each Watershed Management Area is defined by one or more Hydrologic Unit, major surface water body, and responsible Copermittee.

Watershed Management Area Analysis

For each Watershed Management Area, the Copermittees have the option to perform a WMAA for the purpose of developing watershed-specific requirements for structural BMP implementation. Each WMAA includes: GIS layers developed to provide physical characteristics of the watershed management area, a list of potential offsite alternative compliance projects, and areas exempt from hydromodification management requirements.