THE CITY OF SAN DIEGO

Storm Water Standards

PART 1

BMP Design Manual: Chapters For Permanent Site Design, Storm Water Treatment and Hydromodification Management

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The City of SAN DIEGO

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Summary

In May 2013, the California Regional Water Quality Control Board for the San Diego Region reissued (SDRWQCB) a municipal storm water, National Pollutant Discharge Elimination System permit (Municipal Separate Storm Sewer Systems [MS4] Permit) that covered its region. The San Diego Region is comprised of San Diego, Orange, and Riverside County Copermittees. The MS4 Permit reissuance to the San Diego County Copermittees went into effect in 2013 (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 in February 2015 by Order R9-2015-0001, and again in November 2015 by Order R9-2015-0100. As required by the reissued MS4 Permit, the Copermittees have prepared the 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 is available for download at www.projectcleanwater.org.

The City of San Diego (City) is required to adopt jurisdiction[1] specific local BMP Design Manual. Part 1 of the Storm Water Standards is the adaption of the Model BMP Design Manual to the specific considerations for development projects within the City jurisdiction. Part 1 of the Storm Water Standards is designated as the City of San Diego BMP Design Manual ("manual"); this manual significantly conforms to the Model BMP Design Manual and will continue to be used in its present form until the next required permit update.

What this manual is intended to address:

This manual addresses, and provides guidance for complying with, 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 this manual include project applicants, for both private and public developments, their representatives responsible for preparation of Storm Water Quality Management Plans (SWQMPs) and the City staff personnel responsible for review of these plans and associated documents.

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.

[1] The term "jurisdiction" is used to refer to individual copermittees who have independent responsibility for implementing the requirements of 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 explicitly 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 conditions (natural) rather than pre-project conditions.
- 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 curve is revised. Sizing factors were updated.
- 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 flow control performance standards. Project applicants may be allowed to participate in an alternative compliance program without demonstrating technical infeasibility of retention and/or biofiltration BMPs onsite. In such case, they must also provide flow-thru treatment control BMPs on the project site.

Disclaimer:

Currently, the City along with several other Copermittees is 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. General City 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, PDP Exempt 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, PDP Exempt 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 and PDP Exempt Projects may use this chapter as a reference.**

Chapter 8 describes the specific requirements for the content of project submittals to facilitate City's review of project plans for compliance with applicable requirements of the manual and the MS4 Permit. This chapter is applicable to Standard Projects, PDP Exempt Projects, and PDPs. This chapter pertains specifically to the content of project submittals, and not to specific details of City 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 Standard Projects, PDP Exempt 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, PDP Exempt 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.

Chronology of Storm Water Regulations and San Diego Region Model Guidance Documents

Date	Document	Notes
July 16, 1990	MS4 Permit	The SDRWQCB issued general storm water requirements to all jurisdictions within the County of San Diego via the MS4 Permit
February 21, 2001	MS4 Permit	Land Development SUSMP requirements were written into the MS4 Permit during permit reissuance
February 14, 2002	Model SUSMP	Countywide model guidance document was issued for implementation of the 2001 MS4 Permit requirements
January 24, 2007	MS4 Permit	LID and HMP requirements were written into the MS4 Permit during reissuance
July 24, 2008	Model SUSMP	Countywide model guidance document for implementation of the 2007 MS4 Permit requirements, including interim HMP criteria, was prepared
March 2011	Final HMP	Final HMP addresses HMP requirements of the 2007 MS4 Permit
March 25, 2011	Model SUSMP	Countywide model guidance document for implementation of the 2007 MS4 Permit requirements, including final HMP, was completed
May 8, 2013	MS4 Permit	Storm water retention requirements and requirements for protection of critical coarse sediment yield were written into the MS4 Permit during reissuance
February 11, 2015	MS4 Permit	Amends 2013 MS4 permit and provides clarification on water quality equivalency and provides other technical revisions.
June 27, 2015	Model BMP Design Manual	Countywide model guidance document for implementation of the MS4 Permit requirements "Model BMP Design Manual" updates former "Model SUSMP"
November 18, 2015	MS4 Permit	Amends 2013 MS4 permit including revisions to PDP definitions, definition of redevelopment and updates to storm water requirements applicability timeline.
December 17, 2015	Water Quality Equivalency Guidance (WQE)	Region 9 wide guidance establishing a mechanism to correlate quantifiable Alternative Compliance Project benefits with Priority Development Projects
February 2016	Water Quality Improvement Plans (WQIPs)	SDRWQCB accepted WQIPs for the six City WMAs (San Dieguito, Los Peñasquitos, Mission Bay, San Diego River, San Diego Bay, and Tijuana River). This authorizes the City to allow hydromodification management exemptions identified through WMAA in WQIPs and offsite storm water alternative compliance program for PDPs within City's jurisdiction.
February 16, 2016	Model BMP Design Manual	Updates to June 27, 2015 version include updated PDP definitions and definition of redevelopment, updates to storm water requirements applicability timeline, and updates to hydromodification management performance criteria and procedures.

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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
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
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)
SC	Source Control
SCCWRP	Southern California Coastal Water Research Project
SD	Site Design
SDHM	San Diego Hydrology Model
SDRWQCB	San Diego Regional Water Quality Control Board
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

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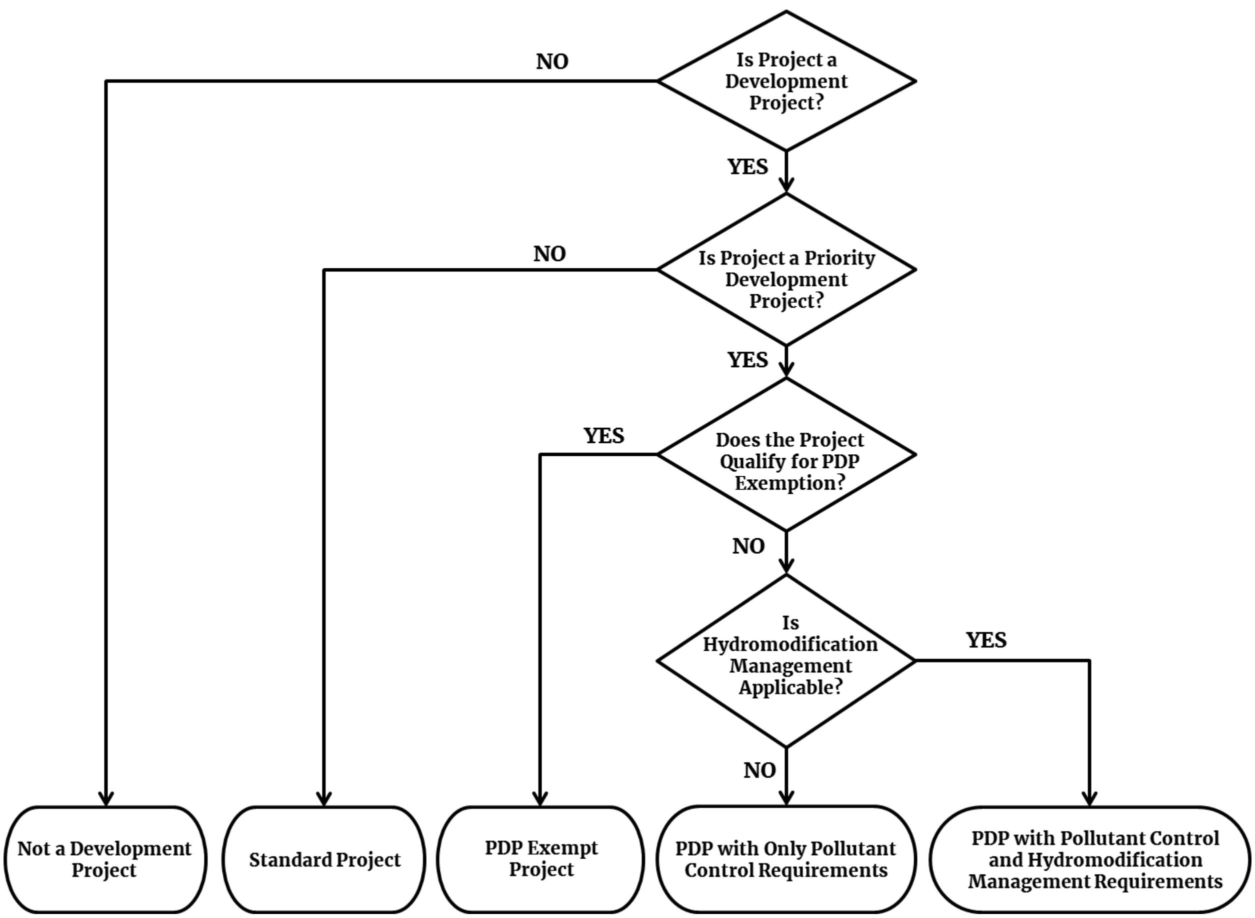
How to Use this Manual

This manual is intended to help a project applicant, in coordination with the City storm water program staff, develop a SWQMP for a development project (public or private) 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. The applicant should begin by checking specific requirements with the City storm water program staff, because every project is different.

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" (refer also to local requirements) 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 in the City. **Chapter 1** also provides an overview of the process of planning, design, construction, operation, and maintenance, with associated City 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 and PDP Exempt Projects	☑		
PDPs with only Pollutant Control Requirements	☑	☑	
PDPs with Pollutant Control and Hydromodification Management Requirements	☑	☑	☑

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 described in **Chapters 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 submittals at the appropriate time in the City 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/PDP Exempt Projects	PDPs
• Standard Projects will proceed to **Chapter 4** for guidance on implementing general, source control and site design requirements. • After **Chapter 4**, Standard Projects will proceed to **Chapter 8** for project submittal requirements.	• PDPs will also proceed to **Chapter 4** for guidance on implementing general, source control and site design requirements. • 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.

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 classified as "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).
- 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 ultimate property owner, and include design measures to ensure access for maintenance and to control maintenance costs (see **Chapter 7**).

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Chapter 1

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 local jurisdictions.

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, including the City of San Diego (City), 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 or location 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 approach[2] that meets the performance standards specified in the MS4 Permit. By following the process outlined in this manual, project applicants (for both private and public 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. **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**.

<u>Alternative BMP design approaches that meet applicable performance standards may also be acceptable.</u>

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 City, 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**.

[2] 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 Copermittee, in their submittal, compliance with applicable performance standards without necessarily following the process identified in this manual.

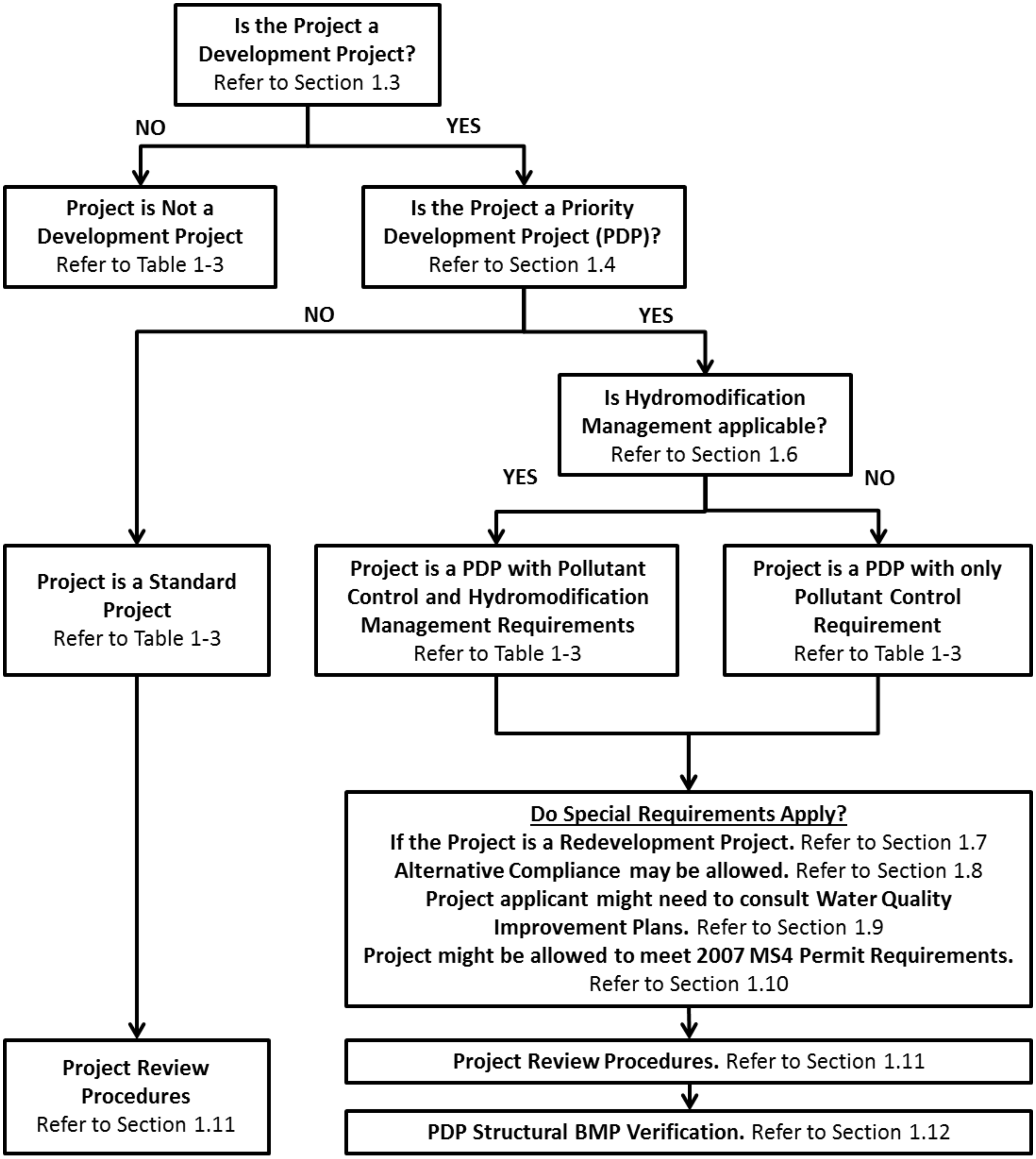

Figure 1-1. Procedural Requirements for a Project to Identify Storm Water Requirements

1.2.1 Determining Applicability of Permanent BMP Requirements

The following **Table 1-1** reiterates the procedural requirements indicated in **Figure 1-1** in a step-wise checklist format. The purpose of **Table 1-1** is to guide applicants to appropriate sections in **Chapter 1** to identify the post-construction storm water requirements applicable for a project. **Table 1-1** is not intended to be used as a project intake form.

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 **Part 2 of the Storm Water Standards** for detailed information on these requirements.

Storm water requirements applicability checklist (Form DS-560) must be completed by all project applicants.

Table 1-1. Checklist for a Project to Identify Applicable Post-Construction Storm Water Requirements

Step 1. Is the project a Development Project?	☐ Yes	☐ No
See **Section 1.3** for guidance. A phase of a project can also be categorized as a development project. If "Yes" then continue to **Step 2**. If "No" then stop here; Permanent BMP requirements do not apply i.e. requirements in **Storm Water Standards - Part 1** are not applicable to the project.		
Step 2. Is the project a PDP?		
Step 2a. Does the project fit one of the PDP definitions a-f? See **Section 1.4.1** for guidance. If "Yes" then continue to **Step 2b**. If "No" then stop here; <u>only</u> Standard Project requirements apply.	☐ Yes	☐ No
Step 2b. Does the project qualify for requiring meeting 2007 MS4 Permit requirements? See **Section 1.10** for guidance. If "Yes" then continue to **Step 2c**. If "No" then go to **Step 2d**.	☐ Yes	☐ No
Step 2c. Does the project fit one of the PDP definitions in the 2007 MS4 Permit? See SDRWQCB Order No. R9-2007-0001, Provision D.1.d. If "Yes" then continue to **Step 2d**. If "No" then stop here; Standard Project requirements apply.	☐ Yes	☐ No
Step 2d. Do one of the exceptions to PDP definitions in this manual apply to the project? See **Section 1.4.3** for guidance. If "Yes" then stop here; Standard Project requirements apply, along with additional requirements that qualify the project for the exception. If "No" then continue to **Step 3**; the project is a PDP.	☐ Yes	☐ No
Step 3. Is the Project Subject to Earlier PDP Requirements Due to a Prior Lawful Approval?	☐ Yes	☐ No
See **Section 1.10** for guidance. If "Yes" then you may follow the structural BMP requirements, including any hydromodification management exemptions, found in 2012 Storm Water Standards. If "No" then continue to **Step 4**.		
Step 4. Do Hydromodification Control Requirements Apply?	☐ Yes	☐ No
See **Section 1.6** for guidance. If "Yes" then continue to **Step 4a**. If "No" then stop here; PDP with only pollutant control requirements, apply to the project.		
Step 4a. Does Protection of Coarse Sediment Supply Areas Apply? See **Section 1.6** for guidance. If "Yes" then stop here; PDP with pollutant control and hydromodification management requirements and requirements to protect coarse sediment supply areas, apply to the project. If "No" then stop here; PDP with pollutant control and hydromodification management requirements, but exclusive of requirements to protect coarse sediment supply areas, apply to the project.	☐ Yes	☐ No

1.3 Defining a Project

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

This manual is intended for new development and redevelopment projects, inclusive of both private and public funded projects. Development projects are defined by the MS4 Permit as "construction, rehabilitation, redevelopment, or reconstruction of any public or private projects". Development projects are issued City permits to allow construction activities. To further clarify, this manual applies only to new 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 must be considered:

- What are the project activities?
- Do they occur onsite or offsite?
- What are the limits of the project (project footprint)?
- 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 1-2 must be 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 1-2 then permanent BMP requirements do not apply to the project i.e. requirements in this manual are not applicable. If permanent BMP requirements apply to a project, **Sections 1.4 to 1.7** will further 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, PDP Exempt Projects and PDPs), and more specific requirements for projects that are classified as PDPs.

Table 1-2. Applicability of Permanent, Post-Construction Storm Water Requirements

Do permanent storm water requirements apply to your project?
Requirements DO NOT apply to:
Replacement of impervious surfaces that are part of a **routine maintenance activity**, such as: • Replacing roof material on an existing building. • Rebuilding a structure to original design after damage from earthquake, fire or similar disasters. • Restoring pavement or other surface materials affected by trenches from utility work. • Resurfacing existing roads and parking lots, including slurry, overlay and restriping. • Routine replacement of damaged pavement, including full depth replacement, if the sole purpose is to repair the damaged pavement. • Resurfacing existing roadways, sidewalks, pedestrian ramps, or bike lanes on existing roads. • Restoring a historic building to its original historic design. • Maintenance activities that are part of a larger master planning effort (for example, a programmatic effort to bring the City in compliance with ADA requirements). • Installation of ground mounted solar arrays over existing impermeable surface. **Note**: Work that creates impervious surface outside of the existing impervious footprint is not considered routine maintenance. Repair or improvements to an existing building or structure that do not alter the size: • 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 increase existing impervious surface footprint and do not expose underlying soil during construction (e.g. roof replacement).

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 the City, and the City 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 City. **Section 1.4.3** presents specific City exemptions.

1.4.1 PDP Categories

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

Projects must 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 (Form I-1)**. 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 (Note: areas beneath roof overhangs should not be double counted). For example, consider a residential 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 (collectively over the entire project site). This includes commercial, industrial, residential, mixed-use, and public development projects on public or private land.

(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, residential, mixed-use, and public development projects on public or private land.

(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 City (see **Section 1.4.2** below to determine if any other local areas have been identified).

For projects adjacent to an ESA, but not discharging to an ESA, the 2,500 square feet threshold does not apply as long as the project does not physically disturb the ESA.

(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.

Exclusions that apply to this category only: Projects creating less than 5,000 square feet of impervious surface and where any added landscaping does not require regular use of pesticides and fertilizers, such as a slope stabilization project using native plants, are excluded from this category. Calculation of the square footage of impervious surface need not include linear pathways that are for infrequent vehicle use, such as for emergency or maintenance access or for bicycle or pedestrian use, if they are built with pervious surfaces or if they sheet flow to surrounding pervious surfaces. See **Section 1.4.2** for additional guidance.

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

(a) Consistent with Table 1-2, areas of a project that are considered exempt from storm water requirements (e.g. routine maintenance activities, resurfacing, etc.) shall not be included as part of "added or replaced" impervious surface in determining project classification.

(b) Swimming pools and decorative ponds with adequate freeboard or an overflow structure that does not release overflow to the MS4.

(c) If the underlying soil is not exposed during construction, then that area need not be included as part of "added or replaced" impervious surface in determining project classification.

(d) Maintenance activities that are part of a larger master planning effort (for example, a programmatic effort to bring the City in compliance with ADA requirements).

   (i) All impermeable areas (new or replaced) required to meet ADA accessible route requirements (ingress/egress to buildings) are exempt from the PDP square footage threshold.

   (ii) These projects shall be considered standard development projects unless the only activity is replacement of impervious area for ADA compliance in which case it shall be treated as routine maintenance. New impermeable surfaces installed for ADA accessible route requirements (ingress/egress to buildings) shall always be considered standard development projects and not 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 Local Additional PDP Categories and/or Expanded PDP Definitions

There are no local additional PDP categories and/or expanded PDP definitions.

1.4.3 Local PDP Exemptions or Alternative PDP Requirements

There are two categories of projects that can be exempted from being classified as PDPs and are referred to as PDP Exempt projects. These projects are exempt from the PDP requirements described in **Section 1.5** (i.e., structural pollutant control and hydromodification management requirements) but shall still meet the Standard Project requirements described in **Section 1.5** (i.e., source control and site design requirements).

<u>PDP Exemption Category 1</u>: **PDP exemption for new or retrofit paved sidewalks, bicycle lanes, or trails:**

This exemption may be applied to new or retrofit paved sidewalks, bicycle lanes, or trails if the project meets one of the following criteria (**Appendix J.1**):

(a) Designed and constructed to direct storm water runoff to adjacent vegetated areas, or other non-erodible permeable areas; OR

(b) Designed and constructed to be hydraulically disconnected[3] from paved streets or roads; OR

(c) Designed and constructed with permeable pavements or surfaces listed in **Appendix J.1.3**.

<u>PDP Exemption Category 2</u>: **PDP exemption for retrofitting or redevelopment of existing paved alleys, streets or roads:**

This exemption may be applied to retrofitting or redevelopment of existing paved alleys, streets, or roads if the project meets one of the following criteria:

(a) The project utilizes BMP options listed in the Green Streets Municipal Handbook[4] according to the applicability guidelines found in **Appendix J.2**.

<u>OR</u>

(b) The project designs and constructs alternative BMP options that provide treatment for the project redevelopment/retrofit area and are acceptable to the City Engineer. The redevelopment/retrofit project footprint is limited to the added or replaced impervious surface only (does not include routine maintenance, etc.). For example, if a turn lane is being added over a length of 200 feet, then the project footprint would be the turn lane area.

Note that not all work within the right-of-way is considered to be a redevelopment project. 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.

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[3] A sidewalk, bicycle lane, or trail would be considered to be hydraulically disconnected from paved streets or roads if they drain via separate drainage pathways (e.g., separate inlets) such that overland flows do not comingle with street or road runoff.

[4] Municipal Handbook: Managing Wet Weather with Green Infrastructure – Green Streets, December 2008, United States Environmental Protection Agency, EPA-833-F-08-009.

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." Projects that are classified as PDPs may be classified as "PDP Exempt Projects" based on **Section 1.4.3**. Source control and site design requirements apply to all projects including Standard Projects, PDP Exempt 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			
Standard Project/ PDP Exempt Project	☑	☑	NA	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.

1.6 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, or a PDP Exempt 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.

The City has 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 City as appropriate for an exemption by the WMAA incorporated into the Water Quality Improvement Plan (WQIP) pursuant to Provision B.3.b.(4) [of the MS4 permit] and accepted by the SDRWQCB.

Refer to Figure 1-2 and the associated criteria describing nodes in Figure 1-2 to determine applicability of hydromodification management requirements. These criteria reflect the latest list of exemptions that are allowed under the 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.
    - o This exemption is subject to the following conditions:
        - (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
            - o 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.

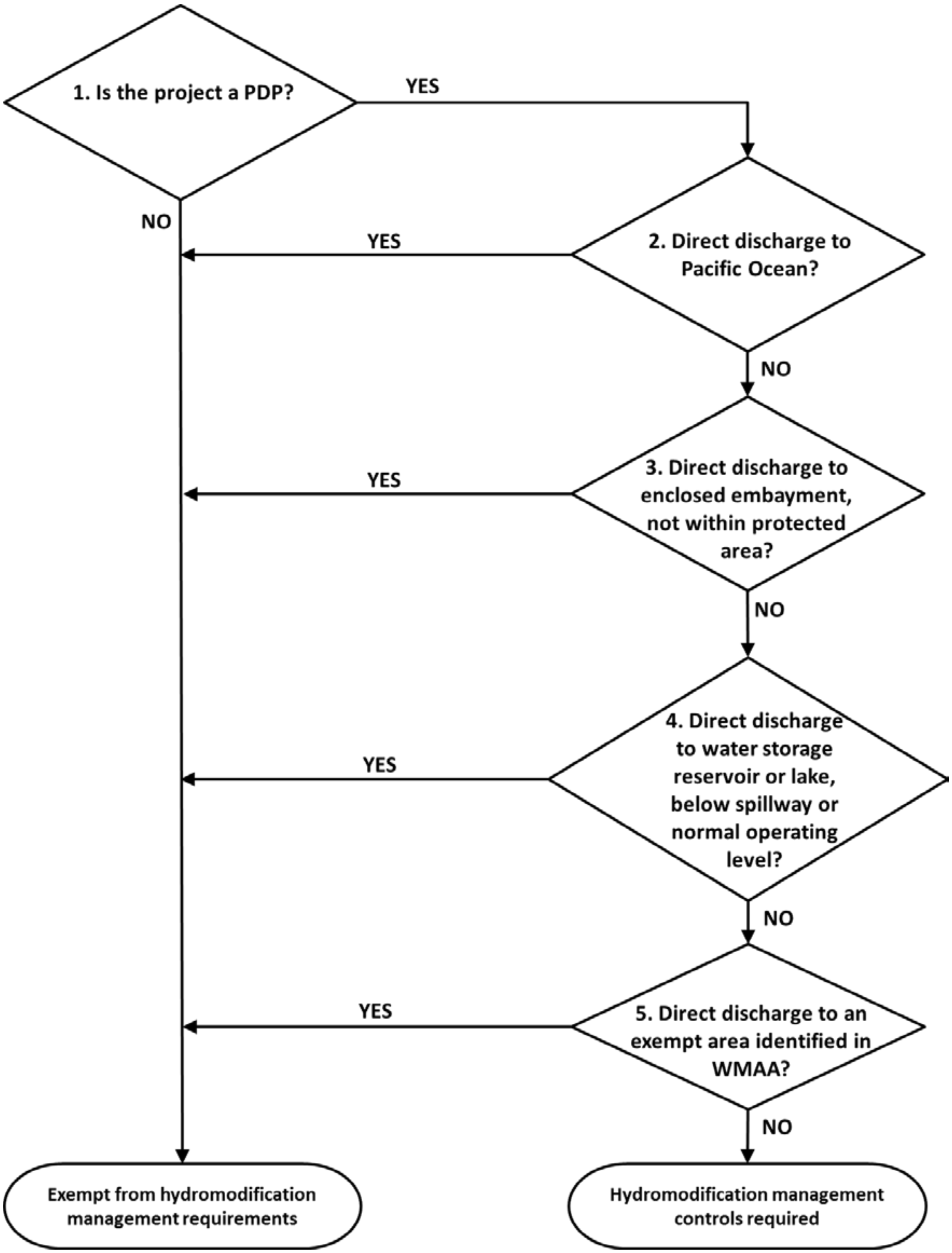
- **Figure 1-2, Node 3** – As allowed by the MS4 Permit, projects discharging directly to enclosed embayments (e.g., San Diego Bay or Mission Bay), by either existing underground storm drain systems or conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the enclosed embayment, are exempt.
  - This exemption is subject to the following conditions:
    - (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
      - 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.
  - Exempt water storage reservoir or lakes within City of San Diego jurisdiction include:
    - (a) Lake Hodges
    - (b) San Vicente Reservoir
    - (c) El Capitan Reservoir
    - (d) Lower Otay Reservoir
    - (e) Upper Otay Reservoir
    - (f) Morena Reservoir
    - (g) Sutherland Reservoir
    - (h) Barrett Reservoir
    - (i) Lake Murray
    - (j) Miramar Reservoir

  - This exemption is subject to the following conditions:
    (a) A properly sized energy dissipation system must be provided in accordance with the City 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 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.
  - 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 are exempt. Refer to the WMAA for any updates to exempt river reaches. Discharging directly refers to either a) existing underground storm drain systems; or b) conveyance channels whose bed and bank are concrete-lined all the way from the point of discharge to the designated area.
  - Designated exempt river reaches identified in the WMAA and approved by the RWQCB within City of San Diego jurisdiction:
    (a) San Dieguito River downstream of Lake Hodges
    (b) San Diego River downstream of confluence with San Vicente Creek
    (c) Sweetwater River downstream of Sweetwater Reservoir
    (d) Otay River downstream of Lower Otay Reservoir Dam
  - 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 City Engineer, but shall never exceed the 100-year floodplain elevation. The City Engineer may require additional analysis of the potential for erosion between the outfall and the 10-year floodplain elevation.
  - No exemption may be granted for conveyance system outlet invert elevations located above the 100-year floodplain elevation.

General note regarding HMP: New outfalls shall meet requirements for energy dissipation size in the Drainage Design Manual regardless of the addition of hydromodification controls. Existing outfalls that are insufficient to accommodate additional flows from proposed upstream development projects may require upgrading and may also disqualify the HMP exemption at the discretion of the City Engineer.



*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 should be followed to estimate the area that requires treatment to satisfy the MS4 Permit requirements:

Step 1. How much total impervious area currently exists on the site?
Step 2. How much existing impervious area will be replaced with new impervious area?
Step 3. How much new impervious area will be created in areas that are pervious in the existing condition?
Step 4. Total created and/or replaced impervious surface = Step 2 + Step 3.
Step 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 created and/or replaced impervious surface area.

Note: Steps 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 may not be included in Step 2 and Step 3 calculation.

For example, a 10,000 square foot of existing development proposes replacement of 4,000 square foot of impervious area. The created and/or replacement area is less than 50% of the total existing development area and so only the 4,000 square foot 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 offsite storm water alternative compliance program. Participation in an offsite storm water 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 also be allowed to participate in an alternative compliance program by using onsite BMPs to treat offsite runoff at the discretion of the City Engineer.

The PDP utilizing the offsite storm water 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 that provides a greater overall water quality benefit for the portion of the pollutants not addressed onsite through retention and/or biofiltration BMPs. Participation in an alternative compliance program could also potentially offset hydromodification management flow control obligations that are not provided onsite (see **Chapter 6** for hydromodification management requirements), provided greater hydromodification management benefits are provided to the watershed by participation in an offsite project.

Refer to **Part 3 of the Storm Water Standards** for guidance for participation in the City's offsite storm water alternative compliance program.

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 documents as appropriate when using this manual as follows:

1. For PDPs that implement flow-thru treatment BMPs, selection of the type of BMP must consider the pollutants and conditions of concerns. Among the selection considerations, the applicant 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, applicants must ensure there is no net impact to critical coarse sediment yield areas through application of the methodology presented in **Section 6.2** of this manual.
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. Applicants should consult the WMAA

for recommended hydromodification management exemptions to determine if the project is eligible.

5. PDP applicants 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 1-3.

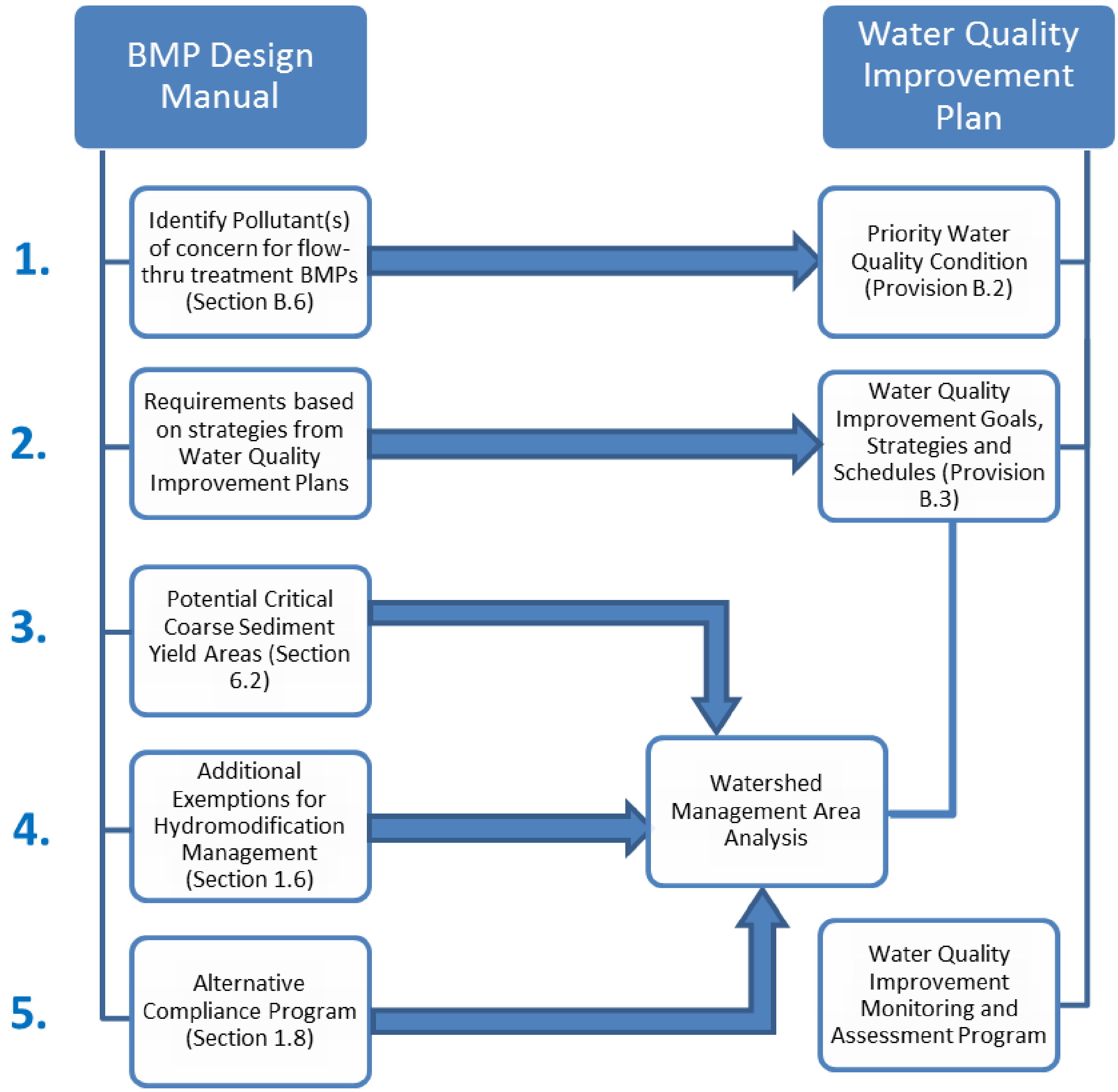


Figure 1-3. Relationship between this Manual and WQIP

The Highest Priority Water Quality conditions (HPWQC) identified in the WQIPs (accepted in February 2016) are summarized in Table 1-4 below:

Table 1-4. Highest Priority Water Quality conditions (HPWQC) identified in the WQIPs

Watershed Management Area	Highest Priority Water Quality Condition
San Dieguito	Indicator Bacteria.
Los Peñasquitos	Hydromodification, Siltation/Sedimentation; Freshwater Discharges; and Indicator Bacteria.
Mission Bay and La Jolla	Indicator Bacteria.
San Diego River	Indicator Bacteria.
San Diego Bay	Indicator Bacteria; Dissolved Copper; Lead; and Zinc (wet weather).
Tijuana	Sedimentation/Siltation (wet weather); and Turbidity (wet weather).

The WQIPs that pertain to the City of San Diego are available at the following location:

- o http://www.waterboards.ca.gov/sandiego/water_issues/programs/stormwater/wqip.shtml

1.10 Storm Water Requirement Applicability Timeline

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

A PDP may be allowed to implement the requirements from the 2012 Storm Water Standards to meet post construction storm water requirements if the project meets all the following criteria prior to **February 16, 2016**:

1. Approved[5] a design that incorporates the storm water drainage system for the PDP in its entirety, including all applicable structural pollutant treatment control and hydromodification management BMPs consistent with the 2012 Storm Water Standards; **AND**
2. Issued a private project permit or approval, or functional equivalent for public projects, that authorizes the PDP applicant to commence construction activities based on a design that incorporates the storm water drainage system approved in conformance with Section 1.10.1.; **AND**
3. Confirmed that there have been construction activities on the PDP site within the 365 days prior to February 16, 2016 **OR** the applicant confirms that construction activities will commence on the PDP site within 180 days after February 16, 2016, where construction activities are undertaken in reliance on the permit or approval, or functional equivalent for public projects, issued by the City in conformance with Section 1.10.2.; **AND**
4. Issued all subsequent private project permits or approvals, or functional equivalent for public projects, that are needed to implement the design initially approved in conformance with

[5] For public projects, a design stamped by the City Engineer, or engineer of record for the project is considered an approved design.

Section 1.10.1. within 5 years of February 16, 2016. The storm water drainage system for the PDP in its entirety, including all applicable structural pollutant treatment control and hydromodification management BMPs must remain in substantial conformity with the design initially approved in conformance with Section 1.10.1. **OR**

5. Project applicant demonstrates that the City lacks land use authority or legal authority to require a PDP to implement the post construction storm water requirements listed above.

For additional guidance and example scenarios related to private projects applicability refer to the City's Development Services Department Notice: 2013 MS4 Permit Storm Water Requirements - Applicability Guidelines, dated December 4, 2015 or subsequent revisions; and for public projects refer to guidance issued by the City Engineer.

1.11 Project Review Procedures

The City reviews project plans for compliance with applicable requirements of this manual and the MS4 Permit.

Specific submittal requirements for documentation of permanent, post-construction storm water BMPs may vary by jurisdiction and project type; however, in all cases the project applicant must provide sufficient documentation to demonstrate that applicable requirements of the BMP Design manual and the MS4 Permit will be met.

For Standard Projects and PDP Exempt Projects, this typically means submitting storm water applicability checklist, Standard SWQMP and copies of the relevant plan sheets showing source control and site design BMPs or other equivalent documents approved by the City Engineer 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 typically means preparing a PDP SWQMP to document that the following general requirements of the MS4 Permit are met, and showing applicable features on site 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 City Engineer must be provided with the first submittal of a project or another preliminary planning stage defined by the jurisdiction. 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.

1.12 PDP Structural BMP Verification

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

Structural BMPs must be verified by the City 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 City Engineer may request the project owner provide a certification that the site improvements for the project have been constructed in conformance with the approved storm water management documents and drawings.

The City Engineer may require inspection of the structural BMPs at each significant construction stage and at completion. Following construction, the City may require an addendum to the SWQMP and require as-builts to address any changes to the structural BMPs that occurred during construction that were approved by the City Engineer. The City may also require a final update to the O&M Plan, and/or execution of a maintenance agreement that will be recorded for the property. A maintenance agreement that is recorded with the property title can then be transferred to future owners.

Certification of structural BMPs, updates to reports, and recordation of a maintenance agreement may occur concurrently with project closeout, but could be required sooner. 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.

Chapter 2

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 general, source control and site design practices that are applicable to all projects (regardless of project type or size; Standard Projects, PDP Exempt Projects and PDPs) when City permits are issued, including unpaved roads and flood management projects.

2.1.1.1 General Requirements

All projects must 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 City 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, PDP Exempt 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)[6];

(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;

(e) Minimization of the impervious footprint of the project;

(f) Minimization of soil compaction to landscaped areas;

[6] 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.

(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 City 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 should be considered as early as the planning/tentative design stage (check with local jurisdiction requirements. 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 MS4 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 must 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 for the remaining volume not reliably retained. 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:

[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.

(ii) If biofiltration BMPs 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 if an alternative compliance program is available in the jurisdiction the project is located, see **Part 3 of the Storm Water Standards**. When an alternative compliance program is utilized:

(i) The PDP must mitigate for the portion of the DCV not reliably retained onsite <u>**and**</u>

(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**.

Demonstrations of feasibility findings and calculations to justify BMP selection and design must be provided by the project applicant in the SWQMP to the satisfaction of the City Engineer. 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 property owners and the City. 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 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**. 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 City the discretion 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 Part 3 of the Storm Water Standards**).

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**. 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.

PDP applicants may be allowed to participate in an alternative compliance program. Refer to **Part 3 of the Storm Water Standards** 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.

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 (ft^3) and it is technically feasible to implement 2,000 ft^3 of retention BMPs and 9,000 ft^3 of biofiltration BMPs sized using Section 2.2.1.(a)(i)[a], and the City has an alternative compliance program to satisfy the requirements of this manual the project applicant should:

1. First, design retention BMPs for 2,000 ft^3.
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 ft^3.
3. Then design biofiltration BMPs for 9,000 ft^3 (calculate equivalent volume for which the pollutants are retained = 9,000/1.5 = 6,000 ft^3).
4. Then complete a technical feasibility for biofiltration BMPs demonstrating that it is only technically feasible to implement biofiltration BMPS for 9,000 ft^3.
5. Estimate the DCV that could not be retained or biofiltered = 10,000 ft^3 – (2,000 ft^3 + 6,000 ft^3) = 2,000 ft^3.
6. Implement flow-thru treatment control BMPs to treat the pollutants in the remaining 2,000 ft^3. 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 ft^3. Refer to **Part 3 of the Storm Water Standards** 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, as part of an approved WMAA and an alternative compliance program developed by the jurisdiction where the project resides, 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 PDP 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 must 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 describes performance standards for hydromodification management, including flow control of post-project storm water runoff and protection of critical sediment yield areas, that must be met by all PDPs unless exempt from hydromodification management requirements per **Section 1.6** of this manual. Each PDP must 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 City 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 should 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 existing 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 must 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 must be:

- $0.1Q_2$ to Q_{10} 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);
- $0.3Q_2$ to Q_{10} for streams with medium susceptibility to erosion and which has a stream susceptibility study prepared and approved by the City Engineer; or
- $0.5Q_2$ to Q_{10} for streams with low susceptibility to erosion and which has a stream susceptibility study prepared and approved by the City Engineer.

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 applicant intends to select the $0.3Q_2$ or $0.5Q_2$ 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 base flow. 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 Q_2 to Q_{10}. 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 BMP Design 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 requirement has its own purpose and each requirement has a separate performance standard 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.

Chapter 3

Development Project Planning and Design

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.

STEP 1: **Coordinate Between Disciplines** Refer to Section 3.1	*Purpose:* Engage and coordinate with owner and other project disciplines (e.g. architect, engineer) early in the design and throughout the design process to support appropriate project decisions.
⇓	
STEP 2: **Gather Project Site Information** Refer to Section 3.2	*Purpose:* Gather information necessary to inform overall storm water planning process and specific aspects of BMP selection; determine the applicable storm water requirements for the project.
⇓	
STEP 3: **Develop Conceptual Site Layout and Storm Water Control Strategies** Refer to Section 3.3	*Purpose:* Use the information obtained in Step 2 to inform the preliminary site design and storm water management strategy. The scope of this step varies depending on whether the project is a Standard Project or a PDP.
⇓	
STEP 4: **Develop Complete Storm Water Management Design** Refer to Section 3.4	*Purpose:* Develop the complete storm water management design by incorporating the site design and storm water management strategies identified in Step 3 and conducting design level analyses. Integrate the storm water design with the site plan and other infrastructure plans.

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.

The City 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.

Owner

- 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).
- 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

In order 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 pollutant control and hydromodification management requirements or a PDP 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, PDP Exempt 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 Exempt Project	☑	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
   (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** and **Appendix H** of this manual. 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 or bypass these areas?

(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 bypass these areas?

(c) If impacts to critical coarse sediment areas are not avoided, what mitigation efforts will be undertaken 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.

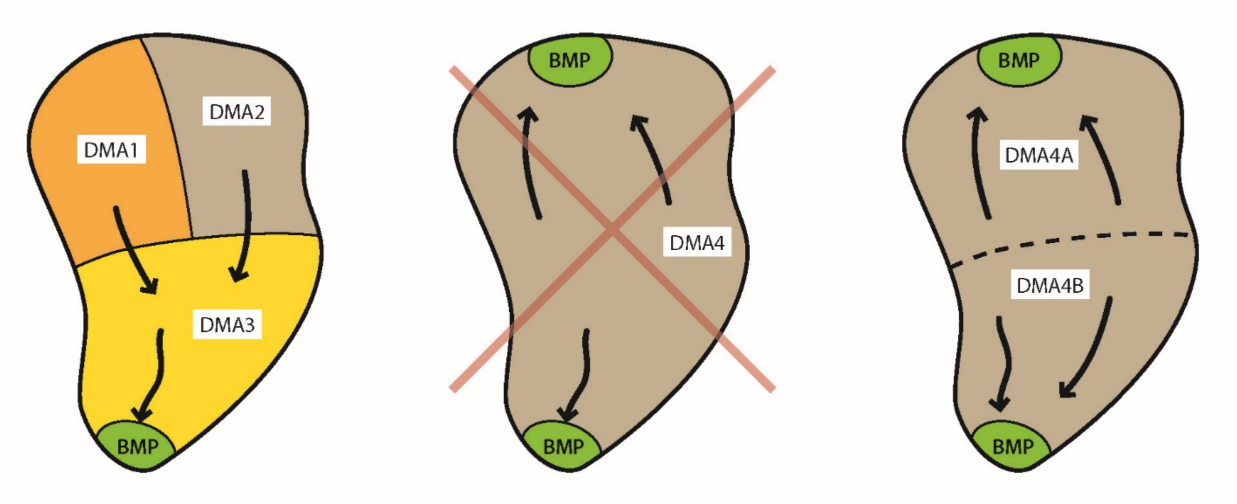


Figure 3-2. DMA Delineation

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.

In scenarios, where the BMP receives any offsite or onsite areas that comingle with the runoff from the project footprint, the following criteria must be met:

1. Where feasible divert up gradient flows away from the BMP subject to drainage and flood control regulation (e.g. dual storm drain system).
2. Where feasible design the BMP to be an offline BMP with diversion flow rate estimated using **Appendix B.1.2**
3. If criteria 1 and/or 2 are determined to be not technically feasible, then at the discretion of the City Engineer, the project applicant may be allowed to size the BMP to only treat the runoff from the project footprint but still receive run on from offsite areas and/or onsite areas that are not considered to be part of the project if the following criteria are met: For safety purposes, design the inflow energy dissipation and the overflow structure in the BMP for the total area draining to the BMP for the design event selected to sizing the storm water conveyance system for flood control purposes. Refer to the project drainage report (Attachment 5 of the SWQMP).

Note: Redevelopment projects that create and/or replace more than 50% of impervious area of the previously existing impervious project area draining to the BMP must be sized for the total project area draining to the BMP (to satisfy the requirements of **Section 1.7**).

Project Footprint: All areas proposed by an applicant to be altered or developed, including both impervious and pervious areas.

Project Area: The project scope boundary indicated in the SWQMP, which includes the project footprint and undisturbed potions within the project property (or properties if the project footprint crosses multiple parcels). For projects in the right-of-way, the Project Area is the entire right-of-way width over the length of the project activities.

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**).
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
   (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 City Engineer may allow alternate assessment methods with appropriate documentation.

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 the City 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 City. In addition, consider the use of the site. Some BMPs may not be suitable for maintenance by individual home owners.

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 Exempt 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. Identify general requirements applicable to the selection and design of BMPs. See **Section 4.1**.
2. Select, identify and detail specific source control BMPs. See **Section 4.2**.
3. Select, identify and detail specific site design BMPs. See **Section 4.3**.
4. 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).
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 avoidance or 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. Follow the design approach described in **Chapter 3** 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:
   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 City of San Diego jurisdiction:

- **Planning for eventual ownership of facilities:** The PDP SWQMP shall clearly identify how final land ownership mapping relates to ownership and location of storm water pollutant treatment and hydromodification control BMPs and their corresponding DMAs. The City reserves the right to reject any proposed PDP SWQMP that is likely to create future conflicts in enforcing the maintenance and effectiveness of BMPs once legally defined land parcels are sold to separate owners.

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. If the overall project is determined to be a PDP, applicants that phase work must still satisfy PDP and other applicable storm water requirements. Applicants cannot phase work to bypass PDP requirements. The project details outlined in the SWQMP will be reviewed cumulatively to determine site specific storm water requirements. The City will also take into account permits issuance within the last five years to determine applicable storm water requirements. For redevelopment projects, the permit issuance date will also determine whether the "50% rule" applies or not.

The City's Single Discipline Preliminary Review service can be helpful to determine submittal requirements for phased projects. This Preliminary Review option is offered to answer any questions regarding feasibility. Review fees are charged for each Single or Multiple Discipline Preliminary Review. However, additional charges and extended review times will be applied towards overall fees for more complex projects. Refer to City of San Diego Information Bulletin 513 for more information.

If a tentative map approval would potentially entitle future owners of individual parcels to construct new or replaced impervious area which, in aggregate, could exceed the thresholds in Section 1.4, then the applicant must either address storm water management requirements for individual parcels or take steps to ensure storm water management requirements can and will be implemented as the phased development project (eg. subdivision) is built out.

If the tentative map application does not include plans for site improvements, the applicant should nevertheless identify the type, size, location, and final ownership of pollutant control and flow control facilities adequate to serve new roadways and any common areas, and to also manage runoff from an expected reasonable estimate of the square footage of future roofs, driveways, and other impervious surfaces on each individual lot. The City Engineer may condition approval of the map on implementation of BMPs in compliance with storm water management requirements when construction occurs on the individual lots. This condition may be enforced by a grant deed of development rights or by a development agreement.

Chapter 4

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 PDP Exempt Projects, Standard Projects, and PDPs. **Checklists I.4** for source control and **I.5** for site design can be used by PDP Exempt Projects, 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 must implement 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 the City.

> **How to comply:** Projects must prepare project plans depicting location of receiving waters and proposed BMPs within the project boundary. These plans must demonstrate that storm water BMPs are not located within Waters of the U.S.

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 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 must incorporate design, construction, and maintenance principles to drain retained water within **96 hours** and minimize standing water. Design calculations must 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 criterion 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 (4.2.1through 4.2.6) are discussed below.

How to comply: Projects must implement all source control BMPs that are applicable to their project. Applicability should be determined through consideration of the development project's proposed features and anticipated pollutant sources associated with them. 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** should 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;
- 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.

Language associated with the stamping (e.g., "No Dumping-Drains to Ocean") must be satisfactory to the City Engineer. The following factsheet provided in **Appendix E** provides more information:

- SC-A – Onsite storm drain inlet labelling

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, approval must be obtained from the sanitary sewer agency). 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.
- 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

- 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 City to minimize pollutant generation at each project site

At its discretion, the City Engineer may determine that additional on-site controls are necessary to minimize pollutant generation. These determinations will be made on a project-specific basis. **Appendix E** provides guidance on permanent controls that are applicable at a project site based on potential sources of runoff pollutants at the project site. Applicants must implement all applicable and feasible source control BMPs listed in **Appendix E**.

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.

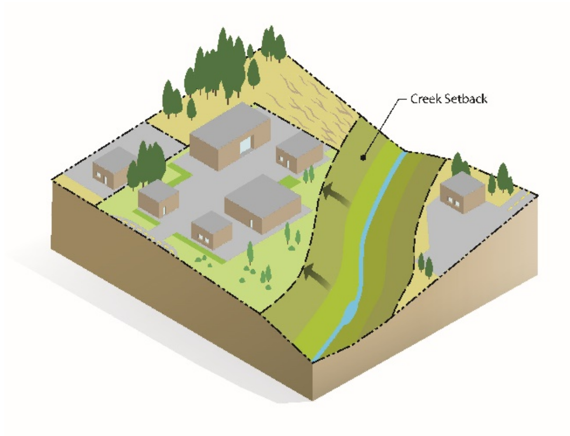
Appendix E also provides the following fact sheets to assist applicants with the proper design of site design features:

- 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 must 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 should be provided by the applicant when a certain site design BMP is considered to be not applicable or not practicable/feasible. Site plans should 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** should be used to document compliance with site design BMP requirements.

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.)**



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.

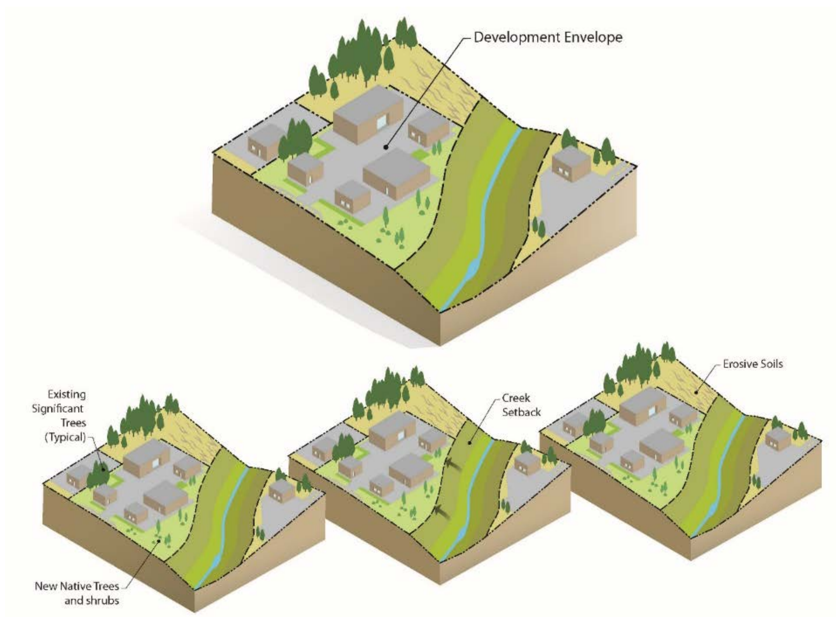
Projects can incorporate this requirement into a project by implementing the following planning and design phase techniques as applicable and practicable:

- 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. SDRWQCB, 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

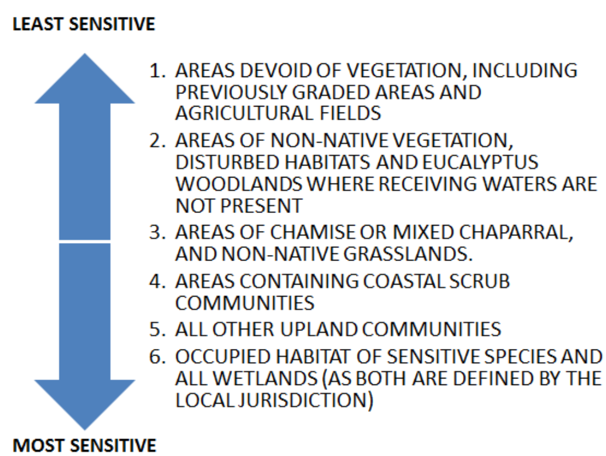
- ☐ **Conserve natural areas within the project footprint including existing trees, other vegetation, and soils**

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.



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.

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

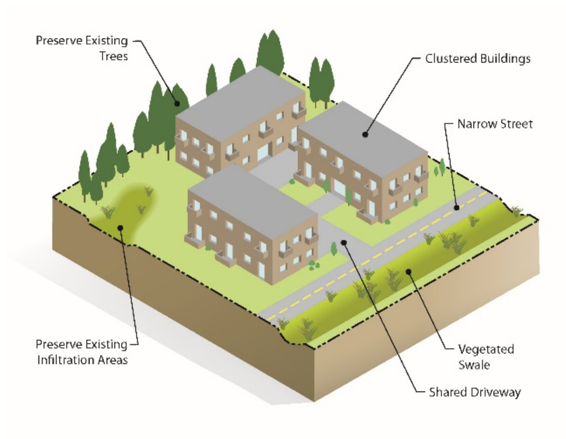


- Identify areas most suitable for development and areas that should be left undisturbed. Additionally, reduced disturbance can be accomplished by increasing building density and increasing height, if possible.
- Cluster development on least-sensitive portions of a site while leaving the remaining land 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.

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.
- 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 this requirement 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 the City 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 parking indoors or underground.
- Minimize the use of impervious surfaces in the landscape design.

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 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 the City WHITEBOOK.

Projects can incorporate this requirement 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. Refer to **SD-F fact sheet in Appendix E** for additional guidance on implementing amended soils within the project footprint.

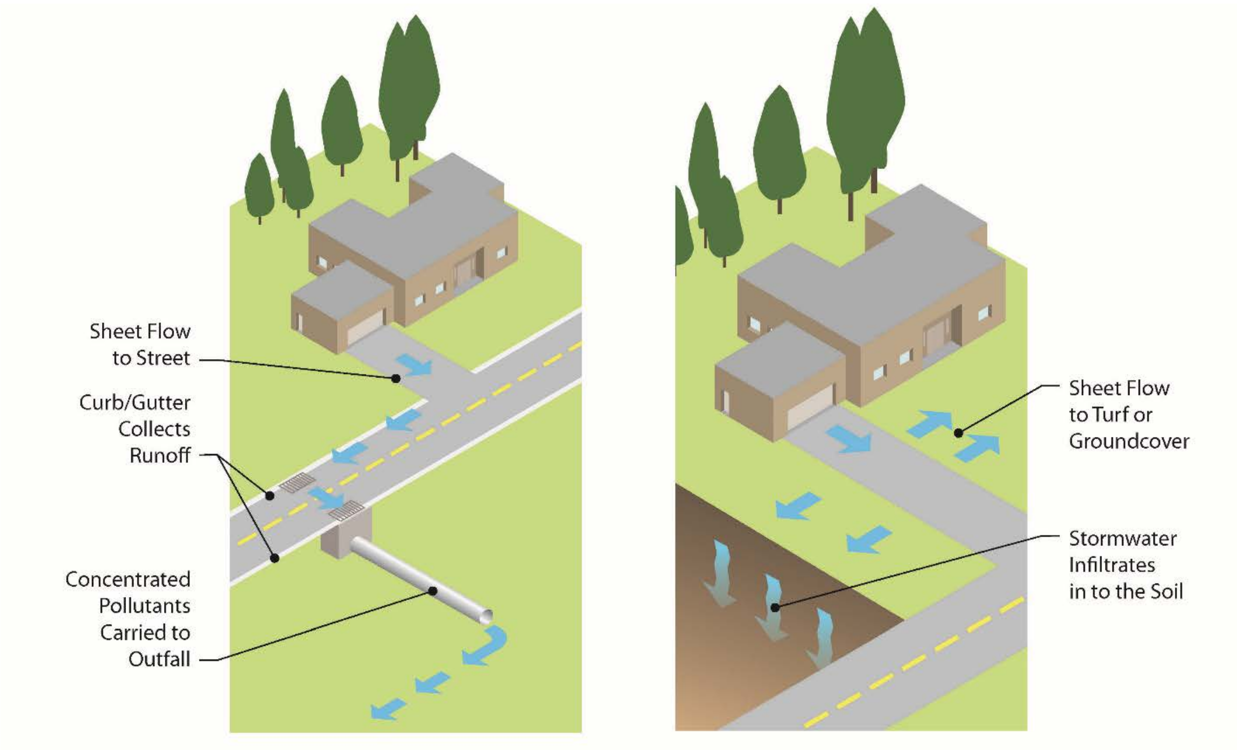
4.3.5: Disperse impervious areas

- ☐ **Disconnect impervious surfaces through distributed 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.



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

- Implement design criteria and considerations listed in impervious area dispersion **SD-B fact sheet 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 or place curb openings, thus allowing roadway runoff to drain to adjacent pervious areas.

- Replace curbs and gutters with roadside vegetated swales or place curb openings 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%.

4.3.6: 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**
- ☐ **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 or on residential lots. 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 underdrain to allow filtration, storage, and evaporation, prior to drainage into the storm drain system.

Projects can incorporate this requirement 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-D in Appendix E**)

4.3.7: 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. Projects can incorporate this requirement by landscaping with native and drought tolerant species.

4.3.8: Harvest and use precipitation

Harvest and use BMPs capture and stores 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-E fact sheet in Appendix E** provides additional detail for designing Harvest and Use BMPs. Projects can incorporate this requirement by installing rain barrels or cisterns, as applicable.

Photograph Courtesy of Arid Solutions, Inc.

Chapter 5

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.

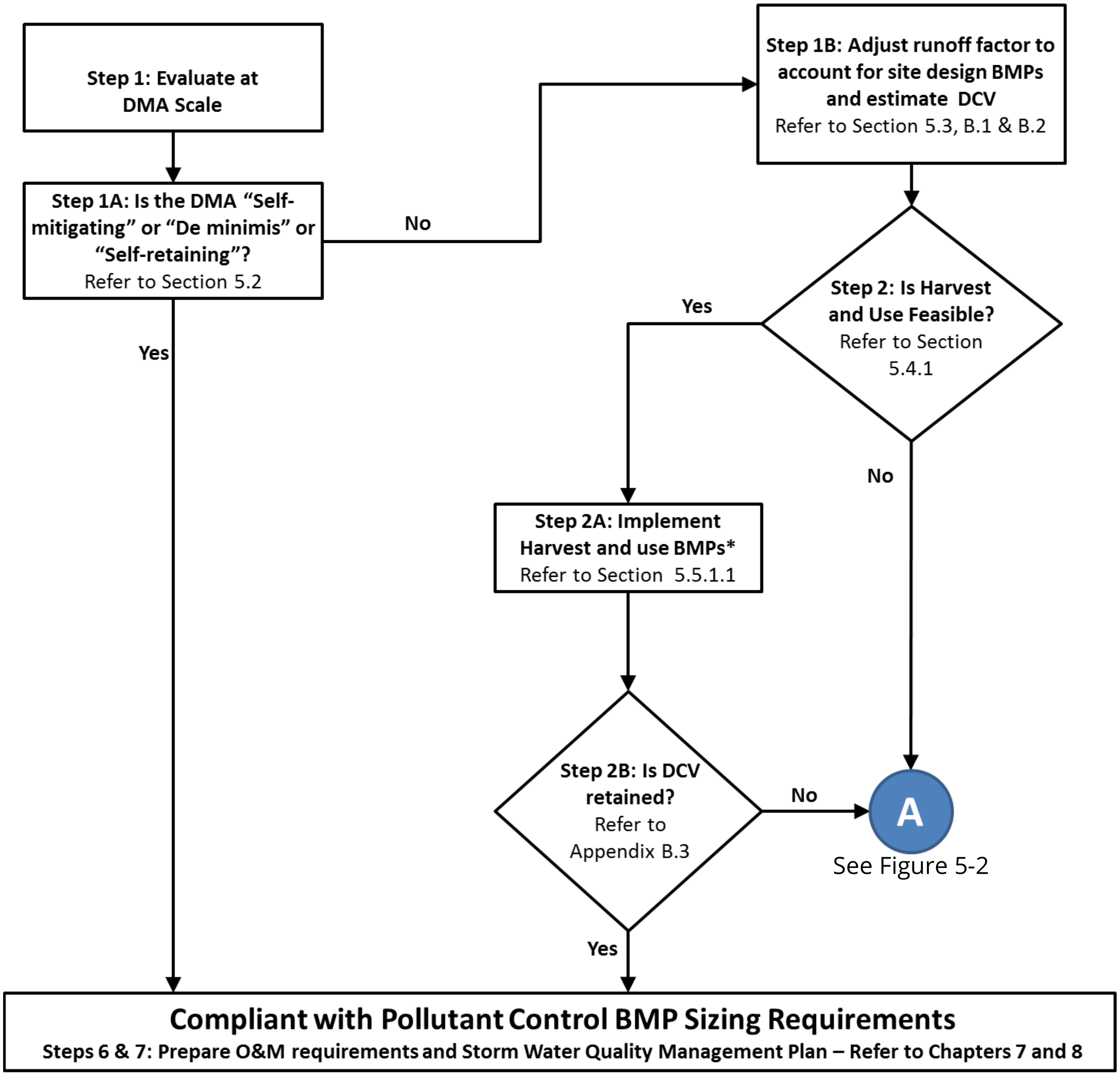
This chapter describes the specific process for determining which category of pollutant control BMP, or combination of BMPs, is most appropriate for the PDP site and how to design the BMP to meet the storm water pollutant control performance standard (per **Section 2.2**).

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**.

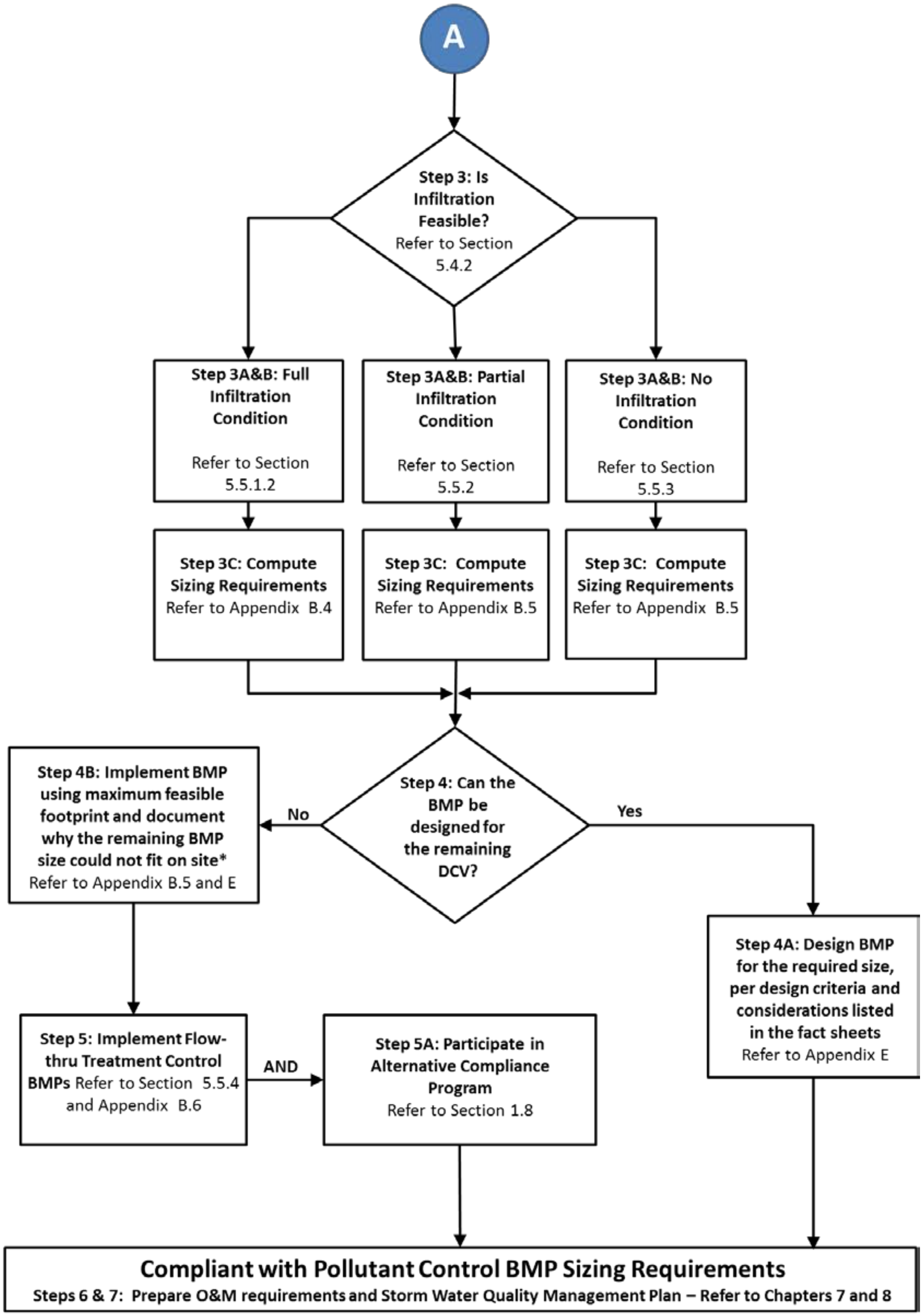
5.1 Steps for Selecting and Designing Storm Water Pollutant Control BMPs

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 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 [City Engineer]

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 guidance in **Appendix C** 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.

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 City Engineer.

Step 5. Implement flow-thru treatment control BMPs for the remaining DCV. See **Section 5.5.4 and Appendix 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 City Engineer.

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.

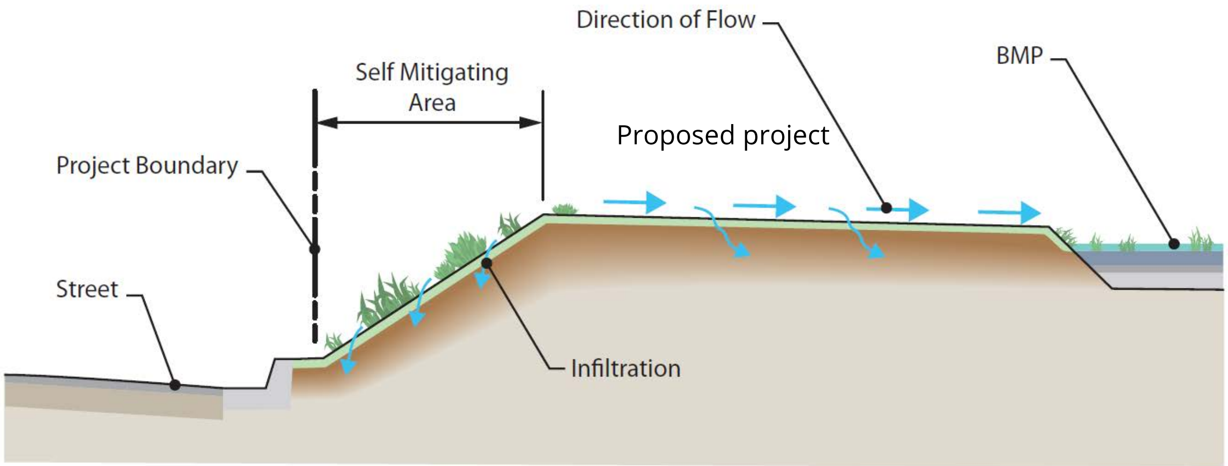


Figure 5-3. Self-Mitigating Area

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 owner and the City Engineer 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-B in Appendix E**), green roofs (**SD-C in Appendix E**) and permeable pavement (**SD-D 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.

Requirements for utilizing this category of DMA:

- Site design BMPs such as impervious area dispersion, green roofs 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 meeting pollutant control requirement are summarized below:
    - SD-B 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-C Self-retaining green roof: a DMA is considered self-retaining if the ratio of total drainage area (including green roof) to area of the green roof is 1:1 (i.e., green roof does not receive any run on).
    - SD-D 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 City Engineer 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, geotechnical concerns), 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 City Engineer. Figure 5-4 illustrates the concept of self-retaining DMAs.

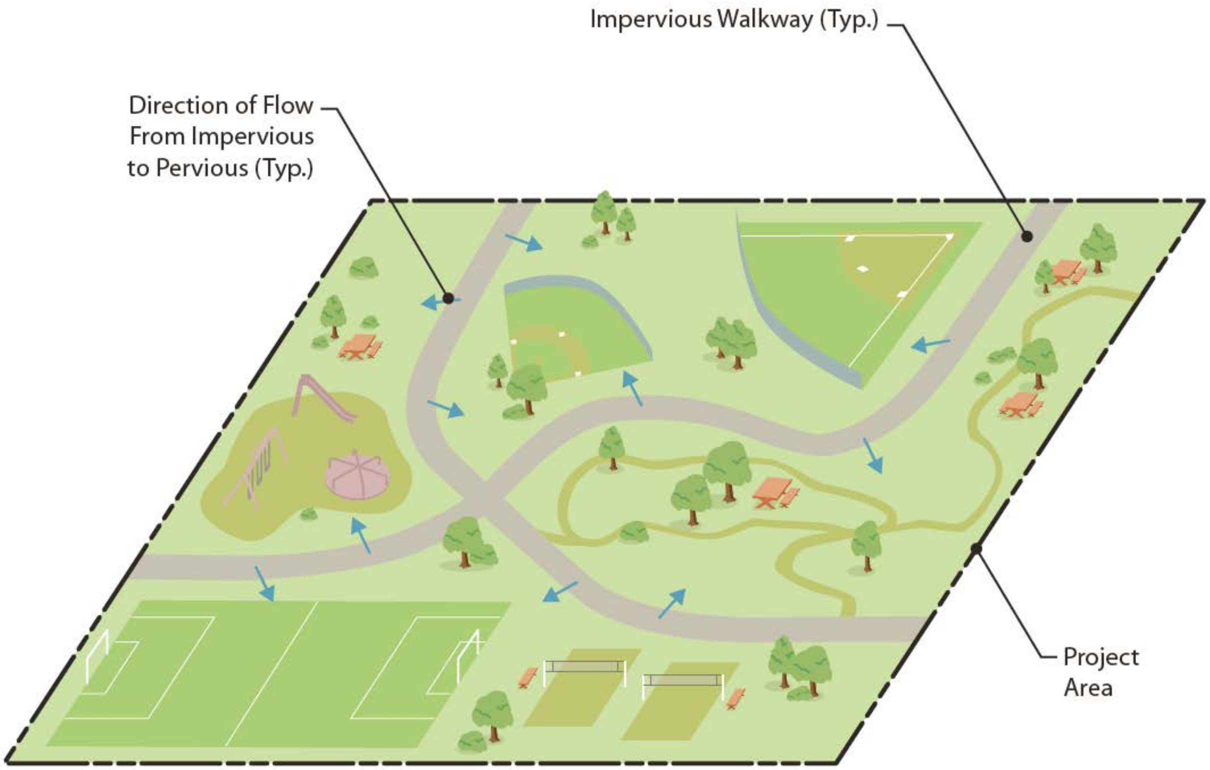


Figure 5-4. Self-retaining Site

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-A Trees
- SD-B Impervious area dispersion
- SD-C Green roofs
- SD-D Permeable pavement
- SD-E 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 City Engineer.

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**.

- **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" checklists located in **Appendix C** or the “Infiltration Feasibility Condition Letter” than meets the requirements in **Appendix C.1.1** 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 the “Infiltration Feasibility Condition Letter” or Worksheets C.4-1 and/or C.4-2**. 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**.

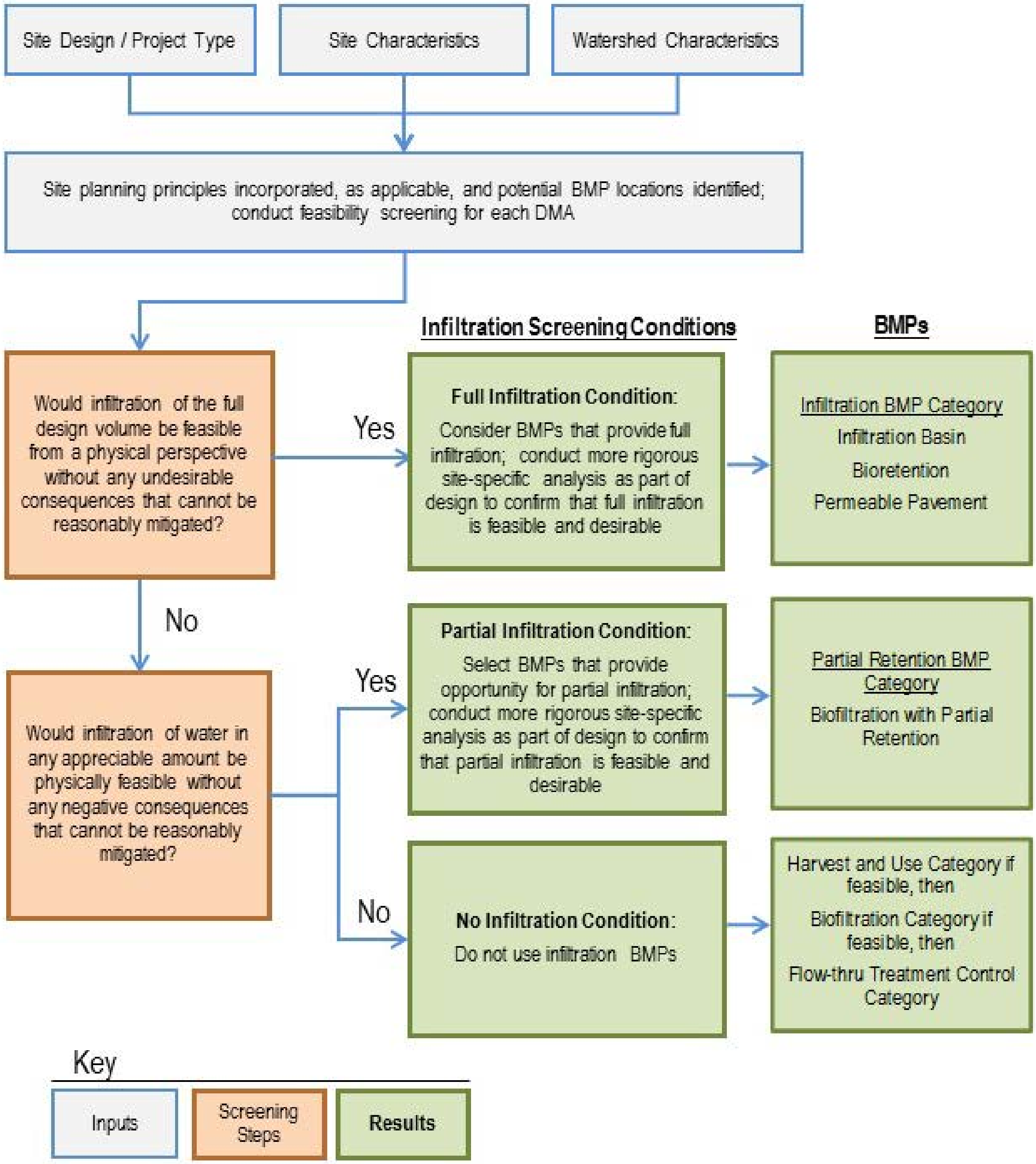


Figure 5-5. Infiltration Feasibility and Desirability Screening Flow Chart

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 City Engineer 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.

The City notes that BMPs may be considered pesticide devices subject to certain requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. § 136 et seq., and related provisions of the California Food & Agriculture Code (CFAC). The City is not responsible for determining any person's compliance with FIFRA and CFAC.

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 INF-4: Dry Wells
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

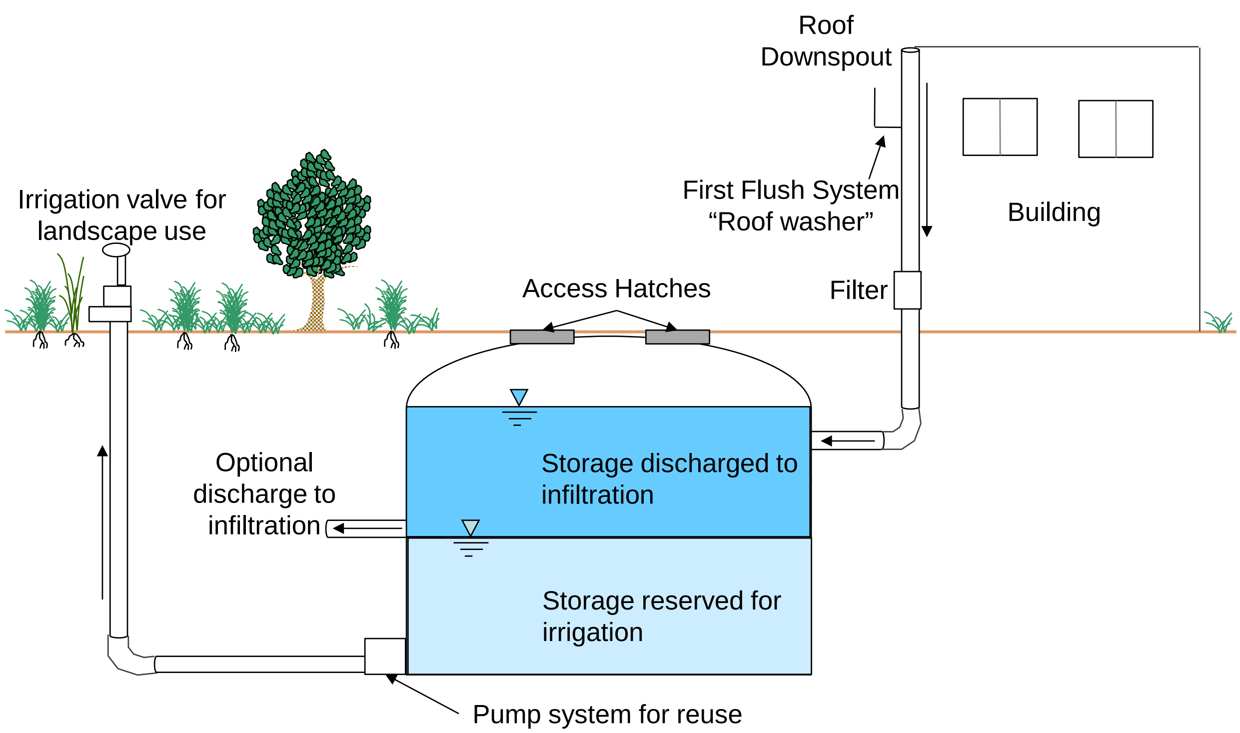


Figure 5-6. Schematic of a Typical Cistern

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 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.
- INF-4: Dry Wells

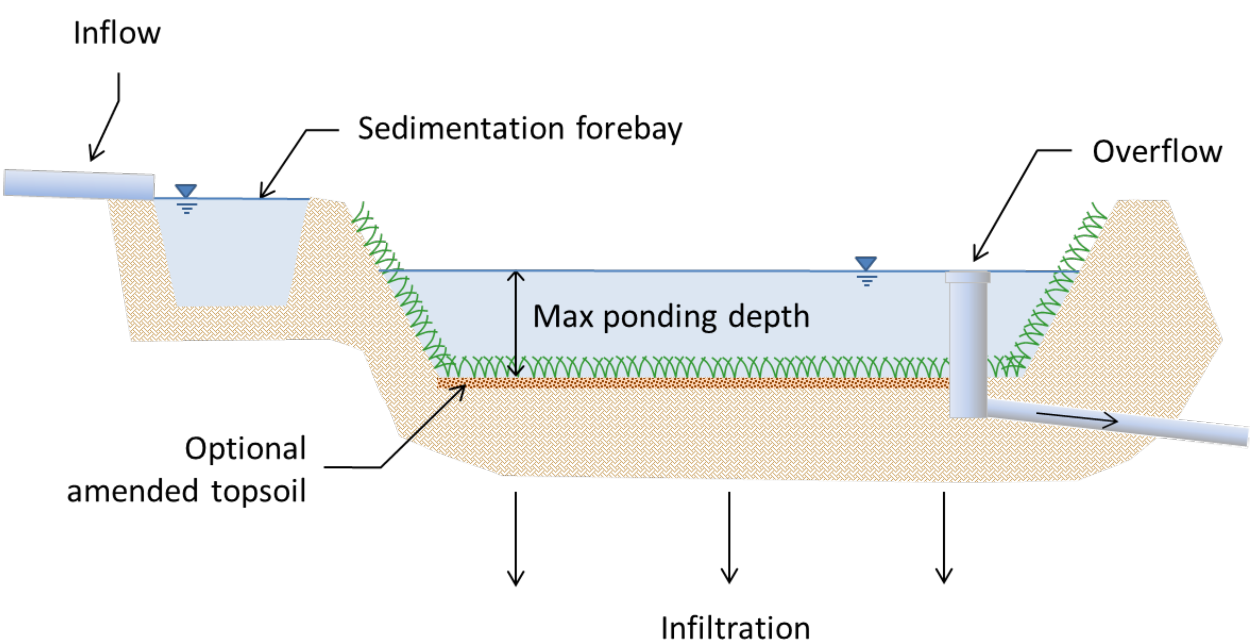


Figure 5-7. Schematic of a Typical Infiltration Basin

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

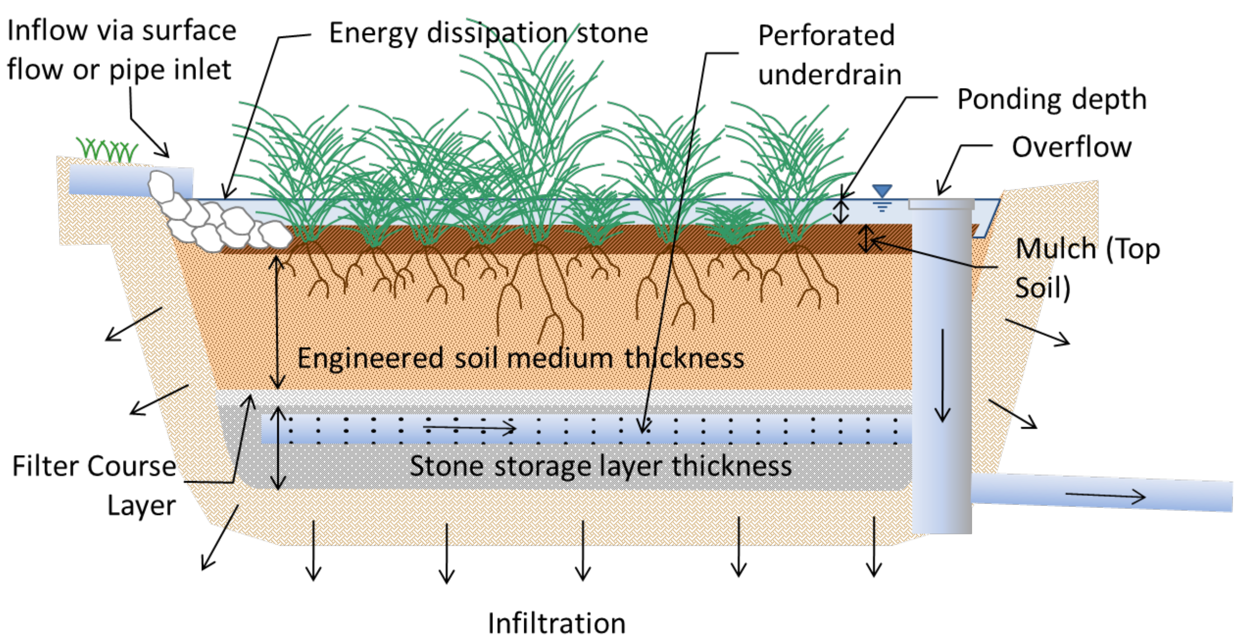


Figure 5-8. Schematic of a Typical Biofiltration with Partial Retention BMP

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 City Engineer, 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

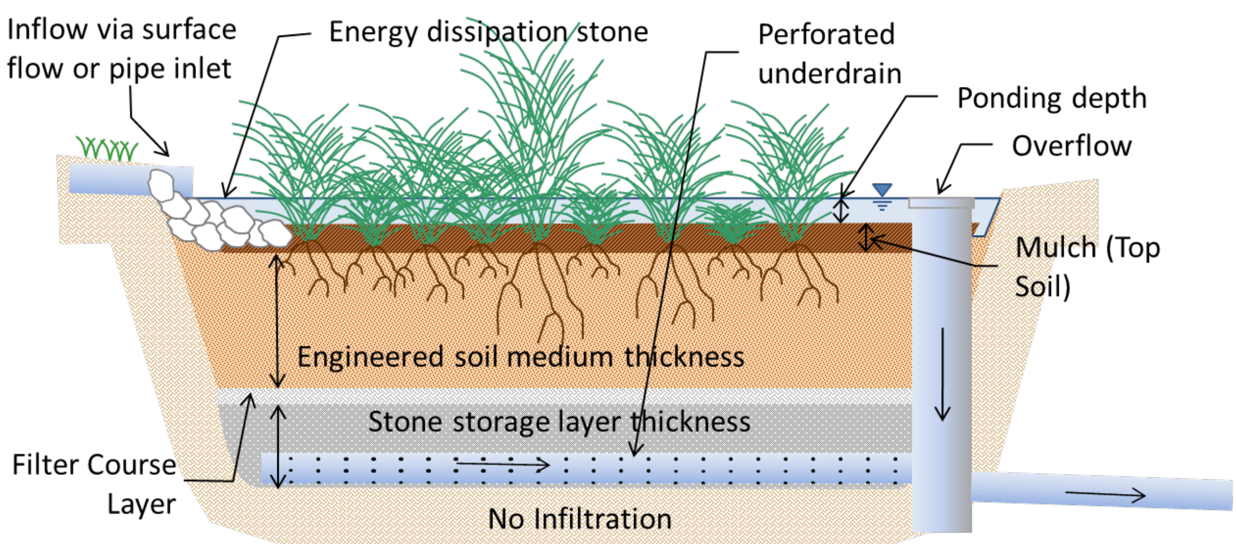


Figure 5-9. Schematic of a Typical Biofiltration Basin

Alternative Biofiltration Options:

Other BMPs, including proprietary BMPs (See **fact sheet BF-3 in Appendix E**) may be classified as biofiltration BMPs if they (1) meet the minimum design criteria listed in **Appendix F** and **Appendix B.5.2**, 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, and (3) are acceptable at the discretion of the City Engineer. 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, the City Engineer 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 City Engineer, a written explanation/reason will be provided to the applicant.

5.5.4 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

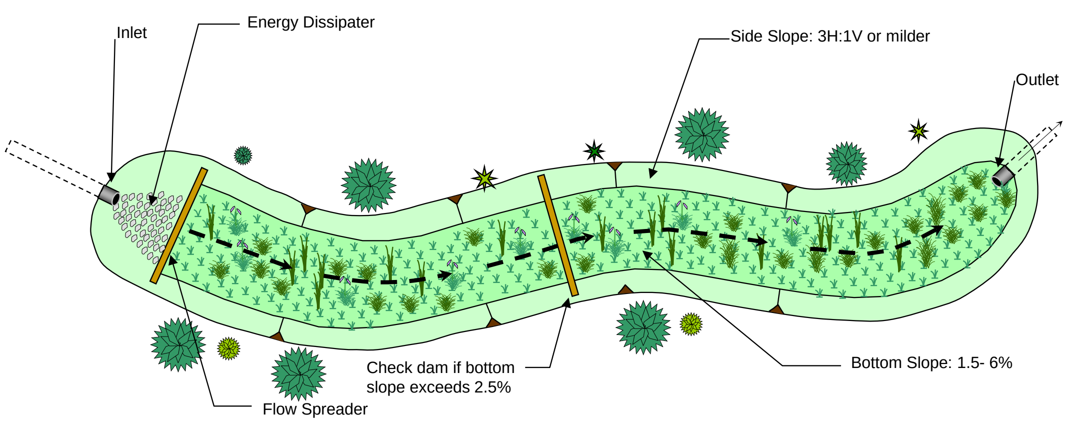


Figure 5-10. Schematic of a Vegetated Swale

Use of Proprietary BMP Options: A proprietary BMP (see **fact sheet FT-5 in Appendix E**) 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 consistent with its applicable performance certifications, and (3) is acceptable at the discretion of the City Engineer. 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, the City Engineer 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 City Engineer, a written explanation/reason will be provided to the applicant.

5.5.5 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 City Engineer. In determining the acceptability of an Alternate BMP, the City Engineer 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 City Engineer, a written explanation/reason will be provided to the applicant. 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 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 City Engineer and shall be documented in the SWQMP. Also refer to **Section 6.3.6** for additional guidance.

Chapter 6

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 in **Appendix H**.

6.1 Hydromodification Management Applicability and Exemptions

As noted in Chapter 1, Section 1.6 a project may be exempt from hydromodification 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 reflect the latest list of exemptions that are allowed under the MS4 Permit and therefore supersedes criteria found in earlier publications. Exempt water bodies within the City of San Diego jurisdiction are shown in an exhibit presented in **Appendix H**.

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[7]. 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.

DMAs classified as De Minimis (per Section 5.2.2) are exempt from Hydromodification Management requirements. DMAs classified as Self-mitigating (per Section 5.2.1) are exempt from Hydromodification Management requirements if they implement a properly sized energy dissipation system to mitigate outlet discharge velocity for the ultimate condition peak design flow for the entire contributing drainage area at the point of compliance.

6.2 Protection of Critical Coarse Sediment Yield Areas

When hydromodification management requirements are applicable according to **Section 6.1**, the applicant must determine if the project will impact any areas that are determined to be critical coarse sediment yield areas (CCSYAs). A CCSYA is an area that has been identified as an active or potential source of coarse sediment to downstream channel reaches. The process for demonstrating that the PDP does not impact CCSYAs is illustrated in Figure 6-1 below, and supplemented with detailed methodologies presented in **Appendix H** of this manual. PDPs complying with this provision of the MS4 Permit are not subject to additional post construction requirements due to the Total Maximum

[7] The San Diego County Regional WMAA report can be download from the Project Clean Water website http://www.projectcleanwater.org/index.php

Daily Load for Sediment in Los Peñasquitos Lagoon. However, PDPs may be subject to the Total Maximum Daily Load requirements during construction.

Appendix H presents technical guidance for onsite mitigation measure related to critical coarse sediment supply yield areas. Alternative mitigation methods may be added to Appendix H as they become available. Additionally, applicants may propose alternate mitigation measures for their project, subject to approval by the City Engineer. All alternate methods must meet the MS4 Permit requirements to demonstrate no net impact to the watershed.

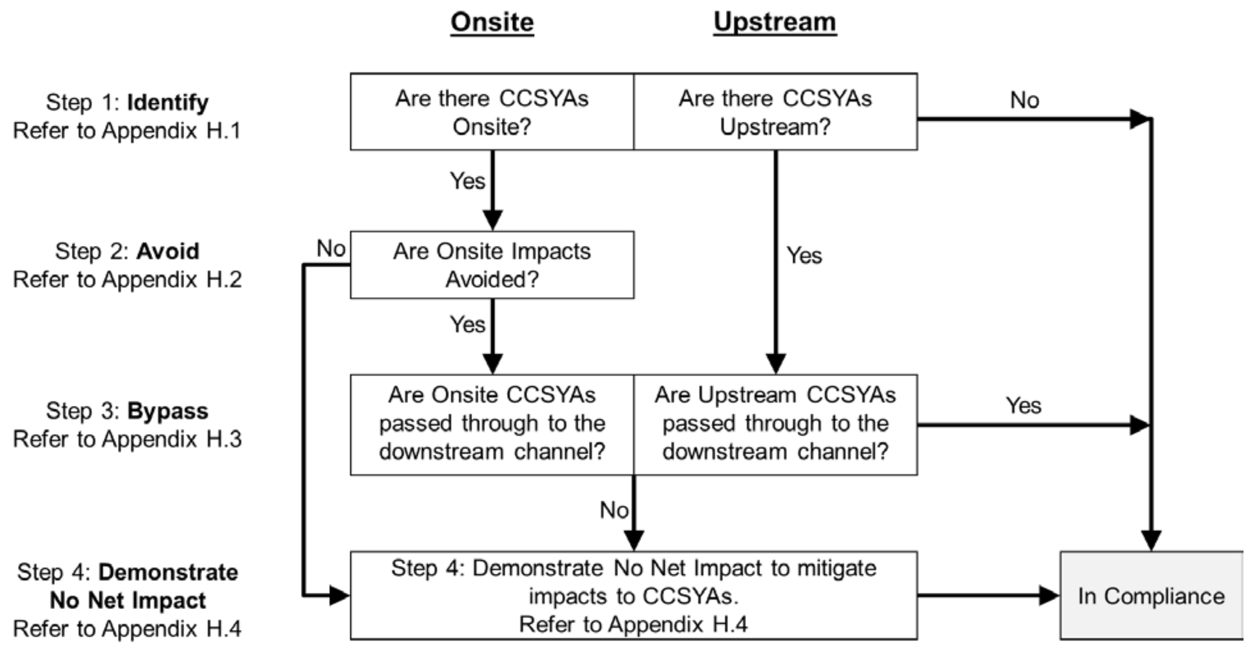


Figure 6-1. Pathways to meet CCSYA requirement

<u>Description of Steps:</u>

Step 1. Applicants must identify CCSYAs located onsite and/or upstream of the project site per the guidance presented in **Appendix H.1**. If no CCSYAs are identified in this step, no further consideration of critical coarse sediment supply is necessary.

Step 2. Applicants should avoid impacts to onsite CCSYAs through effective site design techniques discussed in **Appendix H.2**.

Step 3. Applicants should bypass bed sediment from onsite and/or upstream CCSYAs to downstream receiving waters per guidance presented in **Appendix H.3**.

Step 4. When impacts to CCSYAs are not avoided or passed through, the applicant must demonstrate that the project generates no net impact to the receiving water per guidance presented in **Appendix H.4**

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:

- 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 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 the following approved regression equations:

$$Q_2 = 3.60 \times A^{0.672} \times P^{0.753}$$

$$Q_{10} = 6.56 \times A^{0.783} \times P^{1.07}$$

where:

Q_2	=	2-year recurrence interval discharge in cubic feet per second
Q_{10}	=	10-year recurrence interval discharge in cubic feet per second
A	=	Drainage area in square miles
P	=	Mean annual precipitation in inches (Refer to Table 6-1)

Table 6-1. Mean Annual Precipitation

Gage	Latitude	Longitude	Mean Annual Precipitation (inches)
Oceanside	33.2105556	-117.353333	12.29
Encinitas	33.044567	-117.277213	10.73
Kearney Mesa	32.835118	-117.128456	11.43
Fashion Valley	32.7652778	-117.1758333	10.75
Bonita	32.6561111	-117.0341667	10.88
Poway	32.9522222	-117.0472222	13.08
Fallbrook AP	33.354669	-117.251279	16.18
Lake Wohlford	33.166423	-117.004955	16.63
Ramona	33.0480556	-116.8608333	16.57
Lake Henshaw	33.2386111	-116.7616667	21.58
Borrego	33.2211111	-116.3369444	4.00
Lindbergh	32.7337	-117.1767	10.75
Escondido	33.1197222	-117.095	14.67
Flinn Springs	32.847104	-116.857801	15.55
Lake Cuyamaca	32.9894	-116.5867	31.30
Lower Otay	32.6111	-116.9319	11.90
San Onofre	33.3513889	-117.5319444	11.13
San Vicente	32.912082	-116.926513	16.47
Santee	32.839016	-117.024857	13.15

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 projects with multiple POCs, care should be taken to avoid the diversion of flow from one POC to another. In addition to water balance issues, flow diversion between points of compliance increases the size of the required flow control measures because the post-project drainage area is larger than the pre-development area. Consider the effect of grading changes and conveyances on potential diversions.

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 City Engineer.

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.

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 City Engineer 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 City Engineer, 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 City Engineer.

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 for each POC. 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. If the screening tools are not completed for each POC in a proposed project, then each site must mitigate the peak flows and durations based on a pre-development condition lower flow threshold. Note that the City Engineer 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[8].

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, flow 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. Flow duration statistics determine how often a particular flow rate is exceeded. To determine if a flow control facility meets hydromodification management performance standards, 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 described in **Section 6.3.5.1** or using project-specific continuous simulation modeling described in **Section 6.3.5.2**.

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.

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. Refer to **Appendix G.2** 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

[8] Note: This is different than the way domain of analysis is defined in the March 2011 Final HMP.

for the planned flow control BMPs. There are several available hydrologic models that can perform continuous simulation analyses. Refer to **Appendix G** 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 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 City Engineer.

Appendix B.5.2.2 provides a methodology to size an upstream vault (e.g. cistern) with a downstream biofiltration BMP designed to meet the pollutant control obligations.

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 96 hour drawdown criteria is only applicable for surface ponding i.e. 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.).

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 governing municipality.

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 owner 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 in 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/content/dam/sdc/pds/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.

6.4 In-Stream Rehabilitation

An alternative to onsite flow control for post-project runoff may be in-stream rehabilitation.

Project applicant may be allowed to participate in an in-stream rehabilitation project in lieu of implementing onsite flow control BMPs. Refer to **Part 3 of the Storm Water Standards**.

Chapter 7

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 or site design / 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 City Engineer 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 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 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, SDRWQCB, 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.

Experience has shown provisions to finance and implement maintenance of BMPs can be a major stumbling block to project approval, particularly for **small residential subdivisions**. Project owners 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. Table 7-1 summarizes 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	Determine structural BMP ownership, party responsible for permanent O&M, and maintenance funding mechanism	Prior to first submittal of a project application – discuss with staff at pre-application meeting
2	Identify expected maintenance actions	First submittal of a project application – identify in PDP SWQMP
3	Develop detailed O&M Plan	As required by City Engineer, prior to issuance of construction, grading, building, site development, or other applicable permits
4	Update/finalize O&M Plan to reflect constructed structural BMPs with as-built plans and baseline photos	As required by City Engineer, upon completion of construction of structural BMPs
5	[For private maintenance] Prepare draft O&M Agreement (legal agreement to be recorded against the property by the County Assessor)	As required by City Engineer
6	[For private maintenance] Execute and record O&M Agreement	As required by City Engineer

7.3 Maintenance Responsibility

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

Depending on if the project is public or private, the responsible party and maintenance requirements may vary. Public projects shall consult the City's internal requirements to determine the responsible party and maintenance requirements.

For private projects, the property owner is responsible to ensure inspection, operation and maintenance of permanent structural BMPs on their property unless responsibility has been formally transferred to an agency, community facilities district, homeowners association, property owners association, or other special district. When property ownership changes (i.e., the property is sold or otherwise transferred to a new owner), maintenance responsibility also transfers to the new owner, typically by transfer of a maintenance agreement recorded against the property by the County Assessor. For structural BMPs that will be transferred to an agency, community facilities district, homeowners association, property owners association, or other special district, there may be an interim period during which the property owner is responsible until maintenance responsibility is formally transferred.

For public improvements, the project applicant shall submit plans, a description of required maintenance, and estimates of both annual and long-term maintenance costs, for routing by Development Services to the City department responsible for maintenance of the structural BMPs for review. For CIP projects, the routing shall be done by the Project Manager.

7.4 Long-Term Maintenance Documentation

As part of on-going structural BMP maintenance into perpetuity, property owners are required to provide documentation of maintenance for the structural BMPs on their property to support the City's reporting requirements to the SDRWQCB.

The MS4 Permit requires the City 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." The City 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 SDRWQCB annually. Based on these MS4 Permit requirements, the City Engineer will require property owners 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.

7.5 Inspection and Maintenance Frequency

How often is a property owner required to inspect and maintain permanent structural BMPs on their property?

The minimum inspection and maintenance frequency is annual and must be reported annually. 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 owner'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.
- 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). Signage for vactor truck schedule must be placed in areas where maintenance is scheduled.

- 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 City Engineer.
- 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 project owner should consider the long term cost of maintenance and what type of maintenance contracts a future property owner, homeowners association or property owners association 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

For structural BMPs that use bioretention soil media (BSM), the frequency of maintenance is based on the BSM specification used. When the City maintains these BMPs, it does so in compliance with all local, state, and federal laws governing the handling, transport, and disposal of hazardous waste. Additionally, private BMPs are typically maintained by property owners that are subject to state and federal regulations governing the handling, transport, and disposal of hazardous waste.

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.

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 City Engineer 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 City Engineer 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 City Engineer 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.

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Chapter 8

Submittal Requirements

It is necessary for the City Engineer 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. Specific submittal requirements may vary by jurisdiction. 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 Requirements for PDP Exempt and Standard Projects

8.1.1 PDP Exempt and Standard Projects

For PDP Exempt and Standard Projects, the project submittal must include a storm water applicability checklist referenced in **Appendix A**. A Standard SWQMP forms may be required upon project review. PDP Exempt and Standard Projects shall use the Standard SWQMP forms referenced in **Appendix A** if requested by the project reviewer.

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 referenced 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 a project application.

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 City Engineer's 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.

The engineer of work is required to prepare and submit a hard copy as well as an electronic copy of a PDP SWQMP including all applicable exhibits, which is then reviewed by the City engineering review staff. Refer to **Appendix A** for the minimum required information to be included in a PDP SWQMP. The City engineering reviewer ensures that the PDP SWQMP sufficiently demonstrates how the project will meet all of the site design (see **Chapter 4**), source control (see **Chapter 4**), and structural pollutant control BMP (see **Chapter 5**) requirements. The PDP SWQMP should address whether the project is subject to hydromodification management requirements (see **Chapter 6**) providing structural hydromodification control BMPs or whether the project is exempt from hydromodification requirements providing supporting documentation for the exemptions.

After the PDP SWQMP has been reviewed and accepted by the City engineering reviewer, the applicant must submit a Storm Water Management and Discharge Control Maintenance Agreement (Maintenance Agreement), **DS-3247**; this will be reviewed by the engineering reviewer concurrently with the PDP SWQMP.

The following items shall be included in a Storm Water Management and Discharge Control Maintenance Agreement (Maintenance Agreement), DS-3247:

- Vicinity map
- Site design BMPs for which DCV reduction is claimed for meeting the pollutant control obligations.
- Pollutant control and hydromodification BMPs location and dimensions
- Pollutant control and hydromodification BMPs specifications/cross section/model (for proprietary BMPs)

- Maintenance recommendations and frequency.

Additional information may be required at the discretion of the City engineering reviewer based on the nature of the project. The Maintenance Agreement is signed and notarized by the applicant and by City staff. Following acceptance of the PDP SWQMP, but prior to permit issuance, the City engineering reviewer reviews the Maintenance Agreement and the development plans for consistency with the PDP SWQMP. Once reviewed and approved, the agreement will be recorded against the property at the County Recorder's Office and runs with the land, so maintenance responsibility is transferred with sale of the property and gives the City legal authority to require the property owner to perform maintenance on the structural post-construction BMPs on the site. Permits that construct structural BMPs will not be issued for the project unless the structural post-construction BMP information on the Maintenance Agreement and development plans is consistent with the design in the approved PDP SWQMP.

Note that additional information may be required at the discretion of the reviewer based on the nature of project but as a minimum the information listed in the submittal template in **Appendix A** shall be included in the PDP SWQMP.

Any hydrology or hydraulic calculations, soils reports or geotechnical reports prepared in support of a PDP SWQMP must be prepared by a professional engineer with appropriate registration qualifications issued by the State of California.

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. Local jurisdictions may have varying requirements for a final O&M Plan. Requirements may also vary depending on whether long term O&M will be furnished by a public agency or private entity. 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 SWQMP.

Construction plans shall include the following information:

(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) Private 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 City Engineer. 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.

For private developments, design changes must be reviewed and approved by the Engineer on Record and City Engineer through a construction change, before work can proceed. For CIP projects, a construction change document for storm water BMPs must be approved by the Deputy City Engineer before work can proceed.

Construction changes proposed after permit issuance are reviewed by the City engineering staff prior to approval to ensure that the proposed change is in compliance with the BMP requirements of the Storm Water Standards Manual. Additional information may be required at the discretion of the reviewer based on the nature of project but as a minimum the following documents shall be included in construction changes proposed after permit issuance:

- Original permitted set of plans.
- Original approved SWQMP.
- Construction change plans with all changes bubbled and deltas added identify proposed changes.
- A hard copy as well as an electronic copy of the addendum to the original SWQMP prepared by the original engineer of work identifying proposed changes and their hydrologic effect. If the original engineer of work is no longer available, the new engineer of work shall accept the original SWQMP prior to preparation of the addendum.
- Notice of termination for the original maintenance agreement form must be prepared along with a new maintenance agreement (Storm Water Discharge and Maintenance Agreement)

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 City Engineer 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 City Engineer may require forms or other documentation be submitted prior to the inspection in order to facilitate the structural BMP inspection. Project shall submit Form DS-563: Permanent BMP Construction Self Certification Form.

8.2.3.3 Final O&M Plan

Upon completion of project construction, the local agency 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. Specific requirements and review procedures for this process may vary by jurisdiction, or vary based on the planned maintenance entity (public or private).

If there are no changes from the Operation and Maintenance Plan that was part of the approved SWQMP, then that plan shall be the final. If changes are required, then the applicant shall update the SWQMP and submit to the City, through a construction change.

BMPs must first be approved by City asset owning department prior to permit issuance. An operational check by the BMP owner is completed prior to the submittal of the as-built drawings. The operational check requirements include the Permanent BMP Construction Self Certification Form (**DS-563**) be completed and submitted to the City. The Permanent BMP Construction Self Certification Form (DS-563) shall be completed, signed and sealed by the Engineer of Work. The permanent BMP's are considered accepted in unison with the other improvements shown on the approved plans and BMP Operation & Maintenance (O&M) Manuals are received.

8.2.4 Additional Requirements for Private Entity O&M

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

8.2.4.1 O&M Agreements for Private Structural BMP Maintenance

For privately owned and operated structural BMPs, the local jurisdiction requires execution of an O&M Agreement document.

An O&M Agreement is a recorded document signed by the local jurisdiction and the property owner committing the property owner to maintain the permanent structural BMPs into perpetuity. The O&M Agreement may provide that, if the property owner fails to maintain the storm water facilities, the local jurisdiction may enter the property, restore the storm water facilities to operable condition, and obtain reimbursement, including administrative costs, from the property owner. Specific requirements and procedures for this process may vary by jurisdiction.

Chapter 9

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THE CITY OF SAN DIEGO

Storm Water Standards

PART 1

BMP Design Manual: Appendices For Permanent Site Design, Storm Water Treatment and Hydromodification Management

November 2017 Edition

Prepared by:

Geosyntec consultants

The City of SAN DIEGO

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Contents

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Appendix A

Submittal Templates

The following templates were developed to assist the project applicant and the plan reviewer:

A.1. Storm Water Requirements Applicability Checklist
A.2. Standard SWQMP Forms
A.3. PDP SWQMP

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A.1 Storm Water Applicability Checklist

All projects must complete this checklist (DS-560) to identify the applicable storm water requirements. The purpose of this checklist is to establish the storm water requirements applicable to the project. A copy of this DS-560 checklist can be downloaded from:

https://www.sandiego.gov/sites/default/files/dsdds560.pdf

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A.2 Standard SWQMP Forms

The following Standard SWQMP forms were developed to assist the PDP Exempt and Standard Project applicants and the plan reviewer:

- Form I-4A: Source Control BMP Checklist for Standard Projects
- Form I-5A: Site Design BMP Checklist for Standard Projects

A copy of the Standard SWQMP forms can be downloaded from:

https://www.sandiego.gov/stormwater/regulations

Upon project review, if a Standard SWQMP forms are requested by the City engineering review staff, the checklists (Form I-4A and Form I-5A) must be completed by the project applicant and included on the construction plans. When requested, the applicant is required to submit an electronic and hard copy for engineering review.

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A.3 PDP SWQMP

The PDP SWQMP template was developed to assist the PDP applicants and the plan reviewer. A copy of the PDP SWQMP template can be downloaded from:

https://www.sandiego.gov/stormwater/regulations

The PDP applicant is required to submit an electronic and hard copy of the PDP SWQMP for review. Latest edition of the forms, worksheets and templates from the City website must be used in the submittal. The forms and worksheets in this manual are samples and included for informational purposes only.

The following minimum information must be included in the PDP submittal:

- **Compliance Option,** indicate on the cover page if the project is electing for onsite compliance (Part 1 of Storm Water Standards) or offsite storm water alternative compliance (Part 3 of Storm Water Standards).
- **Certification Page**, stamped and signed (wet signature) by Engineer in Responsible Charge
- **Submittal Record**
- **Project Vicinity Map**, including project area, adjacent street and nearby hydrologic features
- **FORM DS-560**: Storm Water Applicability Checklist, signed by Owner or Agent
- **FORM I-1**: Applicability of Permanent, Post-Construction Storm Water BMP Requirements
- **HMP Exemption Exhibit (for all hydromodification management exempt projects)**, including project area, applicable underground storm drain line and/or concrete lined channels, outfall information (with drawing numbers referenced) and exempt waterbody. Minimum 11 x 17 sheet.
- **FORM I-3B**: Site Information Checklist for PDPs
- **FORM I-4**: Source Control BMP Checklist for PDPs
- **FORM I-5**: Site Design BMP Checklist for PDPs including a site map with all site design BMPs.
- **FORM I-6**: Summary of PDP Structural BMPs (one sheet per BMP)
- **Attachment 1: Backup for PDP Pollutant Control BMPs**
    - **Attachment 1A: DMA Exhibit** including the following information
        - Underlying hydrologic soil group
        - Approximate depth to groundwater
        - Existing natural hydrologic features (watercourses, seeps, springs, wetlands)
        - Critical coarse sediment yield areas to be protected
        - Existing topography and impervious areas
        - Existing and proposed site drainage network and connections to drainage offsite

        - Proposed grading
        - Proposed impervious features
        - Proposed design features and surface treatments used to minimize imperviousness
        - Drainage management area (DMA) boundaries, DMA ID numbers, and DMA areas (square footage or acreage), and DMA type (i.e., drains to BMP, self-retaining, or self-mitigating), impervious area created/replaced (ft^2 or acres)
        - Potential pollutant source areas and corresponding required source controls (see Chapter 4, Appendix E.1, and Form I-3B)
        - Structural BMPs (identify location, type of BMP, cross-section and size/detail)
    - **Attachment 1B: Tabular Summary of DMAs (Worksheet B-1 from Appendix B)** and Design Capture Volume Calculations
    - **Attachment 1C: FORM I-7** Harvest and Use Feasibility Screening
    - **Attachment 1D:** Infiltration Feasibility Information (one or more of the following):
        - Infiltration Feasibility Condition Letter
        - FORM I-8A: Worksheet C.4-1 Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions
        - Form I-8B: Worksheet C.4-2 Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions
        - Worksheet C.4-3: Infiltration and Groundwater Protection for Full Infiltration BMPs
        - FORM I-9: Worksheet D.5-1 Factor of Safety and Design Infiltration Rate Worksheet for Full Infiltration Designs
    - **Attachment 1E: Pollutant Control BMP Design Worksheets / Calculations for each DMA and Structural BMP Worksheets from Appendix B, as applicable.**
- **Attachment 2: Backup for PDP Hydromodification Control Measures**
    - **Attachment 2A:** Hydromodification Management Exhibit including the following information
        - Underlying hydrologic soil group
        - Approximate depth to groundwater
        - Existing natural hydrologic features (watercourses, seeps, springs, wetlands)
        - Critical coarse sediment yield areas to be protected
        - Existing topography
        - Existing and proposed site drainage network and connections to drainage offsite
        - Proposed grading

        - Proposed impervious features
        - Proposed design features and surface treatments used to minimize imperviousness
        - Point(s) of Compliance (POC) for Hydromodification Management, with a POC at each point of discharge
        - Existing and proposed drainage boundary and drainage area to each POC (when necessary, create separate exhibits for pre-development and post-project conditions)
        - Structural BMPs for hydromodification management (identify location, type of BMP, cross-section and size/detail)
    - **Attachment 2B:** Management of Critical Coarse Sediment Yield Areas (CCSYA); See Section 6.2. Must provide a map showing that the project site is outside the CCSYA.
    - **Attachment 2C:** Geomorphic Assessment of Receiving Channels (Optional); See Section 6.3.4
    - **Attachment 2D:** Flow Control Facility Design; Overflow Design Summary for each structural BMP. See Chapter 6 and Appendix G.
- **Attachment 3: Structural BMP Maintenance Plan**
    - **Form DS-3247**: Maintenance Agreement including the following information
        - Vicinity map
        - Site design BMPs for which DCV reduction is claimed for meeting the pollutant control obligations.
        - Pollutant control and hydromodification BMPs location and dimensions
        - Pollutant control and hydromodification BMPs specifications/cross section/model (for proprietary BMPs)
        - Maintenance recommendations and frequency
- **Attachment 4: Copy of Plan Sheets Showing Permanent Storm Water BMPs**, must meet the requirements in Section 8.2.2 in Chapter 8 in Part 1 of the Storm Water Standards and must include the information in the checklist in the PDP submittal template.
- **Attachment 5: Project's Drainage Report**
- **Attachment 6: Project's Geotechnical and Groundwater Investigation Report**, must satisfy the requirements in Appendix C.3.

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Appendix B

Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

Table of Contents:

Sizing worksheets in this Appendix are not intended to be used independently from the overall manual – rather they are intended to be used only as referenced in the manual. All PDP SWQMPs must include a completed **Worksheet B-1** and other completed sizing worksheets from Appendix B, as applicable.

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Worksheet B-1: Tabular Summary of DMAs

Tabular Summary of DMAs								Worksheet B-1	
DMA Unique Identifier	Area (acres)	Impervious Area (acres)	% Imp	HSG	Area Weighted Runoff Coefficient	DCV (cubic feet)	Treated By (BMP ID)	Pollutant Control Type	Drains to (POC ID)
Summary of DMA Information (Must match project description and SWQMP Narrative)									
No. of DMAs	Total DMA Area (acres)	Total Impervious Area (acres)	% Imp		Area Weighted Runoff Coefficient	Total DCV (cubic feet)	Total Area Treated (acres)		No. of POCs

Where: DMA = Drainage Management Area; Imp = Imperviousness; HSG = Hydrologic Soil Group; DCV= Design Capture Volume; BMP = Best Management Practice; POC = Point of Compliance; ID = identifier; No. = Number

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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 (Equation B.1-1) shall be used to calculate the DCV:

Equation B.1-1: Estimating Runoff Factor for Area

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

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) within the project

DCV calculations shall be documented using Worksheet B.2-1 (or equivalent).

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 Equation B.1-2.

Equation B.1-2: Estimating Runoff Factor for Area

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

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.

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[2]	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.

[2]Surface shall be designed in accordance with SD-F (Amended soils) fact sheet in Appendix E

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 inches of rainfall per hour, for each hour of every storm event. The following hydrologic method (Equation B.1-3) shall be used to calculate the diversion flow rate for off-line BMPs:

Equation B.1-1: Hydrologic Method

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

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) within the project footprint.

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

The 85th percentile, 24-hour isopluvial 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:

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.

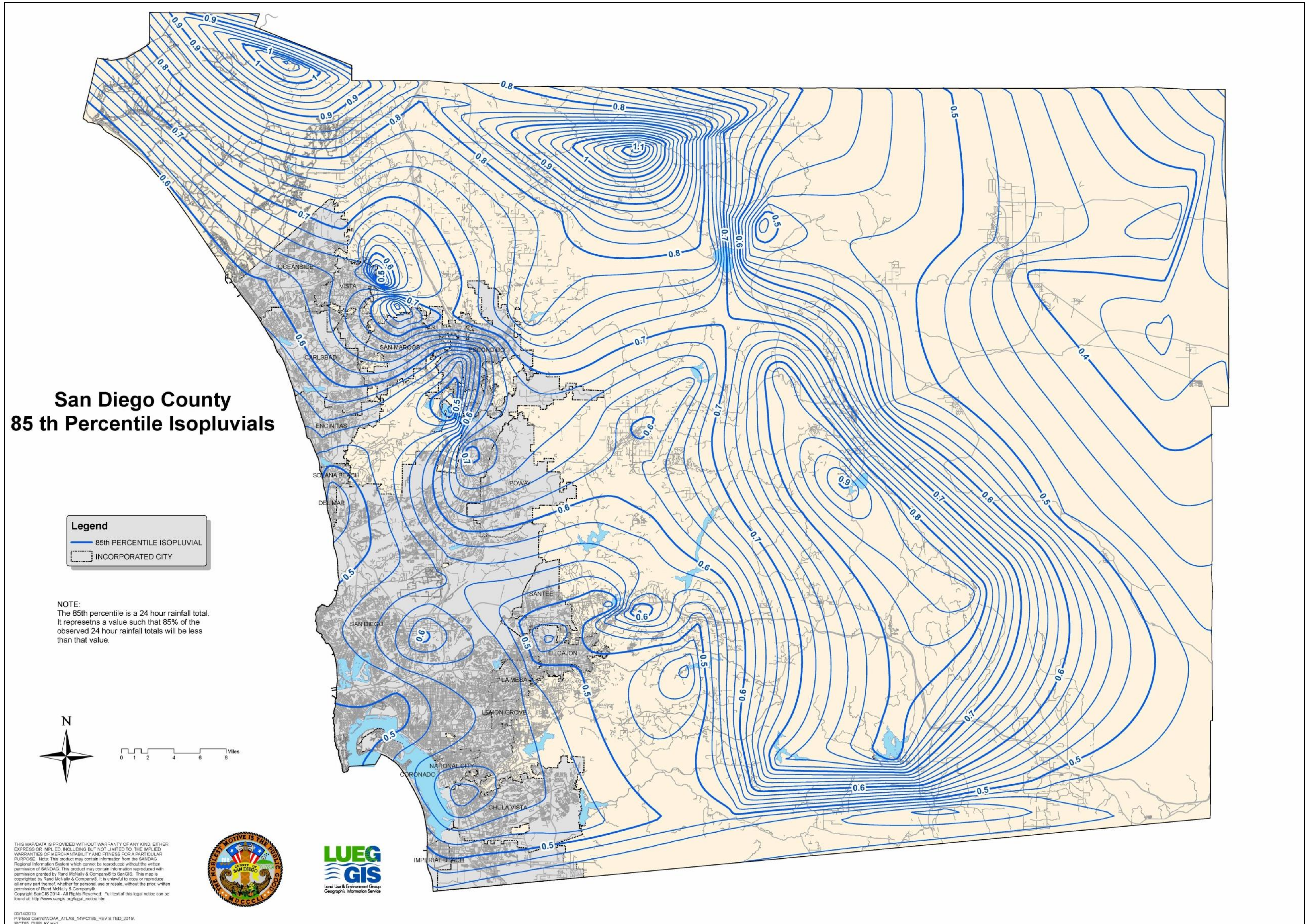

Figure B.1-1: 85th Percentile 24-hour Isopluvial Map

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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-B Impervious area dispersion
- SD-C Green roofs
- SD-D Permeable pavement

B.2.1.1 Impervious Area Dispersion (SD-B)

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-B fact sheet (**Appendix E**). In order to adjust the runoff factor, the pervious area shall have a minimum width (flow length) 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

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 City Engineer.

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 from Table B.2-1 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. Appendix B.5 has adjustment factors for scenarios when the impervious to pervious area ratio is greater than 4.

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-B 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-C factsheet the green roof footprint shall be assigned a runoff factor of 0.10 for adjusted runoff factor calculations when the green roof receives runon from other areas within the project footprint (i.e., multi-level roof or partial green roof).

If a DMA only contains a green roof that is designed in accordance with SD-C fact sheet, then it can be considered as a self-retaining DMA that meets the storm water pollutant control obligations and no additional DCV calculations are necessary for this DMA.

B.2.1.3 Permeable Pavement

When a permeable pavement is implemented in accordance with the SD-D 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. The slope of the permeable pavements designed as site design BMPs must be less than or equal to 5 percent.

Permeable Pavement can also be designed as a structural BMP to treat run on from adjacent areas. Refer to INF-3 factsheet in **Appendix E** 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-A: Trees
- SD-E Rain barrels

B.2.2.1 Trees

Applicants are allowed to take credit for installing new trees using Table B.2-2 or Equation B.2-1 as applicable, when trees are implemented in accordance with SD-A fact sheet and meet the following criteria:

- Total tree credit volume is less than or equal to 0.25 DCV of the project footprint and
- Single tree credit volume is less than or equal to 400 ft^3.

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-A fact sheet. These credit calculations are based on an assumption that each tree and associated trench or box is considered a single BMP, with calculations based on the media storage volume and contributing area.

Table B.2-2 was developed assuming that the entire tributary area is impervious (use Equation B.2-1 if there are different types of surfaces in the contributing area) and an 85th percentile 24-hour rainfall depth of 0.5 inches. The procedure for estimating the tree credit volume using Table B.2-2:

- Delineate the tributary area to the tree and use this tributary area to determine the tree credit volume using Table B.2-2. Use linear interpolation if the tributary area is in between the areas listed in Table B.2-2. When the contributing area is greater than 10,667 ft^2 this simplified method is not allowed.
- Using the amount of soil volume installed to determine the credit using Table B.2-2. Use linear interpolation if the soil volume is in between the values listed in Table B.2-2. When the soil volume is greater than 1,333 ft^3 this simplified method is not allowed.
- Use the smaller tree credit volume of the two estimates.

Table B.2-2: Allowable Reduction in DCV

Tree Credit Volume (ft^3/tree)[1]	Contributing Area (ft^2)	Soil Volume (ft^3)
10	267	33
50	1,333	167
100	2,667	333
150	4,000	500
200	5,333	667
300	8,000	1,000
400	10,667	1,333

Note: [1]If an underdrain is installed only 1/3rd of the tree credit volume shown in Table B.2-2 is allowed.

Applicant can also estimate the tree credit volume using Equation B.2-1.

Equation B.2-1: Tree Credit Volume

$$\boldsymbol{TCV = Minimum(SV \times 0.3,\ 3{,}630 \times d \times C \times A)};$$ With no underdrains installed

$$\boldsymbol{TCV = Minimum(SV \times 0.1,\ 3{,}630 \times d \times C \times A)};$$ When an underdrain is installed

where:

TCV	=	Tree credit volume (ft^3); maximum of 400 ft^3 for one tree and not more than 0.25*DCV from the project footprint for all trees proposed as site design BMPs
SV	=	Soil volume installed with the tree (ft^3)
d	=	85th percentile 24-hr storm depth (inches) from Figure B.1-1
C	=	Area weighted runoff factor (calculate using Appendix B.1.1 and B.2.1)
A	=	Area tributary to the tree (acres)

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-E 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 must be based on the criteria in **Appendix B.3** and HU-1 fact sheet in **Appendix E**.

Worksheet B.2-1: DCV

Design Capture Volume		Worksheet B.2-1		
1	85th 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	Trees Credit Volume Note: In the SWQMP list the number of trees, size of each tree, amount of soil volume installed for each tree, contributing area to each tree and the inlet opening dimension for each tree.	TCV=		cubic-feet
5	Rain barrels Credit Volume Note: In the SWQMP list the number of rain barrels, size of each rain barrel and the use of the captured storm water runoff.	RCV=		cubic-feet
6	Calculate DCV = (3630 x C x d x A) – TCV - RCV	DCV=		cubic-feet

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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

Form I-7: Worksheet B.3-1 provides a screening process for determining the preliminary feasibility for harvest and use BMPs. This worksheet shall be completed for the overall project.

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

<table>
<tr><th colspan="2">Harvest and Use Feasibility Screening</th><th>Worsksheet B.3-1</th></tr>
<tr><td colspan="3">1. Is there a demand for harvested water (check all that apply) at the project site that is reliably present during the wet season?
☐ Toilet and urinal flushing
☐ Landscape irrigation
☐ Other:____________________</td></tr>
<tr><td colspan="3">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.
[Provide a summary of calculations here]</td></tr>
<tr><td colspan="3">3. Calculate the DCV using worksheet B-2.1.
[Provide a results here]</td></tr>
<tr><td>3a. Is the 36-hour demand greater than or equal to the DCV?
Yes / No ⇨
⇩</td><td>3b. Is the 36-hour demand greater than 0.25DCV but less than the full DCV?
Yes / No ⇨
⇩</td><td>3c. Is the 36-hour demand less than 0.25DCV?
Yes
⇩</td></tr>
<tr><td>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.</td><td>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.</td><td>Harvest and use is considered to be infeasible.</td></tr>
</table>

Note: 36-hour demand calculations are for feasibility analysis only, once the feasibility analysis is complete the applicant may be allowed to use a different drawdown time provided they meet the 80 percent of average annual (long term) runoff volume performance standard.

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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.

Note: Table B.3-1 provides a demand estimate for 24 hours, for feasibility analysis this estimate must be multiplied by 1.5 to calculate the 36-hour demand.

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 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.

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.

Equation B.3-1 is used to calculate the Modified Estimated Total Water Usage.

Equation B.3-1: Modified Estimated Total Water Usage

$$\text{Modified ETWU} = ETo_{Wet} \times [[\Sigma(PF \times HA)/IE] + SLA] \times 0.015$$

where:

Modified ETWU	=	Estimated daily average water usage during wet season
ETo_{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
HA	=	Hydrozone Area (sq-ft); A section or zone of the landscaped area having plants with similar water needs. Σ(PF x 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.

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	

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 mo/30 days)×(1 ft/12 in)×(7.48 gal/cu-ft)×(approximately 7 out of 10 days with irrigation demand from October through April)

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

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 must 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 Form I-7: 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 and the remaining DCV must be mitigated using other BMPs.

B.4 Infiltration BMPs

Sizing calculations must 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 (**Appendix 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 (**Appendix 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 City Engineer. 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 Form 1-9: 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 (DCV/A_{BMP})	D_{avg}=		feet
5	Drawdown time, T (D_{avg} *12/K_{design})	T=		hours
6	Provide alternative calculation of drawdown time, if needed.			
7	Provide calculations for effective depth provided in the BMP: Effective Depth = Surface ponding (below the overflow elevation) + gravel storage thickness x gravel porosity (0.4)			

Notes:

1. 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 Appendix B.4.3). In order to use a different drawdown time, BMPs should be sized using the percent capture method (Appendix B.4.2).
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.
3. 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.

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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.

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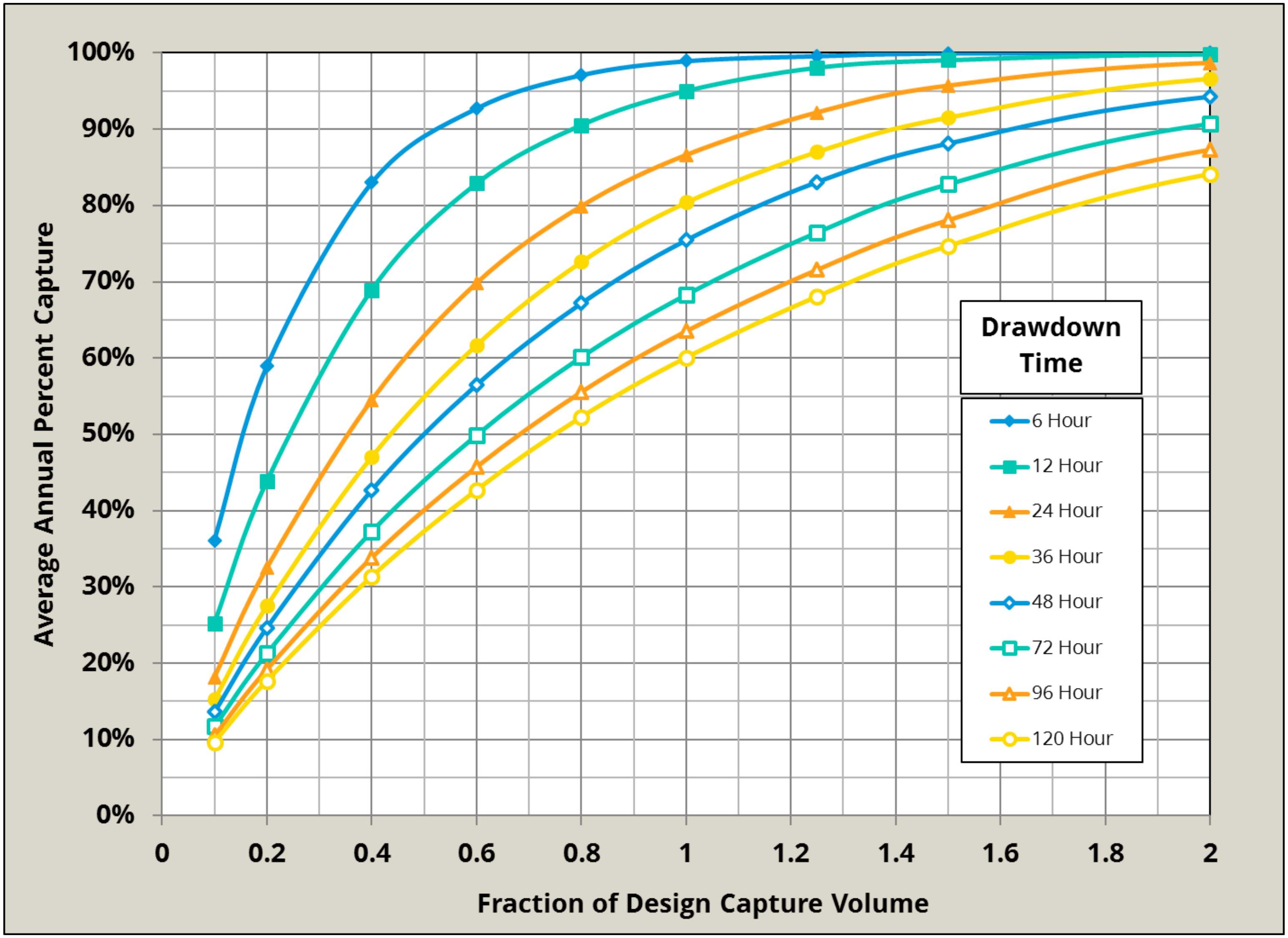

Figure B.4-1: Percent Capture Nomograph

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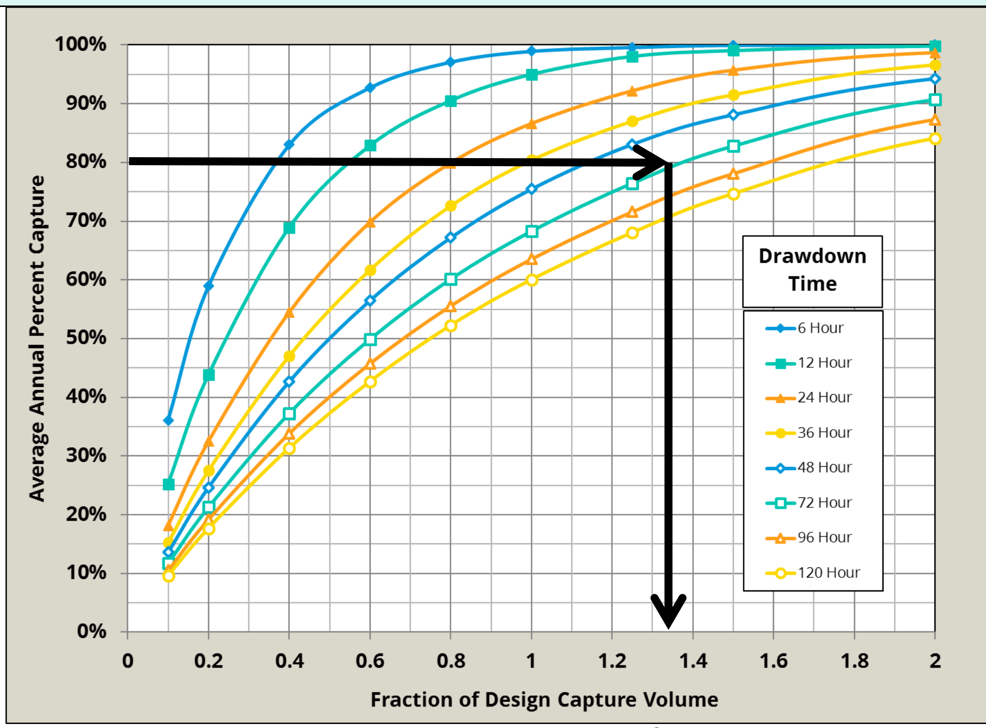
B.4.2.1 Stepwise Instructions for sizing a single BMP:

1. Estimate the drawdown time of the proposed BMP by estimating the design infiltration rate (Form I-9: 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.4-1: Percent Capture Method for Sizing a Single BMP

Given:
• Estimated drawdown time: 72 Hours • DCV: 3000 ft³
Required:
• Determine the volume required to achieve 80 percent capture.
Solution:
1. Estimated drawdown time = 72 Hours 2. Fraction of DCV required = 1.35 3. DCV = 3000 ft³ (Given for this example; To be estimated using Worksheet B.2-1) 4. Required BMP volume = 1.35 x 3000 = 4050 ft³ 5. Design BMP and confirm drawdown Time is ≤ 90 Hours (72 Hours +25%)
Graphical Operations Supporting Solution:



Percent Capture Nomograph

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.
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: Percent Capture Method for Sizing BMPs in Series

Given:

- Estimated drawdown time for downstream BMP: 72 Hours
- DCV for the area draining to the BMP: 3000 ft^3
- Upstream BMP volume: 900 ft^3
- Upstream BMP drawdown time: 24 Hours

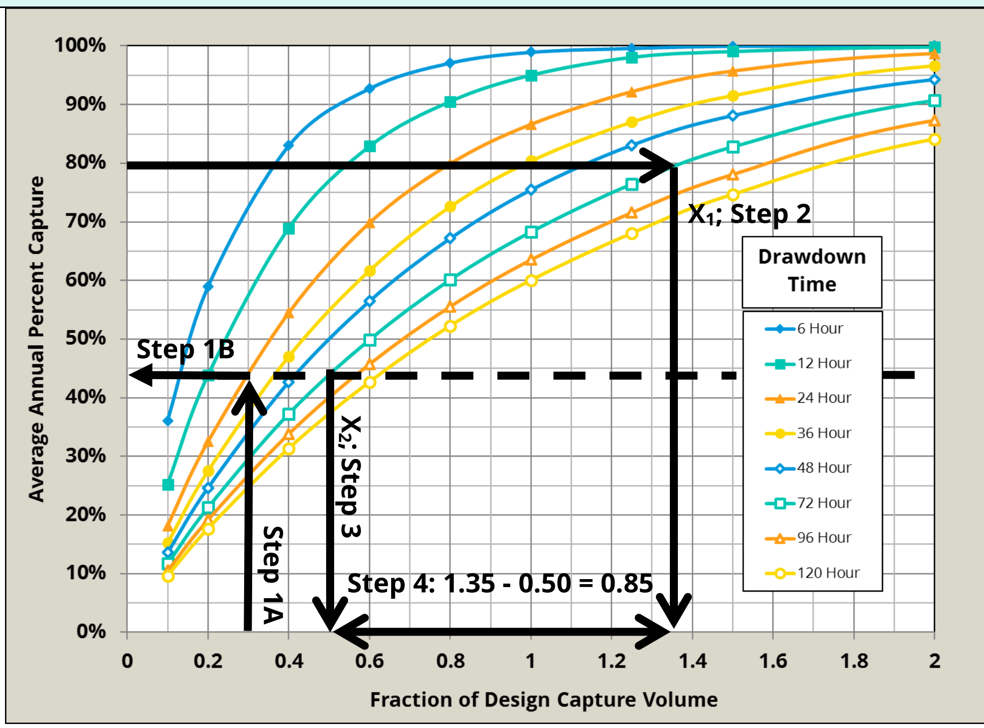
Required:

- Determine the volume required in the downstream BMP to achieve 80 percent capture.

Solution:

1. Step 1A: Upstream BMP Capture Ratio = 900/3000 = 0.3; Step 1B: Average annual capture efficiency achieved by upstream BMP = 44%
2. Downstream BMP drawdown = 72 hours; Fraction of DCV required to achieve 80% capture = 1.35
3. 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)
4. Fraction of DCV Required by downstream BMP = 1.35-0.50 = 0.85
5. DCV (given) = 3000 ft^3; Required downstream BMP volume = 3000 ft^3 x 0.85 = 2,550 ft^3
6. Design BMP and confirm drawdown Time is ≤ 90 Hours (72 Hours +25%)

Graphical Operations Supporting Solution:



Percent Capture Nomograph

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 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 within the City.

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B.5 Biofiltration BMPs

Biofiltration BMPs must be sized using 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.

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.

The MS4 Permit specifies (Footnote 29) that the hydraulic loading rate and other biofiltration design criteria must be selected such that **storm water retention and pollutant removal** are maximized. 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) and a volume retention performance standard (Figure B.5-2) based on the reliable infiltration rate at the site (i.e. measured infiltration rate/factor of safety of 2) is specified. **Appendix B.5.3** provides the technical rationale for the 3 percent minimum sizing factor and the volume retention performance standard.

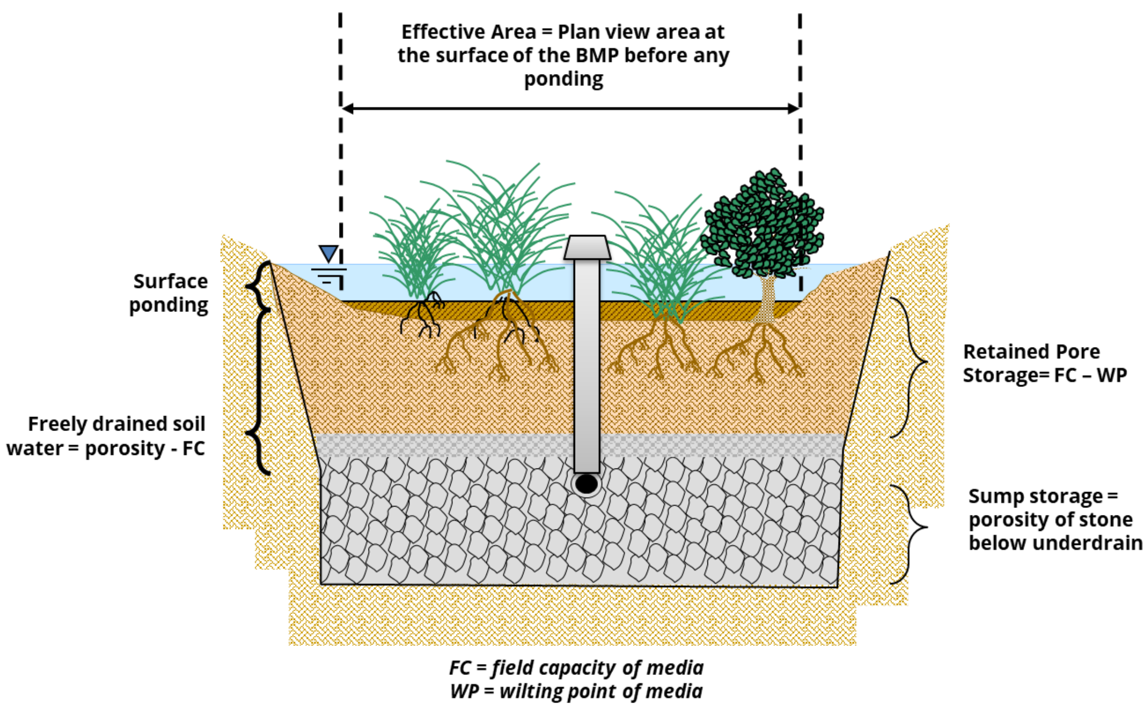

Figure B.5-1 Explanation of Biofiltration Volume Compartments for Sizing Purposes

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

Note: For sizing calculations, it shall be assumed that only 50% of the retained pore storage (field capacity – wilting point) is available for evapotranspiration to account for typical irrigation practices.

The numeric sizing criteria in this appendix are subdivided into:

- **Appendix B.5.1:** Standard[1] biofiltration BMP sizing; and
- **Appendix B.5.2:** Non-Standard[2] and Compact[3] biofiltration BMP sizing.

If a BMP meets the criteria in **Appendix B.5.1**, then it is considered compliant with the required pollutant control performance standard (i.e., for both retention and pollutant removal). It is not necessary to complete worksheets in this appendix for BMPs that meet the criteria in **Appendix B.5.1**. The volume retention performance standard for biofiltration BMPs is presented in **Figure B.5-2**..

When mapped hydrologic soil groups are used for feasibility screening, applicants are allowed to use the following reliable infiltration rates for sizing partial retention BMPs:

- Reliable infiltration rate for NRCS Type D soils = 0.05 in/hr.
- Reliable infiltration rate for NRCS Type C soils = 0.15 in/hr.

The applicant also has an option to perform infiltration testing in lieu of using the rates listed above.

If an applicant performs site-specific testing using a device that has a precision of 0.1 in/hr. and determines that the average measured infiltration rates in the DMA are less than 0.1 in/hr., then the applicant is allowed to size the biofiltration BMP assuming the DMA is a "No Infiltration Condition". In instances where the actual infiltration is not measured because the testing device has a precision of 0.1 in/hr., if the applicant elects to propose a non-standard or a compact biofiltration BMP then a reliable infiltration rate of 0.025 in/hr. must be used to size site design BMPs when there are no geotechnical and/or groundwater hazards identified in **Appendix C**.

If there are geotechnical and/or groundwater hazards identified in **Appendix C**, then the applicant must use a reliable infiltration rate of 0.0 in/hr. for estimating the target volume retention and sizing equivalent site design BMPs.

The required performance standards for different biofiltration BMPs are summarized in **Table B.5-1**.

---

[1] Standard biofiltration BMPs have a media filtration rate equal to or smaller than 5 in/hr. and a media surface area of 3% of contributing area times adjusted runoff factor or greater.

[2] Non-Standard biofiltration BMPs have a media filtration rate equal to or smaller than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor.

[3] Compact (high rate) biofiltration BMPs have a media filtration rate greater than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor. Compact biofiltration BMPs are typically proprietary BMPs that may qualify as biofiltration.

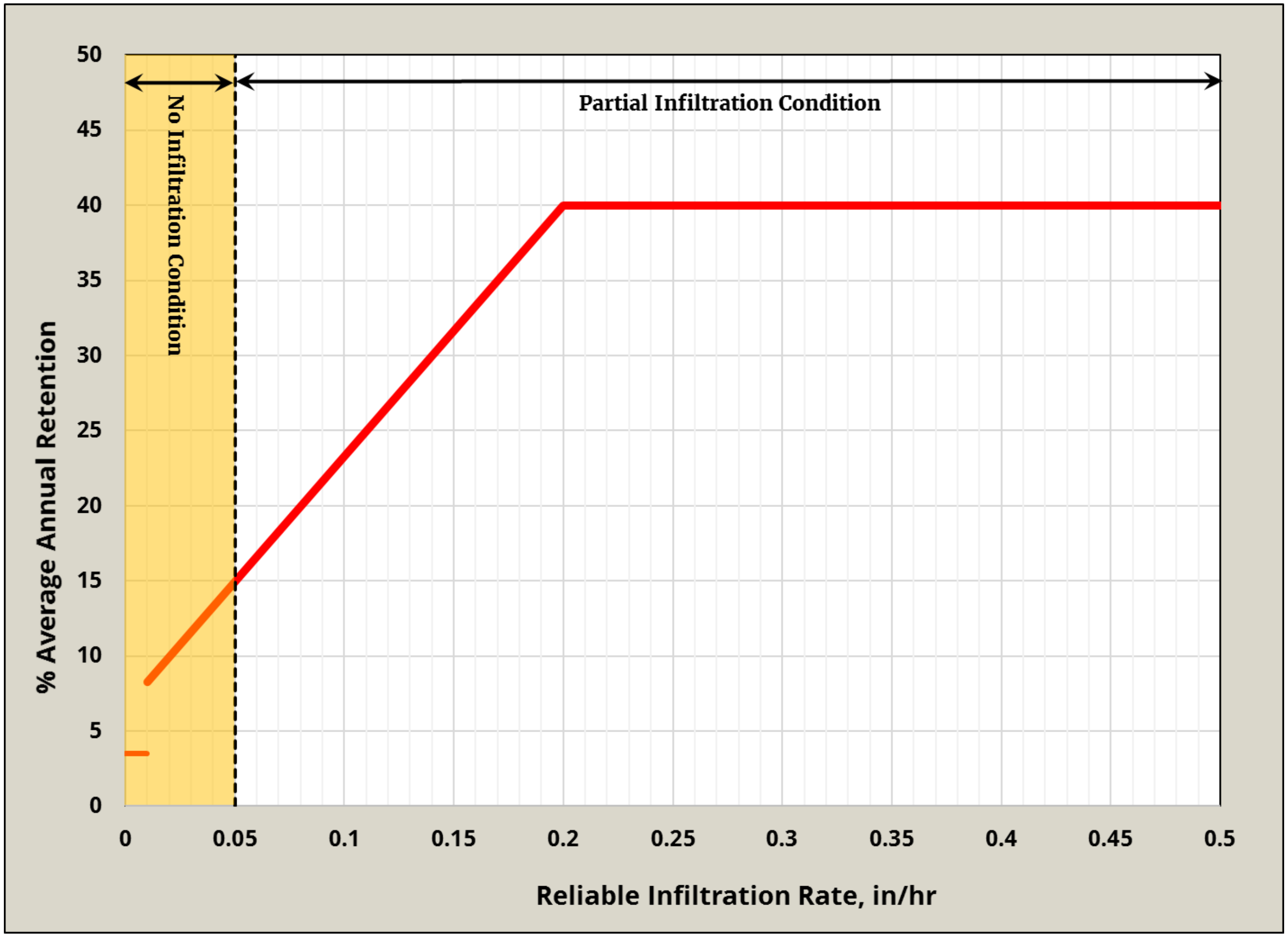

Figure B.5-2 Volume Retention Performance Standard for Partial Infiltration Condition

Note:

For biofiltration BMP sizing, the reliable infiltration rate must be calculated using a factor of safety of 2 i.e., **Reliable infiltration rate = Measured infiltration rate/2**

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Table B.5-1. Summary of Biofiltration Performance Standards

Infiltration Feasibility Condition	Performance Standard
Partial Infiltration Condition (Based on Worksheet C.4-1: Form I-8A and Worksheet C.4-2: Form I-8B) [There is no hierarchy in selecting the type of biofiltration BMP as long as the performance standard for the selected biofiltration BMP is met]	**Standard Biofiltration BMPs:** BMPs must meet the criteria in Appendix B.5.1.1
	Non-Standard Biofiltration BMPs: Pollutant Removal: BMP must be sized using Worksheet B.5-1 and Worksheet B.5-4; **AND** Volume Retention: DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented using Worksheet B.5-3 (to estimate retention from the BMP) and/or Worksheet B.5-7 (if dispersion and/or amended soils are proposed) and/or by implementing other site design BMPs (e.g. rain barrels, trees, etc.).
	Compact Biofiltration BMPs: Pollutant Removal: BMP must meet the criteria in Appendix F. Form I-10 must be completed and submitted with the PDP SWQMP; **AND** Volume Retention: DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented using Worksheet B.5-3 (to estimate retention from the BMP) and/or Worksheet B.5-7 (if dispersion and/or amended soils are proposed) and/or by implementing other site design BMPs (e.g. rain barrels, trees, etc.).

Infiltration Feasibility Condition	Performance Standard
No Infiltration Condition (Based on Infiltration Feasibility Condition Letter and/or Worksheet C.4-1: Form I-8A and/or Worksheet C.4-2: Form I-8B) [There is no hierarchy in selecting the type of biofiltration BMP as long as the performance standard for the selected biofiltration BMP is met]	**Standard Biofiltration BMPs:** BMPs must meet the criteria in Appendix B.5.1.2
	Non-Standard Biofiltration BMPs: Pollutant Removal: BMP must be sized using Worksheet B.5-1 and Worksheet B.5-4; **AND** Volume Retention: DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented by: • DMA has a combined BMP footprint and landscaped area (that meet the criteria in SD-B and SD-F factsheet) of 3% of contributing area times adjusted runoff factor or greater. The landscaped area must have an impervious area to pervious area ratio greater than 1.5:1. This can be documented using Worksheet B.5-6. [OR] • Applicant has an option to use other site design BMPs that will meet the target volume retention calculated using Worksheet B.5-2. This can be documented using Worksheet B.5-6 and/or Worksheet B.5-7.
	Compact Biofiltration BMPs: Pollutant Removal: BMP must meet the criteria in Appendix F. Form I-10 must be completed and submitted with the PDP SWQMP; **AND** Volume Retention: DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented by: • DMA has a combined BMP footprint and landscaped area (that meet the criteria in SD-B and SD-F factsheet) of 3% of contributing area times adjusted runoff factor or greater. The landscaped area must have an impervious area to pervious area ratio greater than 1.5:1. This can be documented using Worksheet B.5-6. [OR] • Applicant has an option to use other site design BMPs that will meet the target volume retention calculated using Worksheet B.5-2. This can be documented using Worksheet B.5-6 and/or Worksheet B.5-7.

B.5.1 Standard Biofiltration BMP Sizing

B.5.1.1 Standard Biofiltration Sizing for Partial Infiltration Condition

If a BMP meets the following criteria and the design criteria in PR-1 fact sheet (**Appendix E.17**), then the BMP is considered to meet its pollutant control performance standard.

1. DMA is categorized as "partial infiltration condition". Completed Worksheet C.4-1: Form I-8A and Worksheet C.4-2: Form I-8B are submitted with the PDP SWQMP;
2. BMP has a media surface area of 3% of contributing area times adjusted runoff factor or greater and does not have an impermeable liner on the bottom of the BMP;
3. Additional documentation (**Worksheet B.5-1**) that show the pollutant control requirements are met is included in the SWQMP submittal if the media filtration rate of the BMP is outlet controlled (example for outlet control: underdrain outlet retrofitted with an orifice cap that controls the filtration flow rate); **AND**
4. BMP provides an aggregate storage thickness greater than the thickness specified in **Table B.5-2** below the underdrain invert.

Table B.5-2. Reliable infiltration rate versus required aggregate storage

Reliable Infiltration Rate (in/hr.)	Minimum Aggregate Storage Thickness (inches) below the underdrain invert
≥ 0.05 in/hr. and ≤ 0.10 in/hr.	6 inches
> 0.10 in/hr. and ≤ 0.15 in/hr.	12 inches
> 0.15 in/hr. and < 0.50 in/hr.	18 inches

Note: For biofiltration BMP sizing, the design infiltration rate must be calculated using a factor of safety of 2 i.e., **Reliable infiltration rate = Measured infiltration rate/2.**

When mapped hydrologic soil groups are used for feasibility screening, applicants are allowed to use the following reliable infiltration rates for sizing partial retention BMPs:

- Reliable infiltration rate for NRCS Type D soils = 0.05 in/hr.
- Reliable infiltration rate for NRCS Type C soils = 0.15 in/hr.

The applicant also has an option to perform infiltration testing in lieu of using the rates listed above.

To document compliance applicant must include the following information in the SWQMP submittal for each standard BMP:

- Required BMP Footprint = Area draining to the BMP * Adjusted runoff factor * 0.03;
- Provided BMP Footprint;
- Reliable Infiltration rate;
- Provided aggregate storage thickness below the underdrain invert;
- Documentation that shows the BMP meets the requirements in PR-1 fact sheet (**Appendix E.17**); and
- Completed Worksheet B.5-1 if the BMP is the outlet controlled. Worksheet B.5-1 is not required if the BMP is not outlet controlled.

B.5.1.2 Standard Biofiltration Sizing in No Infiltration Condition

If a BMP meets the following criteria and the design criteria in BF-1 fact sheet (**Appendix E.18**), then the BMP is considered to meet its pollutant control performance standard.

1. DMA is categorized as “no infiltration condition”. Completed “Infiltration Feasibility Condition Letter” or Worksheet C.4-1: Form I-8A or Worksheet C.4-2: Form I-8B that supports the categorization submitted with the PDP SWQMP;

2. BMP has a media surface area of 3% of contributing area times adjusted runoff factor or greater and has an impermeable liner on the bottom of the BMP (applicant also has an option to not install an impermeable liner on the bottom of the BMP if there are no geotechnical/groundwater hazards identified while completing forms in **Appendix C**); **AND**

3. Additional documentation (**Worksheet B.5-1**) that show the pollutant control requirements are met is included in the SWQMP submittal if the media filtration rate of the BMP is outlet controlled (example for outlet control: underdrain outlet retrofitted with an orifice cap that controls the filtration flow rate).

To document compliance applicant must include the following information in the SWQMP submittal for each standard BMP:

- Required BMP Footprint = Area draining to the BMP * Adjusted runoff factor * 0.03;
- Provided BMP Footprint;
- Documentation that shows the BMP meets the requirements in BF-1 fact sheet (**Appendix E.18**); and
- Completed Worksheet B.5-1 if the BMP is the outlet controlled. Worksheet B.5-1 is not required if the BMP is not outlet controlled.

BMPs that meet the criteria in **Appendix B.5.1** are not required to complete and submit Worksheets in **Appendix B.5.2** in the PDP SWQMP submittal (except in scenarios where the biofiltration BMP is outlet controlled in this case applicant must complete Worksheet B.5-1 and include in the SWQMP submittal).

B.5.2 Non-Standard and Compact Biofiltration BMP Sizing

The following worksheets were developed for project applicants electing to use non-standard non-proprietary biofiltration BMPs and/or use compact biofiltration BMPs.

- **Worksheet B.5.1**: Sizing Method for Pollutant Removal Criteria
- **Worksheet B.5.2**: Sizing Method for Volume Retention Criteria
- **Worksheet B.5.3**: Volume Retention from Biofiltration with Partial Retention BMPs
- **Worksheet B.5.4**: Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration
- **Worksheet B.5.5**: Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit
- **Worksheet B.5.6**: Volume Retention for No Infiltration Condition
- **Worksheet B.5.7**: Volume Retention from Amended Soils

Notes:

1. Project applicants that meet the criteria in Appendix B.5.1 are not required to complete the worksheets in Appendix B.5.2.
2. Project applicants have an option to perform continuous simulation (following guidelines in Appendix G) to document conformance with the performance standard from Chapter 2 in lieu of using the worksheets in Appendix B.5.2.
    - If an applicant elects to perform continuous simulation, the applicant must model both the standard configuration (impervious footprint draining to a 3% biofiltration BMP) and the proposed configuration to show that proposed configuration would achieve volume reduction equal to or greater than the standard configuration. The modeling analysis must be documented in the PDP SWQMP.

Design Assumptions:

For the footprint of non-proprietary BMPs, applicants are allowed to use the plan view area at the surface of the BMP before any ponding, when performing sizing calculations using worksheets presented in **Appendix B.5.2**.

One of the following two methods may also be acceptable:

- **Method 1: Effective area/effective depth method**. This method involves determining the effective depth of water stored in the BMP and identifying the effective area at that elevation. For systems with vertical walls, the effective area is simply the plan view area. For systems with side slopes, the effective area can be approximated as the plan view area inundated when the ponded depth is half full. This is the area of the contour at an elevation half way between the surface of the BMP and the overflow elevation.
- **Method 2: Area takeoff/trapezoidal method**. For more complex BMP geometries, it may be necessary to perform area takeoffs at regular contour intervals within the BMP and apply trapezoidal geometry calculations. The effectively breaks the BMP into horizontal slices. Each horizontal "slice" would have a vertical thickness, an average surface area, and an effective porosity. The product of these values is the storage volume in the slice. The sum of all slices is the total storage volume. The effective area can then be estimated by dividing the total storage volume with depth.

In both methods, volume should only be tabulated below the overflow or bypass elevation of the BMP. Surcharge or freeboard storage should not be included in calculations. When one of the above two methods are used detailed calculations must be included in the SWQMP submittal.

Area draining to the BMP must also include the area of the BMP. Use runoff factor for impervious area (i.e. concrete or asphalt) for the area of the BMP to determine the composite runoff factor for the DMA.

If an applicant performs site-specific testing using a device that has a precision of 0.1 in/hr. and determines that the measured infiltration rates in the DMA are less than 0.1 in/hr., then the applicant is allowed to size the biofiltration BMP assuming the DMA is a "No Infiltration Condition". In instances where the actual infiltration is not measured because the testing device has a precision of 0.1 in/hr., if the applicant elects to propose a non-Standard or a compact biofiltration BMP then a reliable infiltration rate of 0.025 in/hr. must be used to size site design BMPs when there are no geotechnical and/or groundwater hazards identified in **Appendix C**.

If there are geotechnical and/or groundwater hazards identified in **Appendix C**, then the applicant must use a reliable infiltration rate of 0.0 in/hr. for estimating the target volume retention and sizing equivalent site design BMPs.

The 36-hour drawdown percent capture nomograph that can be used to estimate the fraction of the DCV that must be retained to meet the average annual capture performance standard is presented in **Figure B.5-3** below.

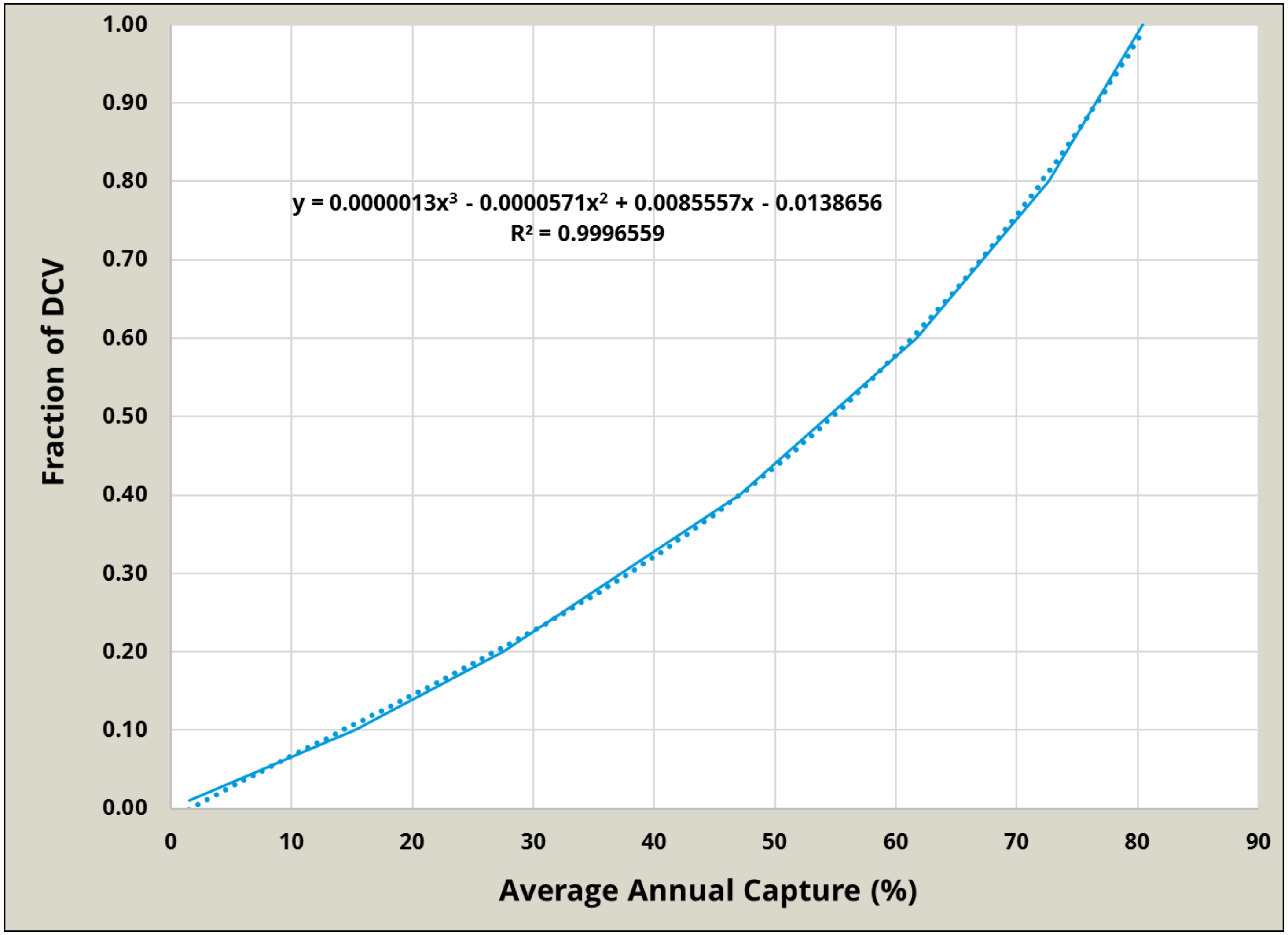

Figure B.5-3. Fraction of DCV versus Average Annual Capture

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Worksheet B.5-1: Sizing Method for Pollutant Removal Criteria

Sizing Method for Pollutant Removal Criteria		Worksheet B.5-1	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85th percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
BMP Parameters			
5	Surface ponding [6 inch minimum, 12 inch maximum]		inches
6	Media thickness [18 inches minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		inches
7	Aggregate storage (also add ASTM No 8 stone) above underdrain invert (12 inches typical) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
8	Aggregate storage below underdrain invert (3 inches minimum) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
9	Freely drained pore storage of the media	0.2	in/in
10	Porosity of aggregate storage	0.4	in/in
11	Media filtration rate to be used for sizing (maximum filtration rate of 5 in/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate (includes infiltration into the soil and flow rate through the outlet structure) which will be less than 5 in/hr.)		in/hr.
Baseline Calculations			
12	Allowable routing time for sizing	6	hours
13	Depth filtered during storm [Line 11 x Line 12]		inches
14	Depth of Detention Storage [Line 5 + (Line 6 x Line 9) + (Line 7 x Line 10) + (Line 8 x Line 10)]		inches
15	Total Depth Treated [Line 13 + Line 14]		inches
Option 1 – Biofilter 1.5 times the DCV			
16	Required biofiltered volume [1.5 x Line 4]		cu. ft.
17	Required Footprint [Line 16/ Line 15] x 12		sq. ft.
Option 2 - Store 0.75 of remaining DCV in pores and ponding			
18	Required Storage (surface + pores) Volume [0.75 x Line 4]		cu. ft.
19	Required Footprint [Line 18/ Line 14] x 12		sq. ft.
Footprint of the BMP			
20	BMP Footprint Sizing Factor (Default 0.03 or an alternative minimum footprint sizing factor from Line 11 in Worksheet B.5-4)		
21	Minimum BMP Footprint [Line 1 x Line 2 x Line 20]		sq. ft.
22	Footprint of the BMP = Maximum (Minimum (Line 17, Line 19), Line 21)		sq. ft.
23	Provided BMP Footprint		sq. ft.
24	Is Line 23 ≥ Line 22? If Yes, then footprint criterion is met. If No, increase the footprint of the BMP.	☐ Yes	☐ No

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Worksheet B.5-2: Sizing Method for Volume Retention Criteria

Sizing Method for Volume Retention Criteria		Worksheet B.5-2	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	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	Measured infiltration rate in the DMA Note: When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30 When in no infiltration condition and the actual measured infiltration rate is unknown enter 0.0 if there are geotechnical and/or groundwater hazards identified in Appendix C or enter 0.05		in/hr.
6	Factor of safety	2	
7	Reliable infiltration rate, for biofiltration BMP sizing [Line 5/ Line 6]		in/hr.
8	Average annual volume reduction target (Figure B.5-2) When Line 7 > 0.01 in/hr. = Minimum (40, 166.9 x Line 7 +6.62) When Line 7 ≤ 0.01 in/hr. = 3.5%		%
9	Fraction of DCV to be retained (Figure B.5-3) When Line 8 > 8% = $0.0000013 \times \text{Line } 8^3 - 0.000057 \times \text{Line } 8^2 + 0.0086 \times \text{Line } 8 - 0.014$ When Line 8 ≤ 8% = 0.023		
10	Target volume retention [Line 9 x Line 4]		cu. ft.

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Worksheet B.5-3: Volume Retention from Biofiltration with Partial Retention BMPs

Volume Retention from Biofiltration with Partial Retention BMPs		Worksheet B.5-3	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85th percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
BMP Parameters			
5	Footprint of the BMP		sq. ft.
6	Media thickness [18 inches minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		inches
7	Media retained pore space [50% of (Field Capacity-Wilting Point)]	0.05	in/in
8	Aggregate storage below underdrain invert (3 inches minimum) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
9	Porosity of aggregate storage	0.4	in/in
10	Measured infiltration rate in the DMA Note: When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30		in/hr.
11	Factor of safety	2	
12	Reliable infiltration rate, for biofiltration BMP sizing [Line 10/ Line 11]		in/hr.
Evapotranspiration: Average Annual Volume Retention			
13	Effective evapotranspiration depth [Line 6 x Line 7]		inches
14	Retained pore volume [(Line 13 x Line 5)/12]		cu. ft.
15	Fraction of DCV retained in pore spaces [Line 14/Line 4]		
16	Evapotranspiration average annual capture [use ET Nomographs in Figure B.5-5, Refer to Appendix B.5.4]		%
Infiltration: Average Annual Volume Retention			
17	Drawdown for infiltration storage [(Line 8 x Line 9)/Line 12]		hours
18	Equivalent DCV fraction from evapotranspiration (use Line 16 and Line 17 in Figure B.4-1; Refer to Appendix B.4.2.2)		
19	Infiltration volume storage [(Line 5 x Line 8 x Line 9)/12]		cu. ft.
20	Infiltration storage: Fraction of DCV [Line 19 /Line 4]		
21	Total Equivalent Fraction of DCV [Line 18 + Line 20]		
22	Biofiltration BMP average annual capture [use Line 21 and 17 in Figure B.4-1]		%
23	Fraction of DCV retained (Figure B.5-3) 0.0000013 x Line 22^3 - 0.000057 x Line 22^2 + 0.0086 x Line 22- 0.014		
24	Volume retention achieved by biofiltration BMP [Line 23 x Line 4]		cu. ft.

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B.5.2.1 Alternative Minimum Sizing factor for Clogging Risk

Worksheet B.5-4 below must be used to support a request for an alternative minimum footprint sizing factor (for clogging) in **Worksheet B.5-1**. 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 City Engineer. If approved, the estimated footprint from the worksheet below can be used in line 20 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 City Engineer. 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.

Table B.5-3: Typical land use total suspended solids (TSS) event mean concentration (EMC) values.

Land Use	TSS EMC[4], mg/L
Single Family Residential	123
Commercial	128
Industrial	125
Education (Municipal)	132
Transportation[5]	78
Multi-family Residential	40
Roof Runoff[6]	14
Low Traffic Areas[7]	50
Open Space	216

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

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

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

[7] Davis and McCuen (2005)

TableB.5-4: 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.

Worksheet B.5-4: Calculation of Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration

Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration				Worksheet B.5-4
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 (default value when using Appendix E fact sheets is 2.0)			lb/sq. ft.
4	Allowable Period to Accumulate Clogging Load (T_L) (default value is 10)			years
Volume Weighted EMC Calculation				
Land Use		**Fraction of Total DCV**	**TSS EMC (mg/L)**	**Product**
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
Sizing Factor for Clogging				
6	Adjustment for pretreatment measures Where: Line 6 = 0 if no pretreatment; Line 6 = 0.25 when pretreatment is included; Line 6 = 0.5 if the pretreatment has an active Washington State TAPE approval rating for "pre-treatment."			
7	Average Annual Precipitation [Provide documentation of the data source in the discussion box; SanGIS has a GIS layer for average annual precipitation]			inches
8	Calculate the Average Annual Runoff (Line 7/12) x Line 1 x Line2			cu-ft/yr
9	Calculate the Average Annual TSS Load (Line 8 x 62.4 x Line 5 x (1 – Line 6))/10^6			lb/yr
10	Calculate the BMP Footprint Needed (Line 9 x Line 4)/Line 3			sq. ft.
11	Calculate the Minimum Footprint Sizing Factor for Clogging [Line 10/ (Line 1 x Line 2)]			
Discussion:				

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B.5.2.2 Sizing Biofiltration BMPs Downstream of a Storage Unit

Introduction

In scenarios, where the BMP footprint is governed based on Option 1 (Line 17 of Worksheet B.5-1) or the required volume reduction for partial infiltration conditions (Line 10 of Worksheet B.5-2) the footprint of the biofiltration BMP can be reduced using the sizing calculations in this **Appendix B.5.2.2** when there is an upstream storage unit (e.g. cistern) that can be used to regulate the flows through the biofiltration BMP.

When this approach is used for sizing biofiltration BMPs the applicant must also verify that the storage unit meets the hydromodification management drawdown requirements and the discharge from the downstream biofiltration BMP will still meet the hydromodication flow control requirements. These calculations must be documented in the PDP SWQMP.

This methodology is **not** applicable when the minimum footprint factor is governed based on the alternative minimum footprint sizing factor calculated using Worksheet B.5-4 (Line 11). A biofiltration BMP smaller than the alternative minimum footprint sizing factor is considered compact biofiltration BMP and may be allowed at the discretion of the City Engineer if the BMP meets the requirements in Appendix F **and** the applicant submits a completed Form I-10.

Sizing Calculation

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

1. Use continuous simulation and demonstrate the following is met:
   (a) The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume and achieves a volume reduction equivalent to Line 10 of Worksheet B.5-2. 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 City Engineer. 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**).
2. Use the simple optimized method in Worksheet B.5-5. The applicant is also required to complete Worksheet B.5-1, B.5-2 and B.5-4 when the applicant elects to use Worksheet B.5-5 to reduce the biofiltration BMP footprint. Worksheet B.5-5 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 for the storage unit includes orifices at different elevations and an overflow structure, 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 are equal to or greater than the retention losses from the conventional biofiltration BMP. This second criterion is only applicable for partial infiltration condition.

For drawdown times that are outside the range of values presented in Table B.5-5 below, the storage unit should be designed to discharge greater than 92% average annual capture to the downstream Biofiltration BMP.

Table B.5-5: 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

Worksheet B.5-5: Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit

Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit		Worksheet B.5-5	
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		cu. ft.
5	Design infiltration rate (measured infiltration rate / 2)		ft./hr.
6	Media Thickness [1.5 feet minimum], also add mulch layer and washed ASTM 33 fine aggregate sand 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 space	0.05	in./in.
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.5-5)		fraction
11	Storage required in cubic feet (Line 4 x Line 10)		cu. ft.
12	Storage provided in the design, minimum (from the elevation that bypasses the biofiltration BMP, overflow elevation)		cu. ft.
13	Is Line 12 ≥ Line 11. If no increase storage provided until this criteria is met	☐ Yes	☐ 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.5-4]		Fraction
17	Required biofiltration footprint [Line 3 x Line 16]		sq. ft.
Criteria 3: Retention requirement [Not applicable for No Infiltration Condition]			
18	Retention Target (Line 10 in Worksheet B.5-2)		cu. ft.
19	Average discharge rate from the storage unit to the biofiltration BMP		cfs
20	Depth retained in the optimized biofiltration BMP {Line 6 x Line 8} + {[(Line 4)/(2400 x Line 19)] x Line 5}		ft.
21	Required optimized biofiltration footprint (Line 18/Line 20)		sq. ft.
Optimized Biofiltration Footprint			
22	Optimized biofiltration footprint, maximum (Line 15, Line 17, Line 21)		sq. ft.

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Worksheet B.5-6: Volume Retention for No Infiltration Condition

Volume Retention for No Infiltration Condition						Worksheet B.5-6
1	Area draining to the 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 BMP [Line 1 x Line 2]					sq. ft.
4	Required area for Evapotranspiration [Line 3 x 0.03]					sq. ft.
5	Biofiltration BMP Footprint					sq. ft.
Landscape Area (must be identified on DS-3247)						
	Identification	**A**	**B**	**C**	**D**	**E**
6	Landscape area that meet the requirements in SD-B and SD-F Fact Sheet (sq. ft.)					
7	Impervious area draining to the landscape area (sq. ft.)					
8	Impervious to Pervious Area ratio [Line 7/Line 6]					
9	Effective Credit Area If Line 8 >1.5, use Line 6; if not use Line 7/1.5					
10	Sum of Landscape area [sum of Lines 9A-9E]					sq. ft.
11	Provided footprint for evapotranspiration [Line 5 + Line 10]					sq. ft.
Volume Retention Performance Standard						
12	Is Line 11 ≥ Line 4? If yes, then volume retention performance standard for no infiltration condition is met. If no, proceed to Line 13				☐ Yes	☐ No
13	Fraction of the performance standard met through the BMP footprint and/or landscaping [Line 11/Line 4]					
14	Target Volume Retention [Line 10 from Worksheet B.5.2]					cu. ft.
15	Volume retention required from other site design BMPs [(1-Line 13) x Line 14]					cu. ft.
Site Design BMP						
	Identification	**Site Design Type**			**Credit**	
16	**A**					cu. ft.
	B					cu. ft.
	C					cu. ft.
	D					cu. ft.
	E					cu. ft.
	Sum of volume retention benefits from other site design BMPs (e.g. trees; rain barrels etc.). [sum of Lines 16A-16E] Provide documentation of how the site design credit is calculated in the PDP SWQMP.					cu. ft.
17	Is Line 16 ≥ Line 15? If yes, then volume retention performance standard for no infiltration condition is met. If no, implement additional site design BMPs.				☐ Yes	☐ No

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Worksheet B.5-7: Volume Retention from Amended Soils

Volume Retention From Amended Soils		Worksheet B.5-7	
1	Impervious area draining to the pervious area		sq. ft.
2	Pervious area (must meet the requirements in SD-B and SD-F Fact Sheets)		sq. ft.
3	Dispersion Ratio [Line 1/Line 2] Note: This worksheet is not applicable when Line 3 > 50 or Line 3 < 0.25		
4	Adjusted runoff factor [(Line 1 * 0.9 + Line 2 * 0.1) / (Line 1 + Line 2)]		
5	85th percentile 24-hour rainfall depth		inches
6	Design capture volume [(Line 1 + Line 2) x Line 4 x (Line 5/12)]		cu. ft.
7	Amendment Depth (Choose from 3”, 6”, 9”, 12”, 15” and 18”)		inches
8	Storage [(porosity – field capacity) + 0.5 * (field capacity – wilting point)]	0.25	in./in.
9	Pervious Storage [Line 2 * (Line 7/12) * Line 8]		cu. ft.
10	Fraction of DCV [Line 9 / Line 6]		
11	Measured Infiltration Rate When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30 When in no infiltration condition and the actual measured infiltration rate is unknown enter 0.0 if there are geotechnical and/or groundwater hazards identified in Appendix C or enter 0.05		in/hr.
12	Factor of Safety	2	
13	Reliable Infiltration Rate [Line 11/Line 12]		in/hr.
14	Dispersion Credit (Based on Figures B.5.6 to B.5.11; Line 10 and Line 13)		
15	Volume retention due to amendment [Line 1 * (Line 5/12) * Line 14]		cu. ft.

The following criteria must be met to get volume reduction credit from amended soils:

- Pervious area must not have an underdrain;
- If pervious area has an impermeable liner, the applicant must use 0.000001 in/hr. for reliable infiltration rate;
- Impervious area must be dispersed uniformly across the pervious area and at non-erosive velocities;
- Pervious area must have a minimum width of 10 feet (exemption to this minimum width criterion is allowed when the contributing flow path length of the impervious area /pervious area width ≤ 2) and a maximum slope of 5%; **and**
- Impervious to pervious area ratio must be less than 50:1.

The applicants have an option to deviate from the criteria listed above, in this case the applicant must perform site specific continuous simulation modeling (following guidelines in Appendix G) to estimate the volume retention benefits from the amended soils and document the analysis in the PDP SWQMP.

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B.5.3 Basis for Minimum Sizing Factor for Biofiltration BMPs

B.5.3.1 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 29):

> **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) and a volume retention performance standard (Figure B.5-2) based on the reliable infiltration rate at the site (i.e. measured infiltration rate/2) is specified. The purpose of this section is to provide the technical rationale for this 3 percent minimum sizing factor and the volume retention performance standard.

B.5.3.2 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 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.5.3.3 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 sizing 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 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 (NRCS Type B Soils, moderate infiltration rates), 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.

Volume Retention Performance Standard

The volume retention performance standard in **Figure B.5-2** was developed to allow for adjustment of the volume retention requirement based on the type of soils present onsite. Constrained sites with poorly draining soils may not be able to install BMPs having a sufficient footprint to satisfy 40% retention performance standard. As such, a sliding scale was developed to adjust the performance standard to match the ability of the site to infiltrate. In effect, the sliding scale produces similar BMP footprint sizes across a varying range of infiltration rates (up to 0.20 inches per hour) for a given 85^{th} percentile 24-hour storm depth.

The "sliding scale" portion (i.e. the sloped portion of the line) of the performance standard indicated in **Figure B.5-2** was determined by estimating the retention associated with a very low infiltration rate (effectively the Y-axis intercept) and then connecting that point to the unadjusted performance standard (0.2 in/hr. infiltration rate, 40% average annual retention) with a straight line. The unadjusted performance standard is based on a 3% BMP footprint size factor and results in a rainfall depth of approximately 0.74 inches. Fixing this rainfall depth and using the same 3% BMP footprint factor, the feasible retention associated with an infiltration rate of 0.01 inches per hour (very low) was estimated using the drawdown percent capture curves presented in Figure B.4-1 and ET percent capture curves presented in **Figure B.5-5**. The resulting retention was estimated to be 8.3% (for 0.01 in/hr. infiltration rate), which became the starting point of the line that then connects to the unadjusted performance standard (0.2 in/hr., 40% retention). The resulting performance standard curve allows flexibility in the design of BMPs or site design features while ensuring consistent performance within the City.

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.5-6**.

Table B.5-6: 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 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.5.3.4 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 City Engineer has discretion to accept alternative sizing factor(s) based on project-specific considerations. Additionally, the recommended minimum sizing factor may change over time as more experience with biofiltration is obtained.

B.5.4 Volume Retention Mechanisms

A series of nomographs were developed using United States Environmental Protection Agency (USEPA) SWMM and parameters listed in **Appendix G** for the Lake Wohlford rain gage and presented in this **Appendix B.5.4** to provide applicants tools to quantify volume retention achieved by a BMP and/or a site design feature that is implemented at the project site.

B.5.4.1 Technical Framework

The total amount of volume retention (reduction) achieved through a BMP and/or site design feature is a function of the amount of water that enters the BMP and/or a site design feature and does not immediately overflow (i.e., the amount of water that is captured), and the portion of the captured water that is "lost" via infiltration, evapotranspiration, and/or consumptive use (i.e., the total of all three is the volume reduction), such that it does not discharge directly to surface water.

When evaluating volume retention and capture efficiency, each BMP and/or site design can be considered to consist of a set of storage compartments, each with a distinct storage volume, discharge rate, and pathway by which water discharges (i.e., surface discharge, infiltration, evapotranspiration). **Figure B.5-4** illustrates this concept. When storage capacity is available in a given compartment, then that compartment of the BMP and/or site design can capture additional inflow. When storage capacity is not available in a given compartment to accept additional inflow, then inflowing water either fills the next storage compartment of the BMP and/or site design, or bypasses the system (if no additional storage is available). The volume retention and capture performance of a BMP and/or site design is primarily a function of the amount of storage volume provided and the rate at which the storage drains to volume retention pathways (i.e., infiltration, evapotranspiration, consumptive use) versus surface discharge pathways.

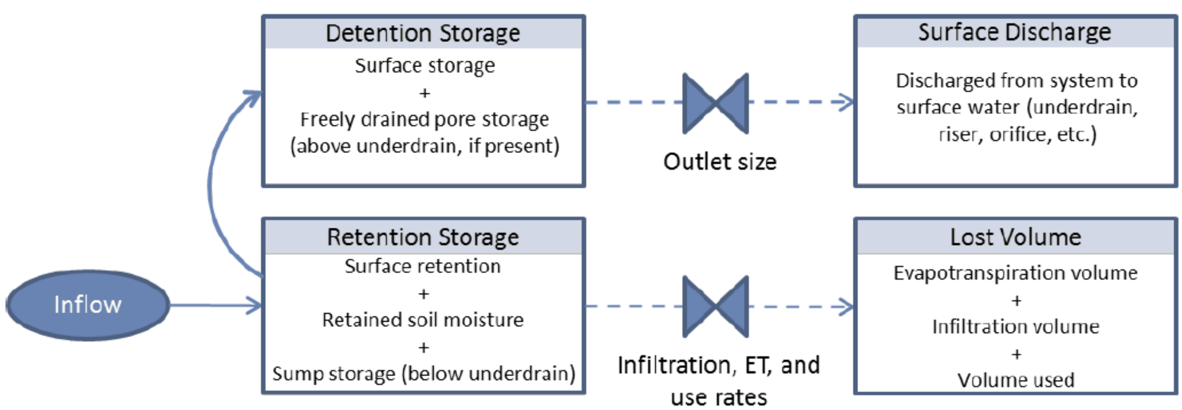

Figure B.5-4. Schematic Representation for Purpose of Volume Retention Analysis

Capture efficiency (or "percent capture") is a metric that measures the percent of rainfall that is captured and managed by a BMP and/or a site design feature (i.e., does not bypass or immediately overflow). Captured storm water may be infiltrated, evapotranspired, or retained for harvest and use, and/or treated and released. Capture efficiency is typically expressed as annual average percent capture. Runoff volume that is not captured by a BMP and/or site design feature is referred to as bypass or overflow. Volume reduction processes can only occur in a BMP and/or site design feature when water is captured.

Long term capture efficiency is primarily a function of the BMP and/or site design feature storage volume (relative to the size and the DCV of the DMA), the drawdown rate and pattern of the storage compartment, and rainfall pattern. Practically, this means that the following parameters can be isolated as primary predictors of capture efficiency for the purpose of developing an approximate predictive tool:

- **Normalized storage volume**, expressed as a fraction of DCV. For example, a 1,000 cubic foot storage volume for a watershed that is 1 acre with a runoff coefficient of 0.9 and an 85th percentile rainfall depth of 0.6 inches would translate to 0.51 times the DCV [1,000 cu-ft × 12 in/ft. / (1 ac × 43,560 sq-ft/ac × 0.9 x 0.6 in)].
- **Drawdown time of the storage volume**. For BMP and/or site design feature storage elements with nominally consistent drawdown rates regardless of season (i.e., infiltration, filtration, orifice-controlled surface discharge), the representative drawdown time can be expressed in hours. For example, a bioretention area with an effective storage depth of 12 inches and an underlying design infiltration rate of 0.2 inches per hour would have a nominal drawdown time of 60 hours (12 inches / 0.2 in/hr.). For BMP and/or site design feature storage elements with seasonally varying drawdown rates (i.e., storage drained by evapotranspiration or irrigation-based consumptive use), the concept of a representative drawdown time is not applicable. In this case, the evapotranspiration storage depth (i.e., the amount of potential evapotranspiration that must occur for the stored water to empty) is a more appropriate indicator of how quickly storage is recovered and can be used (along with climate data input to the model) as a predictor of long term capture efficiency.

By isolating these two most important predictive variables, a limited number of continuous simulation model runs and associated results can be used to describe the expected long term performance of a wide range of BMP and/or site design types and configurations. For example, the results of a long term model simulation for a 0.5xDCV storage with 48-hour drawdown would be representative of a wide range of different BMP and/or site design configurations. The two examples would both be reliably represented by this single model run.

- **Example 1**: 10,000 cu-ft infiltration basin draining 10.2 acres of pavement (equates to 0.5DCV when 85th percentile rainfall is 0.6 inches), with 3-foot ponding depth and a design infiltration rate of 0.75 inches per hour (equates to 48-hour drawdown time).
- **Example 2**: 300 cu-ft of aggregate storage volume below the underdrain invert in a biofiltration with partial retention BMP with a tributary area of 0.367 acres of pavement (equates to 0.5DCV when 85th percentile rainfall is 0.5 inches), with an effective depth of 6 inches and a design infiltration rate of 0.125 in/hr. (equates to 48-hour drawdown time).

It can be seen that an infinite number of potential design combinations could be reflected by this single model run.

B.5.4.2 Modeling Methodology and Results

Three sets of continuous simulation runs were executed in the EPA SWMM using the default parameters in **Appendix G** and the Lake Wohlford rain gage to develop the nomographs that can be used to estimate the volume retention benefits from BMPs and/or site design BMPs.

- **Consistent drawdown runs**: Consistent drawdown runs were used to represent BMPs and/or site design elements that can be approximated as draining at a relatively consistent rate throughout a long term continuous simulation (e.g., infiltration, media filtration, orifice discharge). The template model setup developed for these runs included a tributary subcatchment draining to a storage unit of a given size (varied between runs) modeled with a drawdown rate (varied between runs) that was held constant throughout each simulation. Continuous rainfall-runoff processes were simulated to estimate the continuous runoff hydrograph. Routing through the storage unit was simulated to estimate the long term capture efficiency associated with the given configuration. The results from these runs are presented in **Figure B.4-1** in **Appendix B.4.2**.
- **Evapotranspiration drawdown runs**: Evapotranspiration runs were used to represent BMPs and/or site design elements that drain via evapotranspiration processes, at rates that inherently vary with climatic factors throughout the year. The template model setup developed for these runs included a tributary subcatchment draining to a storage unit of a given size (varied between runs) modeled with a given stored water depth (varied between runs) that was drawn down at the applied evapotranspiration rate (varies on a monthly basis). Continuous rainfall-runoff processes were simulated to estimate the continuous runoff hydrograph. Routing through the storage unit was simulated to estimate the long term evapotranspiration loss associated with the given configuration. Results from these runs are presented in **Figure B.5-5**.

Dispersion runs: Dispersion runs were used to represent site design elements that cannot be simply divided into different storage units because water is dispersed in a thin layer and is acted upon by both infiltration and evapotranspiration processes. The template model setup developed for these runs included a tributary subcatchment draining to two broad, shallow storage units in series (area varied between runs to represent different proportions of pervious area receiving dispersion). The first storage unit was used to represent water stored in the "suction storage" of soil pores that did not freely drain via gravity. This was filled first and was drawn down at the rate established by evapotranspiration inputs. This storage unit also received flow from a "dummy catchment" with 100 percent imperviousness and zero depression storage; effectively representing precipitation directly on the dispersion area. The second storage unit had the same footprint as the first storage unit (i.e., equal to the size of the dispersion area) and received flow when the first storage unit overflowed. These storage units were effectively "stacked" in the model. This storage unit represented the freely drained pore storage (i.e., drained by gravity) in the amended media and any surface ponding in closed depressions. This storage unit was drained via Green-Ampt infiltration processes based on the assigned infiltration parameters (varied between runs). The depth of stored water in the first and second storage compartments was calculated based on the assumed depth of soil amendments (varied between runs) and typical amended soil properties. Continuous rainfall-runoff processes were simulated to estimate the runoff hydrograph. Routing through the storage units was simulated to estimate the long-term capture efficiency and the dispersion credit for the impervious area associated with the given configuration. Results from these runs are presented in **Figure B.5-6** (3″ amendment); **Figure B.5-7** (6″ amendment); **Figure B.5-8** (9″ amendment); **Figure B.5-9** (12″ amendment); **Figure B.5-10** (15″ amendment) and **Figure B.5-11** (18″ amendment).

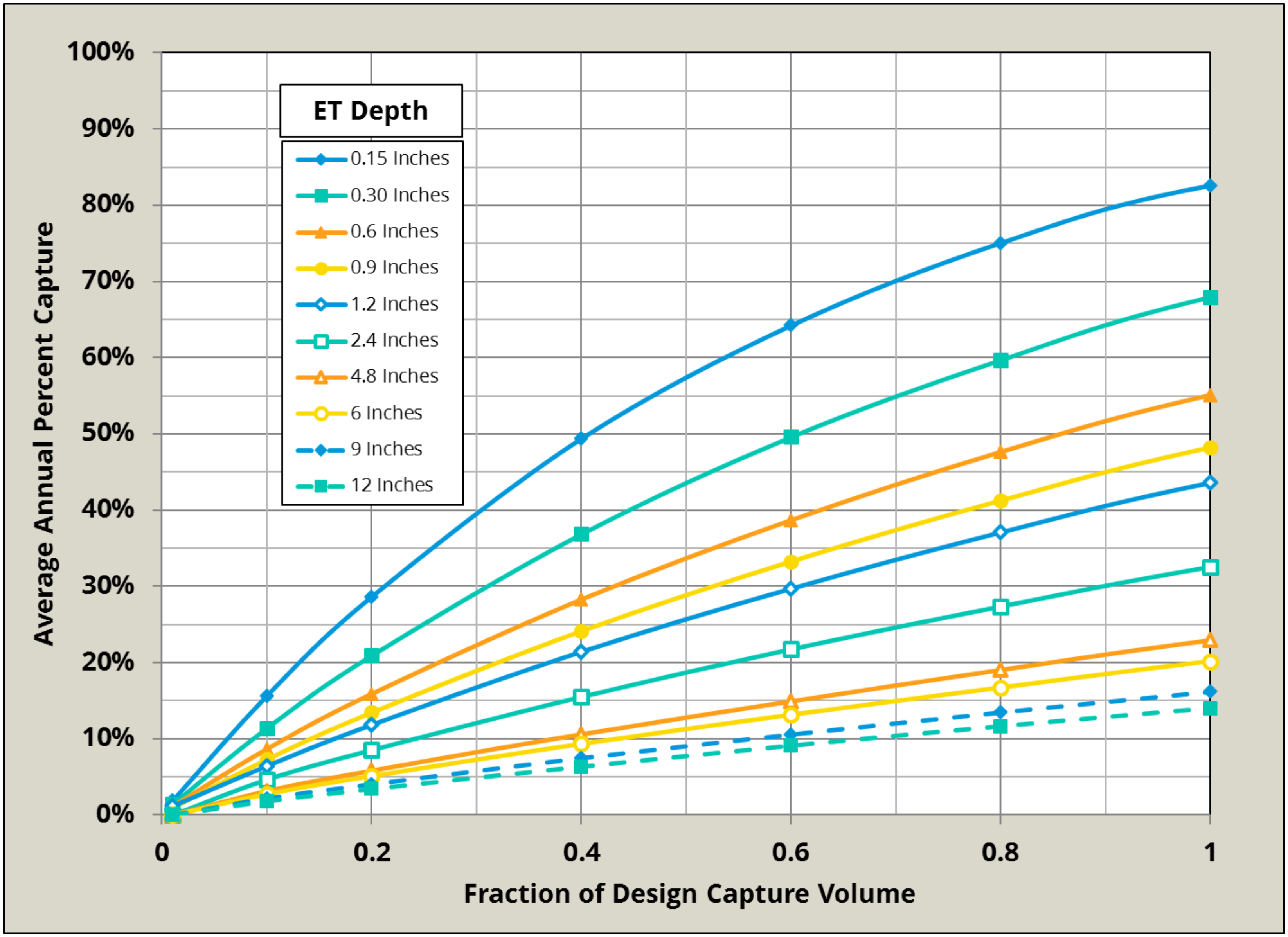

Figure B.5-5. Evapotranspiration Nomographs

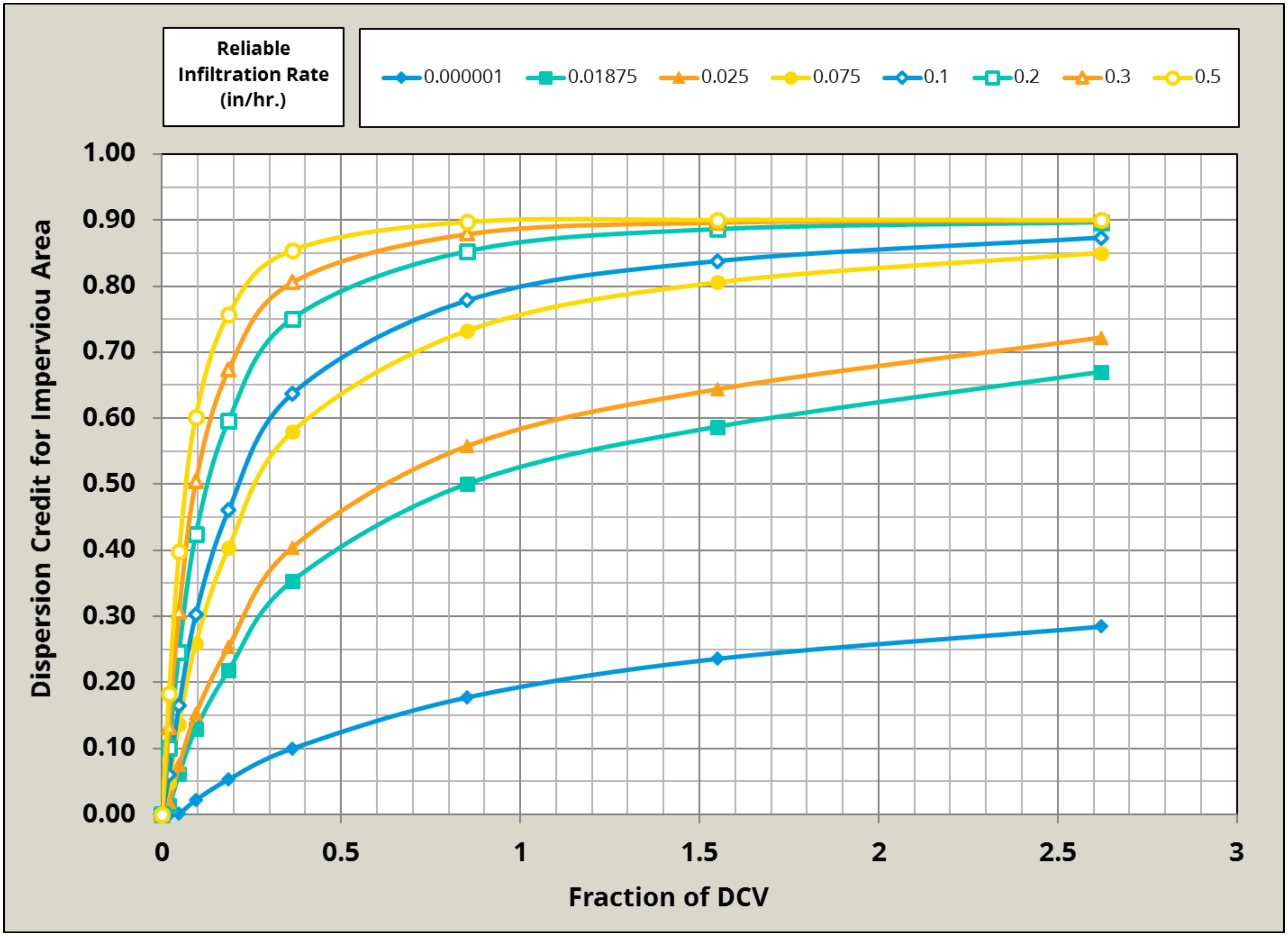

Figure B.5-6. 3" Amendment Dispersion Nomographs

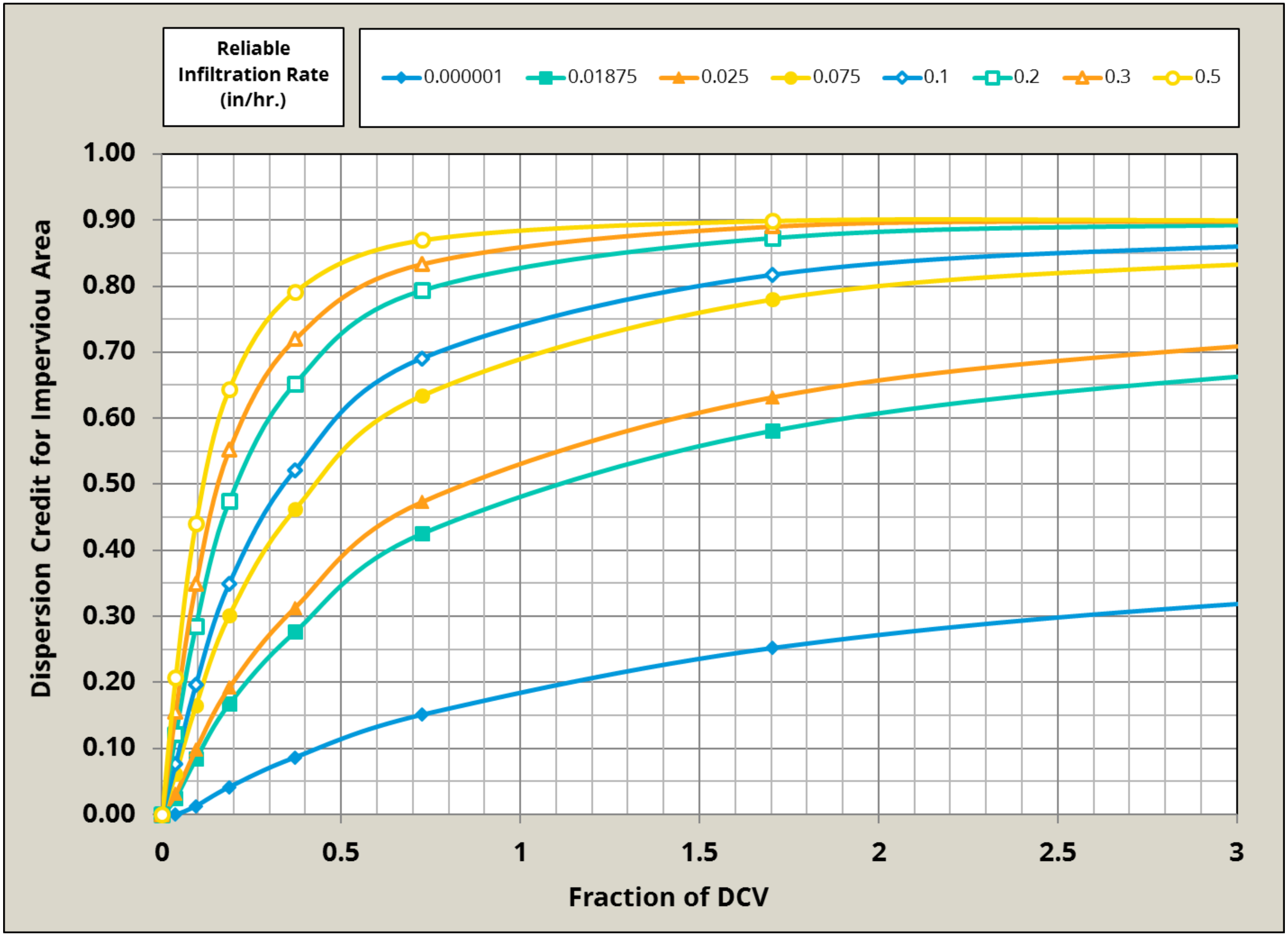

Figure B.5-7. 6" Amendment Dispersion Nomographs

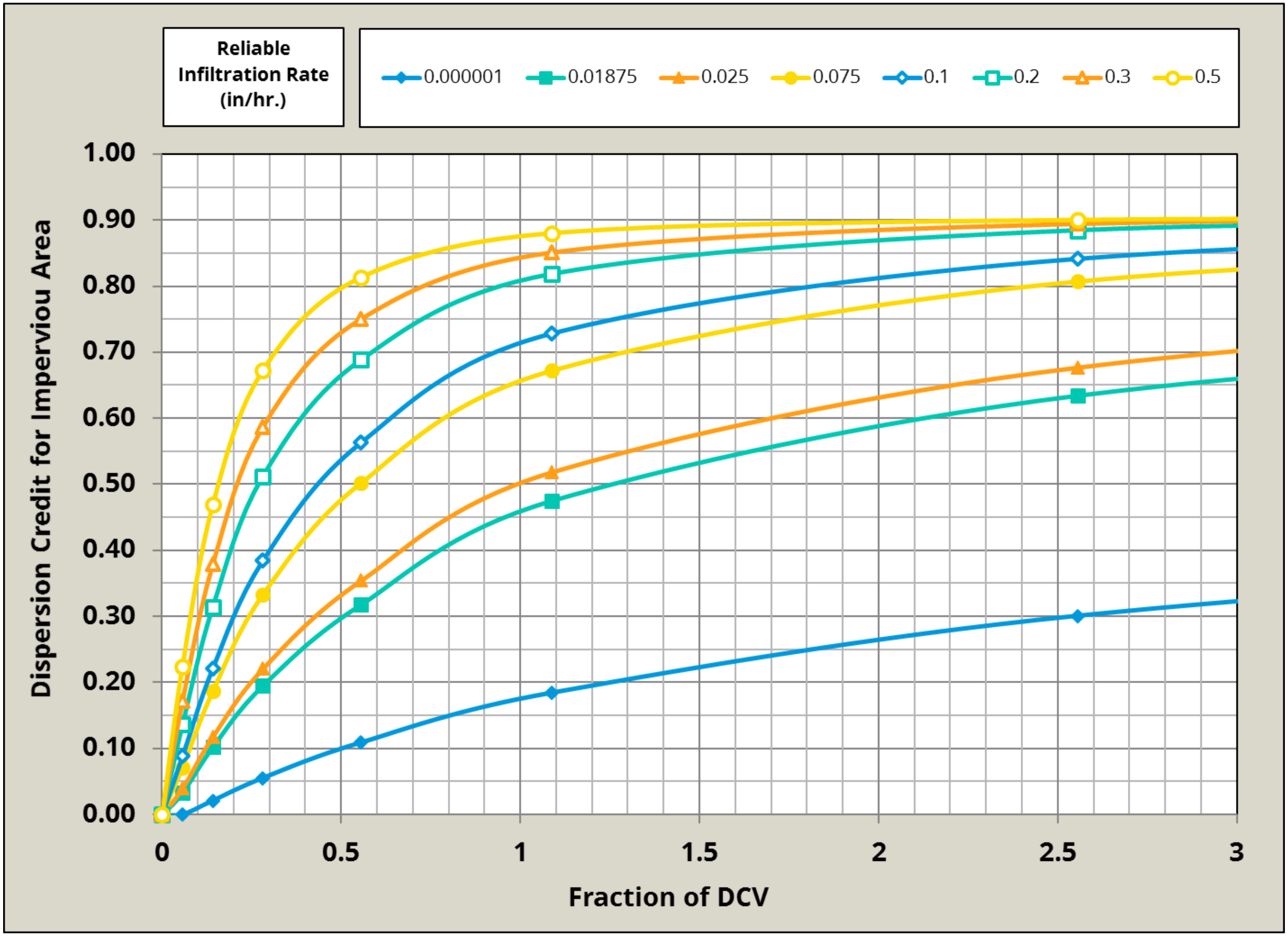

Figure B.5-8. 9" Amendment Dispersion Nomographs

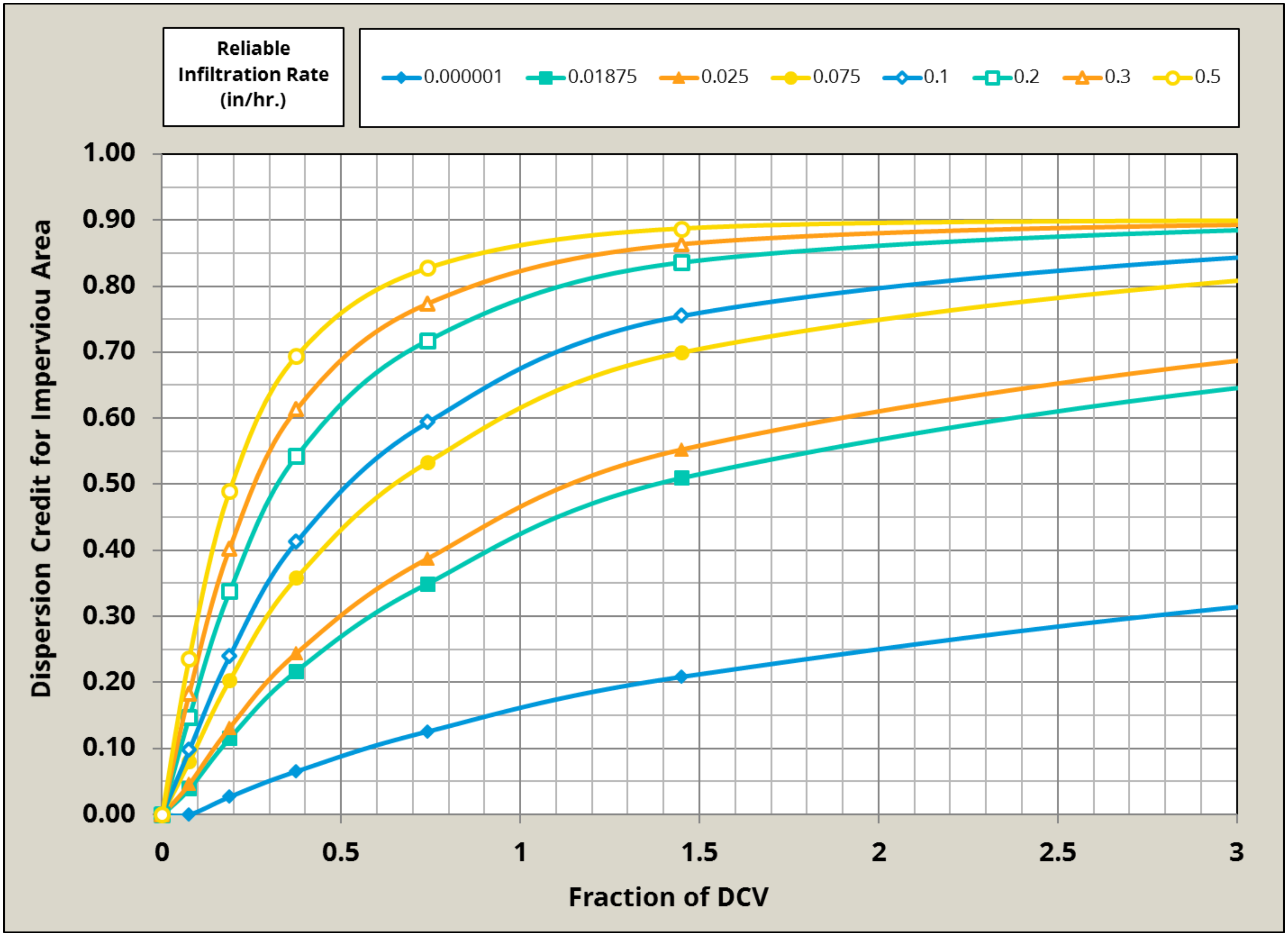

Figure B.5-9. 12" Amendment Dispersion Nomographs

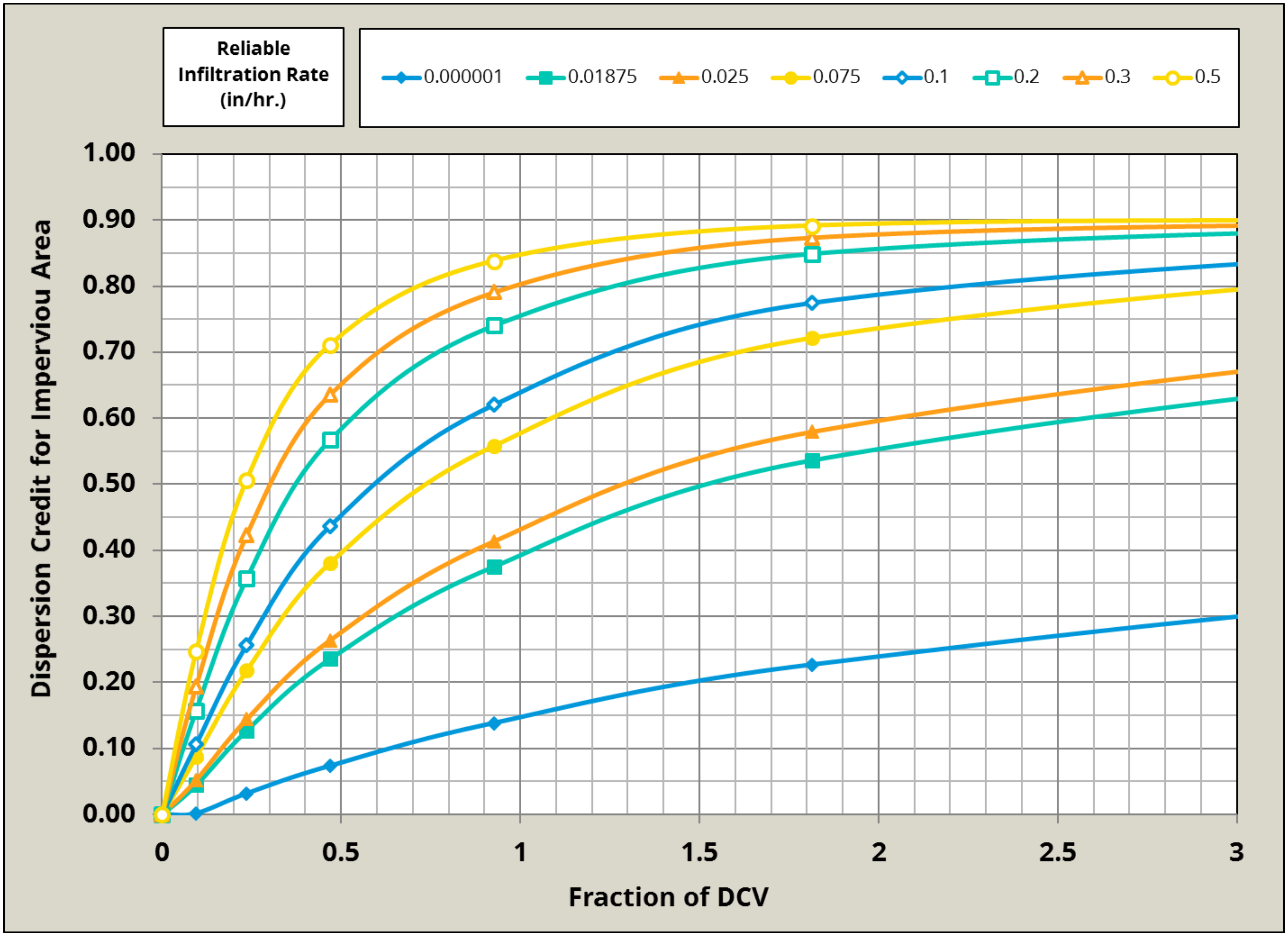

Figure B.5-10. 15" Amendment Dispersion Nomographs

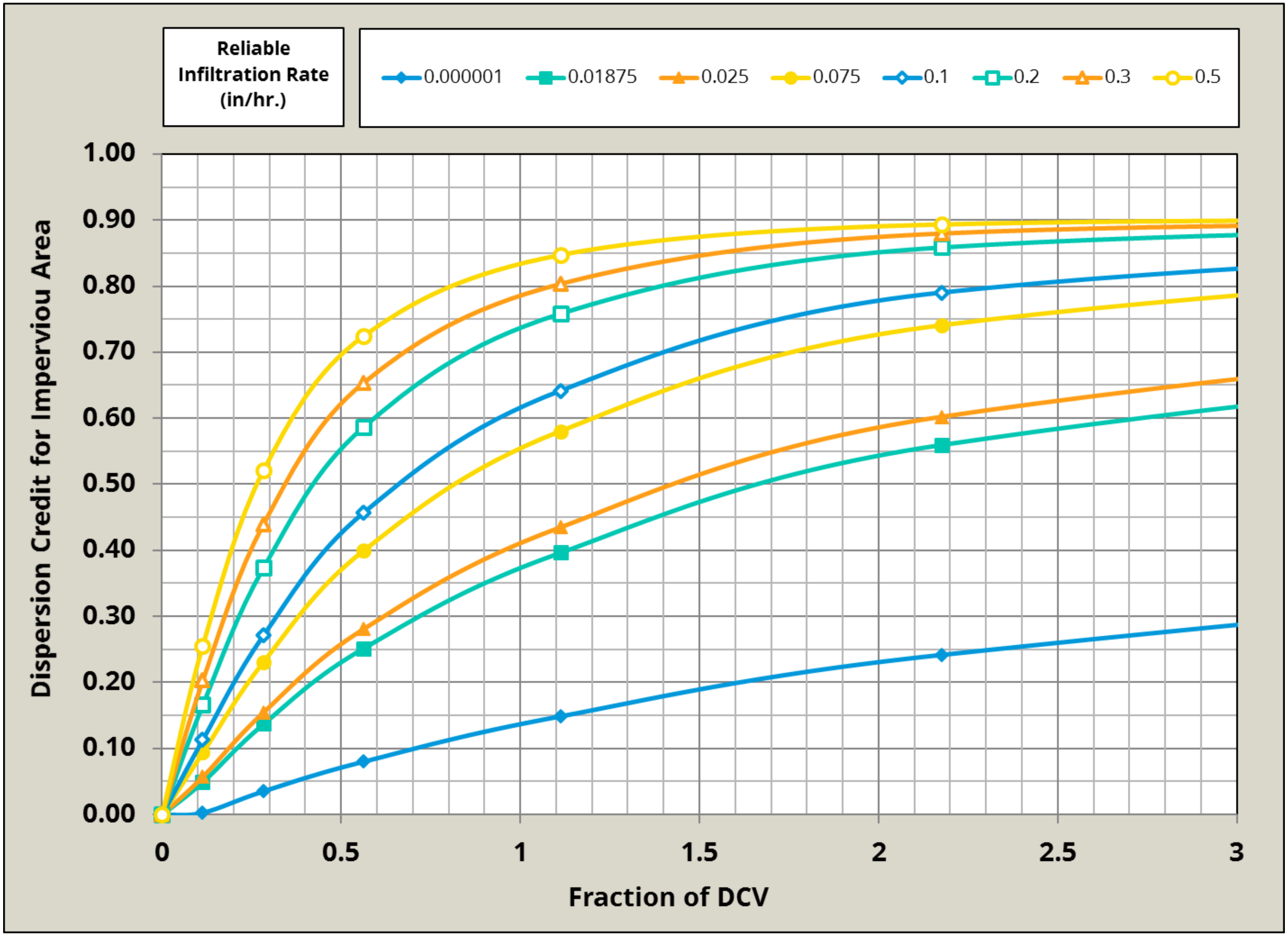

Figure B.5-11. 18" Amendment Dispersion Nomographs

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B.6 Flow-Thru Treatment Control BMPs (for use with Alternative Compliance)

The following methodology must 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**).

Note:

- No pollutant control credit can be claimed for implementing flow-thru treatment control BMPs onsite. Project applicant must participate in alternative compliance for the entire portion of DCV that receives flow-thru treatment.
- Guidance in Appendix B.6 is not applicable for selecting and crediting flow-thru BMPs for offsite storm water alternative compliance.

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:
   (c) Receiving water quality (including pollutants for which receiving waters are listed as impaired under the Clean Water Act section 303(d) List; refer to **Appendix K**);
   (d) Pollutants, stressors, and/or receiving water conditions that cause or contribute to the highest priority water quality conditions identified in the WQIP (refer to **Appendix K and Section 1.9**);
   (e) 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.

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 ft²	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)

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.

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:
   (f) Coarse Sediment and Trash (**Appendix B.6.2.1**)
   (g) Pollutants that tend to associate with fine particles during treatment (**Appendix B.6.2.2**)
   (h) 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	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 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 devises 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.

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 **Appendix 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 used for retention of storm water. 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 ≤ 20 mg/L TSS
100 – 200 mg/L TSS	≥ 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 standards[8]. 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.

[8]Contemporary design standards refer 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.

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	NA3	19	80%	High, effluent and % removal meet criteria without adjustment
Lined Porous Pavement4	356/ 220	229	46	NA3,4	46	80%	High, % removal meets criteria without adjustment
Wet Pond	923/ 933	119	31	NA3	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:

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 City Engineer.** 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 City Engineer 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 City Engineer, a written explanation/reason will be provided to the applicant.

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.
   (i) 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.
   (j) 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 City Engineer 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 City Engineer, a written explanation/reason will be provided to the applicant.

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 Effluent1, mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc2, mg/L	Volume-Adjusted Removal Efficiency2	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 (Equation B.6-1) shall be used to calculate the flow rate to be filtered or treated.

Equation B.6-1: Flow Rate

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

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.

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Appendix C

Geotechnical and Groundwater Investigation Requirements

Feasibility of storm water infiltration is dependent on the geotechnical and groundwater conditions at the project site. The feasibility analysis must be conducted at a DMA level.

This appendix is subdivided into the following:

- **Appendix C.1 Simple Feasibility Criteria:** This appendix is applicable when standard setbacks are used to make a determination that the DMA is in a **no infiltration condition**.
- **Appendix C.2 Detailed Feasibility Criteria:** This appendix can be used for feasibility determination for all DMAs.
- **Appendix C.3 Geotechnical and Groundwater Investigation Report Requirements**: This is applicable to all projects.

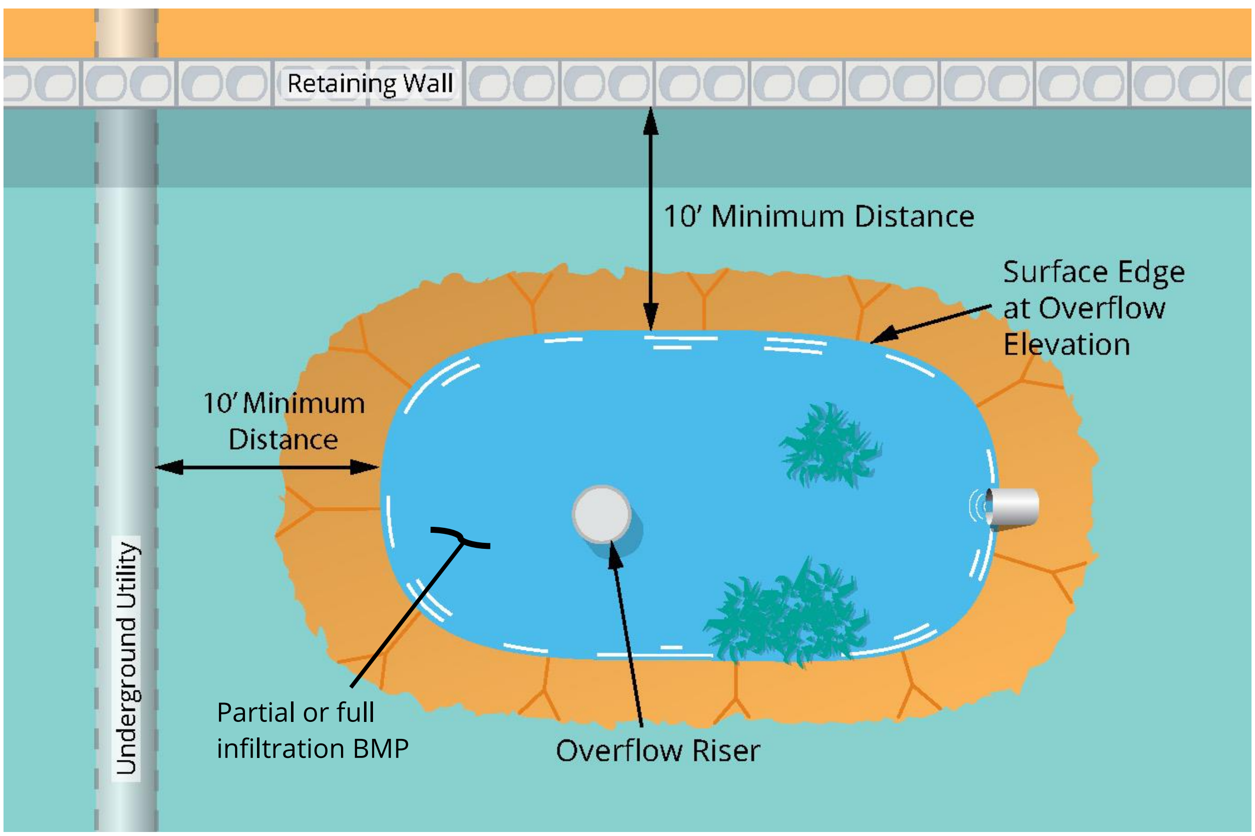
The permits required for land development and construction within the City are issued by the Development Services Department. These permits fall into two general categories: development permits and construction permits. Development permits or entitlements are discretionary in nature, granted at the discretion of a decision maker. Depending on the type of project, the decision maker could be City staff, a Hearing Officer, the Planning Commission, or the City Council. Examples of development permits include Coastal Development Permits, Site Development Permits, Neighborhood Development Permits, Conditional Use Permits, lot splits, condominium conversions, and Tentative Maps. Construction permits are ministerial, which means that projects found to comply with City standards and existing property entitlements can be permitted without a public hearing. Grading plans, improvement plans, and building plans are examples of ministerial permits.

C.1 Simple Feasibility Criteria

When one of the following standard setbacks cannot be avoided, the applicant can classify the DMA as no infiltration condition provided an infiltration feasibility condition letter that meets the requirements in **Appendix C.1.1**. is included in the SWQMP submittal.

- Full and partial infiltration BMPs shall not be placed within existing fill materials greater than 5 feet thick; or
- Full and partial infiltration BMPs shall not be proposed within 10 feet (horizontal radial distance) of existing underground utilities, structures, or retaining walls; or
- Full and partial infiltration BMPs shall not be proposed within 50 feet of a natural slope (>25%) or within a distance of 1.5H from fill slopes where H is the height of the fill slope; or
- Full and partial infiltration BMPs shall not be proposed within 100 feet of contaminated soil or groundwater sites; or
- Other physical impairments (i.e., fire road egress, public safety considerations, etc.)

The setbacks must be the closest horizontal radial distance between the surface edge (at the overflow elevation) of the BMP to existing underground utilities, structures, retaining walls; or natural slopes; or fill slopes; or contaminated soil or groundwater site. The schematic for the setbacks is shown below.



C.1.1 Infiltration Feasibility Condition Letter

The geotechnical engineer shall provide an **Infiltration Feasibility Condition Letter** in the SWQMP to demonstrate that the DMA is in a no infiltration condition. The letter shall be stamped/signed by a licensed geotechnical engineer who prepared the letter.

The letter shall be submitted during the discretionary phase for private projects and during the initial project submittal to the Public Works Department for public projects. The letter shall at a minimum document:

- The phase of the project in which the geotechnical engineer first analyzed the site for infiltration feasibility.
- Results of previous geotechnical analyses conducted in the project area, if any.
- The development status of the site prior to the project application (i.e., new development with raw ungraded land, or redevelopment with existing graded conditions).
- The history of design discussions for the project footprint, resulting in the final design determination.
- Full/partial infiltration BMP standard setbacks to underground utilities, structures, retaining walls, fill slopes, and natural slopes applicable to the DMA that prevent full/partial infiltration.
- The physical impairments (i.e., fire road egress, public safety considerations, etc.) that prevent full/partial infiltration.
- The consideration of site design alternatives to achieve partial/full infiltration within the DMA.
- The extent site design BMPs requirements were included in the overall design.
- Conclusion or recommendation from the geotechnical engineer regarding the DMA's infiltration condition.
- An Exhibit for all applicable DMAs that clearly labels:
    - Proposed development areas and development type.
    - All applicable features and setbacks that prevent partial or full infiltration, including underground utilities, structures, retaining walls, fill slopes, natural slopes, and existing fill materials greater than 5 feet.
    - Potential locations for structural BMPs.
    - Areas where full/partial infiltration BMPs cannot be proposed.

Completion of **Worksheet C.4-1(Form I-8A) and/or Worksheet C.4-2 (Form I-8B)** is not required in instances where the applicant submits an infiltration feasibility condition letter that meets the requirements in this section.

C.2 Detailed Feasibility Criteria

This appendix provides guidelines for performing and reporting feasibility analysis for infiltration with respect to geotechnical and groundwater conditions. It provides a framework for feasibility analysis at two phases of project development:

- **Planning Phase:** Simpler methods of conducting preliminary screening for feasibility; and
- **Design Phase:** When preliminary screening indicates infiltration is feasible, more rigorous analysis is needed to confirm feasibility and to develop design considerations and mitigation measures, if required.

Planning Phase At this project stage, 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 during development. During this phase, project geotechnical consultants are typically responsible for exploring geologic conditions, performing preliminary analyses, and identifying particular design aspects that require more detailed investigation at later phases. As part of this process, the role of a planning- level infiltration feasibility assessment is to reach 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 purpose of the planning phase is to identify potential geotechnical and groundwater impacts resulting from infiltration 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 potential 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 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 the planning phase, the analyses conducted in the 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 to determine 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 (Form I-8A) and Worksheet C.4-2 (From I-8B) are provided to document infiltration feasibility screening. Worksheet C.4.1 (Form I-8A) includes information to be evaluated by geotechnical professionals and Worksheet C.4-2 (Form I-8B) includes information to be evaluated by environmental professionals, hydrogeologists and civil engineers. These worksheets are divided into two parts:

Part 1 "Full Infiltration Feasibility Screening Criteria" is used to determine if the full design volume can be potentially infiltrated onsite.

Part 2 "Partial Infiltration versus No Infiltration Feasibility Screening Criteria" is used to determine if any amount of volume can be infiltrated. This is only used when the result of Part 1 is negative.

Note that it is not required to investigate each and every criterion in the worksheet, a single "no" answer in Part 1 and Part 2 controls the feasibility. If all the answers in Part 1 are "yes" then completion of Part 2 is not required. Note that a planning phase categorization, is 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.

The applicant has discretion to implement full infiltration BMPs even in scenarios where the reliable infiltration rate is less than or equal to 0.5 inches per hour if there are no geotechnical or groundwater hazards associated with implementation of full infiltration BMPs.

C.2.1 Geotechnical Feasibility Criteria

This section is divided into seven factors that shall be considered by the project geotechnical professional, as applicable, while assessing the feasibility 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 required to assess the remaining factors. However, if proposing infiltration BMPs, then each applicable factor in this section must be addressed.

The requirements in this section (**Appendix C.2.1**) are not applicable for DMAs that are identified as no infiltration condition based on one of the setbacks listed under **Appendix C.1** and submission of the **Infiltration Condition Letter** with the SWQMP that meets the requirements in **Appendix C.1.1**.

C.2.1.1 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, presence of fill materials and hydrostratigraphic or confining units;
- Review of previous geotechnical investigations in the area; and
- Site-specific geotechnical and/or geologic investigations (e.g., borings, infiltration tests, etc.).

Geotechnical investigations shall also seek to provide an assessment of whether soil infiltration properties are likely to be uniform or variable across the project site. Appendix D provides guidance on determining infiltration rates for planning and design phases.

C.2.1.2 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.

Volume changes in the soil can be induced by infiltration. The designer(s) must be aware of and consider these mechanisms while completing the feasibility screening including:

- Hydroconsolidation;
- Hydrocollapse;
- Expansive soils; and
- Liquefaction.

C.2.1.3 Slope Stability

Infiltration of storm water has the potential to result in increased risk of slope failure of nearby slopes. This shall be assessed as part of both the project planning and design phases. Many factors impact the stability of slopes, including, but not limited to, slope inclination, soil strength, unit weight, geologic structure, and seepage forces. Increases in moisture content or rising ground water in the vicinity of a slope, which may result from storm water infiltration, have the potential to change the soil strength, unit weight and to add or cause seepage forces to the slope, which may destabilize the slope. When evaluating the effect of infiltration on the slope stability, the designer must consider all types of potential slope failures.

Slopes steeper than 4:1 (horizontal to vertical) are generally not suitable for infiltration systems unless demonstrated otherwise in a geotechnical investigation report. Slope setbacks for infiltration BMPs shall be determined on an individual project basis by a qualified professional and the approval of the setbacks is at the discretion of the City Engineer. **Worksheet C.4-1 (Form I-8A)** provides standard setbacks that may be used to establish infeasibility for infiltration BMPs without performing additional analysis. As a guideline, infiltration zones shall be set back at least 50 feet or 1.5 times the height of the slope unless evaluated by the geotechnical engineer.

C.2.1.4 Utility Considerations

Utilities are either public or private infrastructure components that include underground pipelines and vaults (e.g., potable water, sewer, storm water, and 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 shall 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 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 design, but the designer must be aware of the potential cost impacts to the design during the planning phase.

Utility setbacks for infiltration BMPs shall be determined on an individual project basis by a qualified professional, the approval of the setbacks is at the discretion of the City Engineer. **Worksheet C.4-1 (Form I-8A)** provides standard setbacks that may be used to establish infeasibility for infiltration BMPs without performing additional analysis.

C.2.1.5 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 several 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.2.1.6 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 retained earth and other surface loading conditions such as nearby structures. Foundations include shallow foundations (spread and strip footings, mats) and deep foundations (piles, piers). Retaining walls and foundations can be impacted by increased water infiltration and result of potential increases in lateral pressures and reductions in soil strength. The geotechnical professional shall consider these factors while performing the infiltration feasibility screening.

C.2.1.7 Other Factors

While completing the feasibility screening, other factors determined by the geotechnical professional to influence the feasibility of infiltration related to geotechnical conditions shall also be considered.

C.2.1.8 Geotechnical Mitigation Measures

The following are intended as examples (not exclusive) of reasonable and not reasonable mitigation measures. Other measures may need to be considered for specific projects.

Typically reasonable:

- Configure infiltration BMPs to infiltrate water into native soil to avoid fill or other geotechnical hazards.
- Configure site with consideration to infiltration feasibility to avoid geotechnical hazards.
- Over-excavate and backfill with permeable material below BMPs to avoid infiltration into less permeable fill. A reasonable excavation limit below the BMP is 5 feet.

- Implement selective grading practices to place permeable materials in areas of proposed BMPs.
- Inclusion of an impermeable barrier in BMP side walls (5 feet) to reduce potential for lateral water movement.
- Consider that partial infiltration BMPs have a supplemental discharge pathway (underdrains) to limit infiltration when soil infiltration capacity is exceeded.

Not typically reasonable:

- Major improvements to existing building foundations to increase structural stability, such as requiring deep foundations when such foundations would not otherwise be required.
- Inclusion of cutoff trenches and drainage features to control downslope or off-site effects of increased infiltration.
- Installing mechanical devices to pump storm water to another area on the property for the purposes of implementing pollutant control BMPs across DMAs.

C.2.2 Groundwater Quality and Water Balance Feasibility Criteria

This section is divided into seven factors that shall be considered by qualified design professionals as applicable, while assessing the feasibility 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 required to assess the remaining factors**. However, if proposing infiltration BMPs, then each applicable factor in this section must be addressed.

The requirements in this section (**Appendix C.2.2**) are not applicable for DMAs that are identified as no infiltration condition based on one of the setbacks listed under **Appendix C.1** and submission of the **Infiltration Condition Letter** with the SWQMP that meets the requirements in **Appendix C.1.1**.

C.2.2.1 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. If ALL of the following criteria are met, then full infiltration must be avoided:
    - Cation Exchange Capacity(CEC) < 5 millequivalents per 100 g, as measured by the sodium acetate method (US EPA Method 9081); and,
    - United States Department of Agriculture (USDA) texture class of loamy sand or sand as determined by laboratory analysis of soil texture; and,
    - Soil organic matter content < 1% by mass as determined by loss on ignition (ASTM D2974); and,

  - A seasonally high groundwater table within 10 feet of the bottom surface of the proposed full infiltration BMP.
- 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 full infiltration is under consideration for one of the above conditions, a site-specific analysis shall be conducted to determine where infiltration-based BMPs can be used without adverse impacts.

C.2.2.2 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 full 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.

C.2.2.3 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 planning phase 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.2.2.4 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, full infiltration BMPs must not be used for areas of industrial or light industrial activity.

The project applicant has an option to classify other land uses and activities that pose high threat to water quality not suitable for infiltration BMPs if source control BMPs to prevent exposure of high threat activities could not be implemented, or runoff from such activities could not be first treated or filtered to remove pollutants prior to infiltration. Approval of infeasibility due to high threat to water quality is evaluated on a case by case basis and is at the discretion of the City Engineer.

C.2.2.5 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 protection of groundwater quality. It is recommended that coordination be initiated early in the planning phase to determine whether specific site assessment activities apply or whether these agencies have data available that may support the planning and design phases.

C.2.2.6 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 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.

The following simple screening criteria can be used to determine if a more in-depth analysis is required:

- Proposed infiltration BMP is located within 250 feet of an ephemeral or year round stream; and,
- The proposed BMPs will be full infiltration BMPs; and,
- The seasonal high groundwater depth below the bottom surface of the infiltration BMP is less than 20 feet.

If any of the above screening criteria are not met, then infiltration is feasible. If all of the above screening criteria are met, additional investigations shall be performance by a qualified design professional.

C.2.2.7 Other Factors

While completing the feasibility screening, other factors determined by the qualified design professional to influence the feasibility and desirability of infiltration related to groundwater quality and water balance shall also be considered.

C.2.2.8 Groundwater Quality and Water Balance Mitigation Measures

The following are intended as examples (not exclusive) of reasonable and not reasonable mitigation measures. Other measures may need to be considered for specific projects.

Typically reasonable:

- Consider site layout changes to avoid contaminated soils or soils that lack adequate treatment capacity.
- Design infiltration BMPs to include biofiltration media or an amended media layer if site soils are deemed to lack the treatment capacity to be protective of groundwater quality.

Not typically reasonable:

- Requiring cleanup of contaminated sites for the primary purpose of allowing storm water infiltration.
- Active storm water pretreatment methods.
- Inclusion of cutoff trenches and drainage features to prevent groundwater migration toward contaminated sites.

C.3 Geotechnical and Groundwater Investigation Report Requirements

The geotechnical investigation report(s) addressing onsite storm water infiltration shall include the following elements, as applicable. These and other 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.3.1 Site Evaluation

Site evaluation shall identify the following:

- Areas of contaminated soil or contaminated groundwater within the site;
- “Brown fields” near 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 BMP.

C.3.2 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.3.2.1 Subsurface Exploration

Characterization of potential infiltration rates is a critical step in the categorization of the infiltration feasibility condition. Typically, subsurface exploration, sampling, and testing are necessary for characterizing infiltration rates as well as evaluating potential geologic or geotechnical hazards and constraints associated with storm water infiltration.

For the design phase, a minimum of two (2) in situ percolation or infiltration tests shall be conducted within 50-feet of each proposed full storm water infiltration BMP (also refer to Table D.3-2 as in some instances based on the test method selected more than 2 tests may be required). The tests shall be conducted at the same elevation as the base of the proposed full infiltration BMP and be representative of the conditions below the proposed full infiltration BMP.

An exploratory excavation shall be extended to a depth of at least 10-feet below the base of a proposed full infiltration BMP to demonstrate adequate separation from groundwater.

All exploratory excavations shall be logged in detail and the logs shall be included in the geotechnical investigation report. Low permeability or impermeable materials (i.e. clay horizons) shall be identified. Indicate any obvious evidence of soil contamination.

All exploratory excavations shall be properly filled at the completion of testing.

C.3.2.2 Material Testing and Infiltration Testing

Various material testing and in situ infiltration testing methods and guidance for appropriate factor of safety for full infiltration BMPs are discussed in detail in **Appendix D**. Infiltration testing methods described in **Appendix D** include surface and shallow excavation and deeper subsurface tests.

C.3.2.3 Evaluation of Depth to Groundwater

An evaluation of the depth to groundwater is required to confirm the feasibility of infiltration. Full infiltration BMPs may not be feasible in high groundwater conditions (within 10 feet of the base of infiltration BMP) unless an exemption is granted by the City Engineer. The 10 feet separation criterion is not applicable for partial infiltration condition BMPs.

C.3.3 Reporting Requirements by the Project Geotechnical Consultant

The geotechnical 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.
- **Worksheet C.4-1 (Form I-8A)** completed by the project geotechnical consultant.
    - **<u>Note</u>**: Form I-8A is not required for DMAs that are determined to be in a <u>No Infiltration Condition</u> based on **Worksheet C.4-2 (Form I-8B)** or by submitting a no infiltration condition letter that meets the requirements in **Appendix C.1.1**.
- 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 factors of safety to be applied to infiltration testing results. The site may be broken into sub-basins based on the opinion of the geotechnical consultant with different infiltration rates.
- Describe the infiltration test results and/or correlation with published infiltration rates based on soil parameters or classification. For planning phase feasibility screening and design of partial infiltration BMPs, a factor of safety of 2 must be used. When full

infiltration BMPs are proposed, the geotechnical engineer must complete Section A (Suitability Assessment) in **Worksheet D.5-1 (Form I-9)** and include it in the geotechnical report.

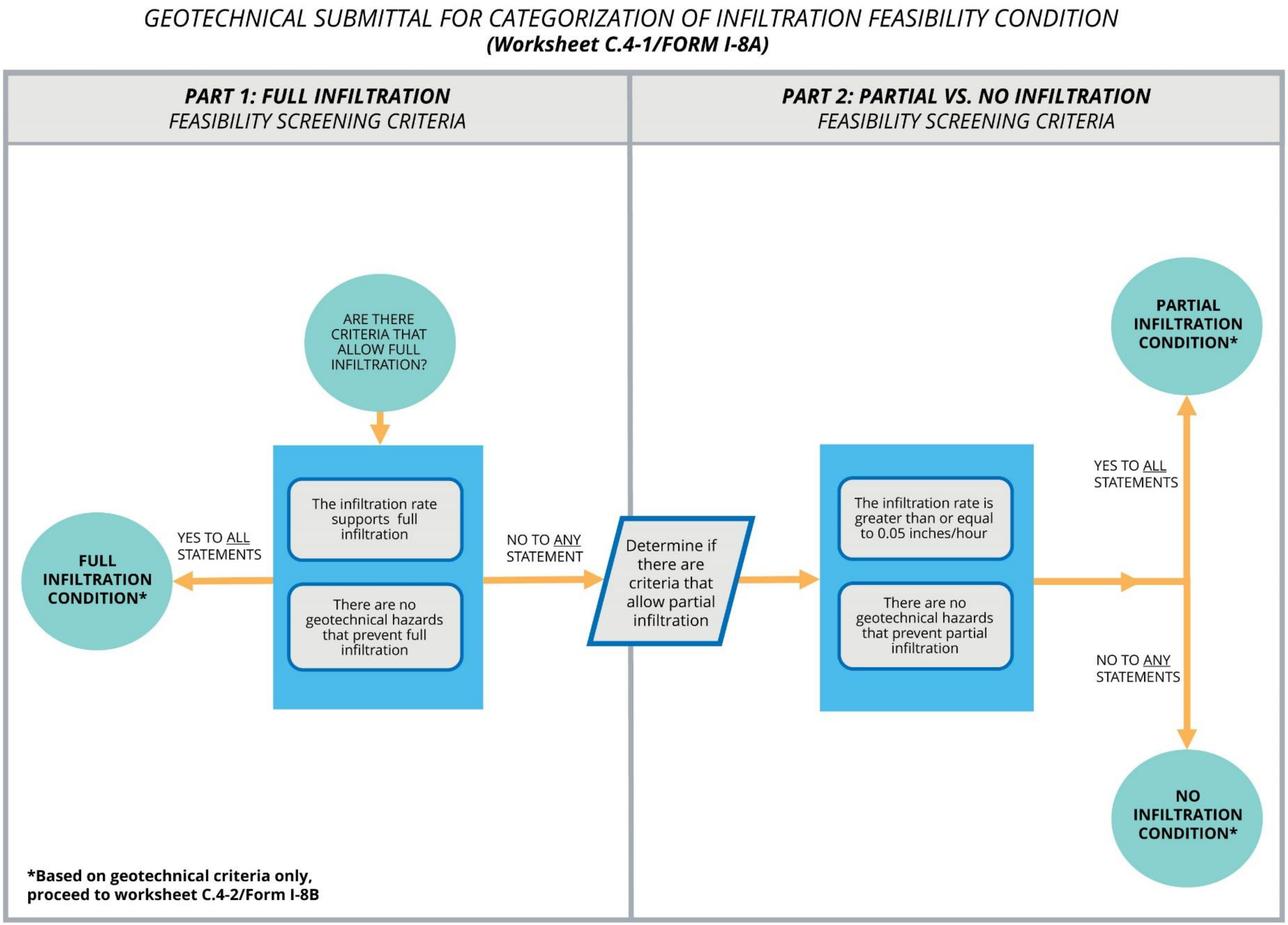
- Investigate the subsurface geological conditions and geotechnical conditions that would affect infiltration or migration of storm water toward structures, slopes, utilities, or other features. Provide an opinion on the anticipated flow path of infiltrated water. Indicate if the water will flow into pavement sections, utility trench bedding, wall drains, foundation drains, other permeable improvements, or daylight.
- Investigate depth to groundwater. Include an estimate of the high seasonal groundwater elevations.
- Provide the reliable infiltration rates.
- Provide a concluding opinion regarding whether or not the proposed onsite storm water infiltration BMP will result in soil piping, daylight water seepage, slope instability, or ground settlement.
- Recommend reasonable measures to substantially mitigate or avoid 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.
- 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 reasonable measures that could be used to reduce the minimum separations or to mitigate the potential impacts of infiltration BMPs.

C.3.4 Reporting Requirements by the Project SWQMP Preparer

The project SWQMP preparer has the following responsibilities:

- Complete **Worksheet C.4-2 (Form I-8B)** and include it in the PDP SWQMP submittal.
    - **Note**: Form I-8B is not required for DMAs that are determined to be in a <u>No Infiltration Condition</u> based on **Worksheet C.4-1 (Form I-8A)** or by submitting a no infiltration condition letter that meets the requirements in **Appendix C.1.1**.
- In the PDP SWQMP provide a concluding opinion whether or not proposed infiltration BMPs will affect seasonality of ephemeral streams.
- Evaluate proposed use of the site (industrial use, residential use, etc.), soil and groundwater data and provide a concluding opinion in the PDP SWQMP 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.

- **Worksheet C.4-3 and Worksheet D.5-1 (Form I-9)** must be completed and included it in the PDP SWQMP submittal when full infiltration BMPs are proposed.


GEOTECHNICAL SUBMITTAL FOR CATEGORIZATION OF INFILTRATION FEASIBILITY CONDITION
(Worksheet C.4-1/FORM I-8A)
PART 1: FULL INFILTRATION
FEASIBILITY SCREENING CRITERIA
PART 2: PARTIAL VS. NO INFILTRATION
FEASIBILITY SCREENING CRITERIA
ARE THERE CRITERIA THAT ALLOW FULL INFILTRATION?
The infiltration rate supports full infiltration
There are no geotechnical hazards that prevent full infiltration
YES TO ALL STATEMENTS
FULL INFILTRATION CONDITION*
NO TO ANY STATEMENT
Determine if there are criteria that allow partial infiltration
The infiltration rate is greater than or equal to 0.05 inches/hour
There are no geotechnical hazards that prevent partial infiltration
YES TO ALL STATEMENTS
PARTIAL INFILTRATION CONDITION*
NO TO ANY STATEMENTS
NO INFILTRATION CONDITION*
*Based on geotechnical criteria only, proceed to worksheet C.4-2/Form I-8B

Worksheet C.4-1: Categorization of Infiltration Feasibility Condition Based on Geotechnical Conditions[9]

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]
Part 1 - Full Infiltration Feasibility Screening Criteria		
DMA(s) Being Analyzed:		Project Phase:
Criteria 1: Infiltration Rate Screening		
1A	Is the mapped hydrologic soil group according to the NRCS Web Soil Survey or UC Davis Soil Web Mapper Type A or B and corroborated by available site soil data[11]? ☐ Yes; the DMA may feasibly support full infiltration. Answer "Yes" to Criteria 1 Result or continue to Step 1B if the applicant elects to perform infiltration testing. ☐ No; the mapped soil types are A or B but is not corroborated by available site soil data (continue to Step 1B). ☐ No; the mapped soil types are C, D, or "urban/unclassified" and is corroborated by available site soil data. Answer "No" to Criteria 1 Result. ☐ No; the mapped soil types are C, D, or "urban/unclassified" but is not corroborated by available site soil data (continue to Step 1B).	
1B	Is the reliable infiltration rate calculated using planning phase methods from Table D.3-1? ☐ Yes; Continue to Step 1C. ☐ No; Skip to Step 1D.	
1C	Is the reliable infiltration rate calculated using planning phase methods from Table D.3-1 greater than 0.5 inches per hour? ☐ Yes; the DMA may feasibly support full infiltration. Answer "Yes" to Criteria 1 Result. ☐ No; full infiltration is not required. Answer "No" to Criteria 1 Result.	
1D	**Infiltration Testing Method.** Is the selected infiltration testing method suitable during the design phase (see Appendix D.3)? Note: Alternative testing standards may be allowed with appropriate rationales and documentation. ☐ Yes; continue to Step 1E. ☐ No; select an appropriate infiltration testing method.	

[9] Note that it is not required to investigate each and every criterion in the worksheet, a single "no" answer in Part 1, Part 2, Part 3, or Part 4 determines a full, partial, or no infiltration condition.

[10] This form must be completed each time there is a change to the site layout that would affect the infiltration feasibility condition. Previously completed forms shall be retained to document the evolution of the site storm water design.

[11] Available data includes site-specific sampling or observation of soil types or texture classes, such as obtained from borings or test pits necessary to support other design elements.

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions	Worksheet C.4-1: Form I-8A[10]
1E	**Number of Percolation/Infiltration Tests.** Does the infiltration testing method performed satisfy the minimum number of tests specified in Table D.3-2? ☐ Yes; continue to Step 1F. ☐ No; conduct appropriate number of tests.
IF	**Factor of Safety.** Is the suitable Factor of Safety selected for full infiltration design? See guidance in D.5; Tables D.5-1 and D.5-2; and Worksheet D.5-1 (Form I-9). ☐ Yes; continue to Step 1G. ☐ No; select appropriate factor of safety.
1G	**Full Infiltration Feasibility.** Is the average measured infiltration rate divided by the Factor of Safety greater than 0.5 inches per hour? ☐ Yes; answer "Yes" to Criteria 1 Result. ☐ No; answer "No" to Criteria 1 Result.
Criteria 1 Result	Is the estimated reliable infiltration rate greater than 0.5 inches per hour within the DMA where runoff can reasonably be routed to a BMP? ☐ Yes; the DMA may feasibly support full infiltration. Continue to Criteria 2. ☐ No; full infiltration is not required. Skip to Part 1 Result.
Summarize infiltration testing methods, testing locations, replicates, and results and summarize estimates of reliable infiltration rates according to procedures outlined in D.5. Documentation should be included in project geotechnical report.	

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]	
Criteria 2: Geologic/Geotechnical Screening			
2A	If all questions in Step 2A are answered "Yes," continue to Step 2B. For any "No" answer in Step 2A answer "No" to Criteria 2, and submit an "Infiltration Feasibility Condition Letter" that meets the requirements in Appendix C.1.1. The geologic/geotechnical analyses listed in Appendix C.2.1 do not apply to the DMA because one of the following setbacks cannot be avoided and therefore result in the DMA being in a no infiltration condition. The setbacks must be the closest horizontal radial distance from the surface edge (at the overflow elevation) of the BMP.		
2A-1	Can the proposed full infiltration BMP(s) avoid areas with existing fill materials greater than 5 feet thick below the infiltrating surface?	☐ Yes	☐ No
2A-2	Can the proposed full infiltration BMP(s) avoid placement within 10 feet of existing underground utilities, structures, or retaining walls?	☐ Yes	☐ No
2A-3	Can the proposed full infiltration BMP(s) avoid placement within 50 feet of a natural slope (>25%) or within a distance of 1.5H from fill slopes where H is the height of the fill slope?	☐ Yes	☐ No
2B	When full infiltration is determined to be feasible, a geotechnical investigation report must be prepared that considers the relevant factors identified in Appendix C.2.1. If all questions in Step 2B are answered "Yes," then answer "Yes" to Criteria 2 Result. If there are "No" answers continue to Step 2C.		
2B-1	**Hydroconsolidation.** Analyze hydroconsolidation potential per approved ASTM standard due to a proposed full infiltration BMP. Can full infiltration BMPs be proposed within the DMA without increasing hydroconsolidation risks?	☐ Yes	☐ No
2B-2	**Expansive Soils.** Identify expansive soils (soils with an expansion index greater than 20) and the extent of such soils due to proposed full infiltration BMPs. Can full infiltration BMPs be proposed within the DMA without increasing expansive soil risks?	☐ Yes	☐ No

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]	
2B-3	**Liquefaction**. If applicable, identify mapped liquefaction areas. Evaluate liquefaction hazards in accordance with Section 6.4.2 of the City of San Diego's Guidelines for Geotechnical Reports (2011 or most recent edition). Liquefaction hazard assessment shall take into account any increase in groundwater elevation or groundwater mounding that could occur as a result of proposed infiltration or percolation facilities. Can full infiltration BMPs be proposed within the DMA without increasing liquefaction risks?	☐ Yes	☐ No
2B-4	**Slope Stability**. If applicable, perform a slope stability analysis in accordance with the ASCE and Southern California Earthquake Center (2002) Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California to determine minimum slope setbacks for full infiltration BMPs. See the City of San Diego's Guidelines for Geotechnical Reports (2011) to determine which type of slope stability analysis is required. Can full infiltration BMPs be proposed within the DMA without increasing slope stability risks?	☐ Yes	☐ No
2B-5	**Other Geotechnical Hazards.** Identify site-specific geotechnical hazards not already mentioned (refer to Appendix C.2.1). Can full infiltration BMPs be proposed within the DMA without increasing risk of geologic or geotechnical hazards not already mentioned?	☐ Yes	☐ No
2B-6	**Setbacks.** Establish setbacks from underground utilities, structures, and/or retaining walls. Reference applicable ASTM or other recognized standard in the geotechnical report. Can full infiltration BMPs be proposed within the DMA using established setbacks from underground utilities, structures, and/or retaining walls?	☐ Yes	☐ No

<table>
<tr><th colspan="2">Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions</th><th colspan="2">Worksheet C.4-1: Form I-8A[10]</th></tr>
<tr><td>2C</td><td>Mitigation Measures. Propose mitigation measures for each geologic/geotechnical hazard identified in Step 2B. Provide a discussion of geologic/geotechnical hazards that would prevent full infiltration BMPs that cannot be reasonably mitigated in the geotechnical report. See Appendix C.2.1.8 for a list of typically reasonable and typically unreasonable mitigation measures.

Can mitigation measures be proposed to allow for full infiltration BMPs? If the question in Step 2 is answered “Yes,” then answer “Yes” to Criteria 2 Result.
If the question in Step 2C is answered “No,” then answer “No” to Criteria 2 Result.</td><td>☐ Yes</td><td>☐ No</td></tr>
<tr><td>Criteria 2 Result</td><td>Can infiltration greater than 0.5 inches per hour be allowed without increasing risk of geologic or geotechnical hazards that cannot be reasonably mitigated to an acceptable level?</td><td>☐ Yes</td><td>☐ No</td></tr>
<tr><td colspan="4">Summarize findings and basis; provide references to related reports or exhibits.</td></tr>
<tr><th colspan="2">Part 1 Result – Full Infiltration Geotechnical Screening [12]</th><th colspan="2">Result</th></tr>
<tr><td colspan="2">If answers to both Criteria 1 and Criteria 2 are “Yes”, a full infiltration design is potentially feasible based on Geotechnical conditions only.

If either answer to Criteria 1 or Criteria 2 is “No”, a full infiltration design is not required.</td><td colspan="2">☐ Full infiltration Condition

☐ Complete Part 2</td></tr>
</table>

[12] To be completed using gathered site information and best professional judgement considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by City Engineer to substantiate findings.

<table>
<tr><th colspan="2">Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions</th><th>Worksheet C.4-1: Form I-8A[10]</th></tr>
<tr><td colspan="3">Part 2 – Partial vs. No Infiltration Feasibility Screening Criteria</td></tr>
<tr><td colspan="2">DMA(s) Being Analyzed:</td><td>Project Phase:</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">Criteria 3 : Infiltration Rate Screening</td></tr>
<tr><td>3A</td><td colspan="2">NRCS Type C, D, or “urban/unclassified”: Is the mapped hydrologic soil group according to the NRCS Web Soil Survey or UC Davis Soil Web Mapper is Type C, D, or “urban/unclassified” and corroborated by available site soil data?
☐ Yes; the site is mapped as C soils and a reliable infiltration rate of 0.15 in/hr. is used to size partial infiltration BMPS. Answer “Yes” to Criteria 3 Result.
☐ Yes; the site is mapped as D soils or “urban/unclassified” and a reliable infiltration rate of 0.05 in/hr. is used to size partial infiltration BMPS. Answer “Yes” to Criteria 3 Result.
☐ No; infiltration testing is conducted (refer to Table D.3-1), continue to Step 3B.</td></tr>
<tr><td>3B</td><td colspan="2">Infiltration Testing Result: Is the reliable infiltration rate (i.e. average measured infiltration rate/2) greater than 0.05 in/hr. and less than or equal to 0.5 in/hr?
☐ Yes; the site may support partial infiltration. Answer “Yes” to Criteria 3 Result.
☐ No; the reliable infiltration rate (i.e. average measured rate/2) is less than 0.05 in/hr., partial infiltration is not required. Answer “No” to Criteria 3 Result.</td></tr>
<tr><td>Criteria 3 Result</td><td colspan="2">Is the estimated reliable infiltration rate (i.e., average measured infiltration rate/2) greater than or equal to 0.05 inches/hour and less than or equal to 0.5 inches/hour at any location within each DMA where runoff can reasonably be routed to a BMP?
☐ Yes; Continue to Criteria 4.
☐ No: Skip to Part 2 Result.</td></tr>
<tr><td colspan="3">Summarize infiltration testing and/or mapping results (i.e. soil maps and series description used for infiltration rate).</td></tr>
</table>

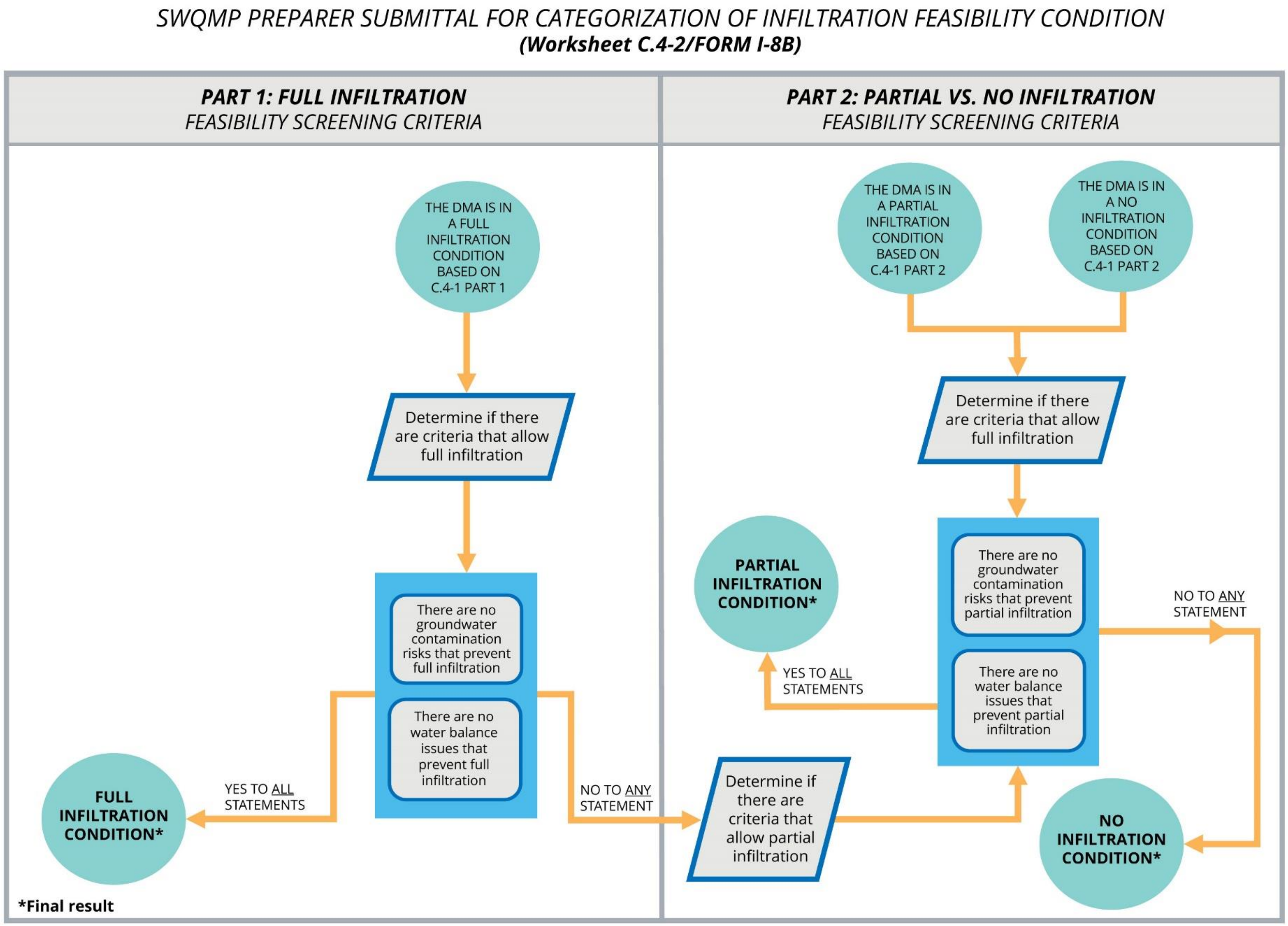
Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]	
Criteria 4: Geologic/Geotechnical Screening			
4A	If all questions in Step 4A are answered "Yes," continue to Step 2B. For any "No" answer in Step 4A answer "No" to Criteria 4 Result, and submit an "Infiltration Feasibility Condition Letter" that meets the requirements in Appendix C.1.1. The geologic/geotechnical analyses listed in Appendix C.2.1 do not apply to the DMA because one of the following setbacks cannot be avoided and therefore result in the DMA being in a no infiltration condition. The setbacks must be the closest horizontal radial distance from the surface edge (at the overflow elevation) of the BMP.		
4A-1	Can the proposed partial infiltration BMP(s) avoid areas with existing fill materials greater than 5 feet thick?	☐ Yes	☐ No
4A-2	Can the proposed partial infiltration BMP(s) avoid placement within 10 feet of existing underground utilities, structures, or retaining walls?	☐ Yes	☐ No
4A-3	Can the proposed partial infiltration BMP(s) avoid placement within 50 feet of a natural slope (>25%) or within a distance of 1.5H from fill slopes where H is the height of the fill slope?	☐ Yes	☐ No
4B	When full infiltration is determined to be feasible, a geotechnical investigation report must be prepared that considers the relevant factors identified in Appendix C.2.1 If all questions in Step 4B are answered "Yes," then answer "Yes" to Criteria 4 Result. If there are any "No" answers continue to Step 4C.		
4B-1	**Hydroconsolidation.** Analyze hydroconsolidation potential per approved ASTM standard due to a proposed full infiltration BMP. Can partial infiltration BMPs be proposed within the DMA without increasing hydroconsolidation risks?	☐ Yes	☐ No
4B-2	**Expansive Soils.** Identify expansive soils (soils with an expansion index greater than 20) and the extent of such soils due to proposed full infiltration BMPs. Can partial infiltration BMPs be proposed within the DMA without increasing expansive soil risks?	☐ Yes	☐ No

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]	
4B-3	**Liquefaction**. If applicable, identify mapped liquefaction areas. Evaluate liquefaction hazards in accordance with Section 6.4.2 of the City of San Diego's Guidelines for Geotechnical Reports (2011). Liquefaction hazard assessment shall take into account any increase in groundwater elevation or groundwater mounding that could occur as a result of proposed infiltration or percolation facilities. Can partial infiltration BMPs be proposed within the DMA without increasing liquefaction risks?	☐ Yes	☐ No
4B-4	**Slope Stability**. If applicable, perform a slope stability analysis in accordance with the ASCE and Southern California Earthquake Center (2002) Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California to determine minimum slope setbacks for full infiltration BMPs. See the City of San Diego's Guidelines for Geotechnical Reports (2011) to determine which type of slope stability analysis is required. Can partial infiltration BMPs be proposed within the DMA without increasing slope stability risks?	☐ Yes	☐ No
4B-5	**Other Geotechnical Hazards.** Identify site-specific geotechnical hazards not already mentioned (refer to Appendix C.2.1). Can partial infiltration BMPs be proposed within the DMA without increasing risk of geologic or geotechnical hazards not already mentioned?	☐ Yes	☐ No
4B-6	**Setbacks.** Establish setbacks from underground utilities, structures, and/or retaining walls. Reference applicable ASTM or other recognized standard in the geotechnical report. Can partial infiltration BMPs be proposed within the DMA using recommended setbacks from underground utilities, structures, and/or retaining walls?	☐ Yes	☐ No
4C	**Mitigation Measures.** Propose mitigation measures for each geologic/geotechnical hazard identified in Step 4B. Provide a discussion on geologic/geotechnical hazards that would prevent partial infiltration BMPs that cannot be reasonably mitigated in the geotechnical report. See Appendix C.2.1.8 for a list of typically reasonable and typically unreasonable mitigation measures. Can mitigation measures be proposed to allow for partial infiltration BMPs? If the question in Step 4C is answered "Yes," then answer "Yes" to Criteria 4 Result. If the question in Step 4C is answered "No," then answer "No" to Criteria 4 Result.	☐ Yes	☐ No

Categorization of Infiltration Feasibility Condition based on Geotechnical Conditions		Worksheet C.4-1: Form I-8A[10]	
Criteria 4 Result	Can infiltration of greater than or equal to 0.05 inches/hour and less than or equal to 0.5 inches/hour be allowed without increasing the risk of geologic or geotechnical hazards that cannot be reasonably mitigated to an acceptable level?	☐ Yes	☐ No
Summarize findings and basis; provide references to related reports or exhibits.			

Part 2 – Partial Infiltration Geotechnical Screening Result[13]	Result
If answers to both Criteria 3 and Criteria 4 are "Yes", a partial infiltration design is potentially feasible based on geotechnical conditions only. If answers to either Criteria 3 or Criteria 4 is "No", then infiltration of any volume is considered to be infeasible within the site.	☐ Partial Infiltration Condition ☐ No Infiltration Condition

[13] To be completed using gathered site information and best professional judgement considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by City Engineer to substantiate findings.


SWQMP PREPARER SUBMITTAL FOR CATEGORIZATION OF INFILTRATION FEASIBILITY CONDITION
(Worksheet C.4-2/FORM I-8B)
PART 1: FULL INFILTRATION
FEASIBILITY SCREENING CRITERIA
PART 2: PARTIAL VS. NO INFILTRATION
FEASIBILITY SCREENING CRITERIA
THE DMA IS IN A FULL INFILTRATION CONDITION BASED ON C.4-1 PART 1
Determine if there are criteria that allow full infiltration
There are no groundwater contamination risks that prevent full infiltration
There are no water balance issues that prevent full infiltration
YES TO ALL STATEMENTS
FULL INFILTRATION CONDITION*
NO TO ANY STATEMENT
*Final result
THE DMA IS IN A PARTIAL INFILTRATION CONDITION BASED ON C.4-1 PART 2
THE DMA IS IN A NO INFILTRATION CONDITION BASED ON C.4-1 PART 2
Determine if there are criteria that allow full infiltration
There are no groundwater contamination risks that prevent partial infiltration
There are no water balance issues that prevent partial infiltration
PARTIAL INFILTRATION CONDITION*
YES TO ALL STATEMENTS
NO TO ANY STATEMENT
Determine if there are criteria that allow partial infiltration
NO INFILTRATION CONDITION*

Worksheet C.4-2: Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions[14]

<table>
<tr><th colspan="2">Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions</th><th>Worksheet C.4-2: Form I-8B[15]</th></tr>
<tr><td colspan="3">Part 1 - Full Infiltration Feasibility Screening Criteria</td></tr>
<tr><td colspan="2">DMA(s) Being Analyzed:</td><td>Project Phase:</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">Criteria 1: Groundwater Screening</td></tr>
<tr><td>1A</td><td colspan="2">Groundwater Depth. Is the depth to seasonally high groundwater tables (normal high depth during the wet season) beneath the base of any full infiltration BMP greater than 10 feet?
☐ Yes; continue to Step 1B.
☐ No; The depth to groundwater is less than or equal to 10 feet, but site layout changes or reasonable mitigation measures can be proposed to support full infiltration BMPs. Continue to step 1B.
☐ No; The depth to groundwater is less than or equal to 10 feet and site layout changes or reasonable mitigation measures cannot be proposed to support full infiltration BMPs. Answer "No" for Criteria 1 Result.</td></tr>
<tr><td>1B</td><td colspan="2">Contaminated Soil/Groundwater. Are proposed full infiltration BMPs at least 250 feet away from contaminated soil or groundwater sites? This can be confirmed using GeoTracker (geotracker.waterboards.ca.gov) to identify open contaminated sites. The setbacks must be the closest horizontal radial distance from the surface edge (at the overflow elevation) of the BMP.
☐ Yes; continue to Step 1C.
☐ No; However, site layout changes or reasonable mitigation measures can be proposed to support full infiltration BMPs. Continue to Step 1C.
☐ No; Site layout changes or reasonable mitigation measures cannot be proposed to support full infiltration BMPs. Answer "No" to Criteria 1 Result.</td></tr>
</table>

[14] Note that it is not required to investigate each and every criterion in the worksheet, a single "no" answer in Part 1, Part 2, part 3, or Part 4 determines a full, partial, or no infiltration condition.

[15] This form must be completed each time there is a change to the site layout that would affect the infiltration feasibility condition. Previously completed forms shall be retained to document the evolution of the site storm water design.

Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions	Worksheet C.4-2: Form I-8B[15]
1C	**Inadequate Soil Treatment Capacity.** Are full infiltration BMPs proposed in DMA soils that have adequate soil treatment capacity? The DMA has adequate soil treatment capacity if **ALL** of the following criteria (detailed in C.2.2.1) for all soil layers beneath the infiltrating surface are met: • USDA texture class is sandy loam or loam or silt loam or silt or sandy clay loam or clay loam or silty clay loam or sandy clay or silty clay or clay; and • Cation Exchange Capacity (CEC) greater than 5 milliequivalents/100g; and • Soil organic matter is greater than 1%; and • Groundwater table is equal to or greater than 10 feet beneath the base of the full infiltration BMP. ☐ Yes; continue to Step 1D. ☐ No; However, site layout changes or reasonable mitigation measures can be proposed to support full infiltration BMPs. Continue to Step 1D. ☐ No; Site layout changes or reasonable mitigation measures cannot be proposed to support full infiltration BMPs. Answer "No" to Criteria 1 Result.
1D	**Other Groundwater Contamination Hazards.** Are there site-specific groundwater contamination hazards not already mentioned (refer to Appendix C.2.2) that can be reasonably mitigated to support full infiltration BMPs? ☐ Yes; there are other contamination hazards identified that can be mitigated. Answer "Yes" to Criteria 1 Result. ☐ No; there are other contamination hazards identified that cannot be mitigated. Answer "No" to Criteria 1 Result. ☐ N/A; no contamination hazards are identified. Answer "Yes" to Criteria 1 Result.
Criteria 1 Result	Can infiltration greater than 0.5 inches per hour be allowed without increasing risk of groundwater contamination that cannot be reasonably mitigated to an acceptable level? See Appendix C.2.2.8 for a list of typically reasonable and typically unreasonable mitigation measures. ☐ Yes; Continue to Part 1, Criteria 2. ☐ No; Continue to Part 1 Result.

Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions	Worksheet C.4-2: Form I-8B[15]
Summarize groundwater quality and any mitigation measures proposed. Documentation should focus on groundwater table, mapped soil types and contaminated site locations.	

Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions	Worksheet C.4-2: Form I-8B[15]
Criteria 2: Water Balance Screening	
2A	**Ephemeral Stream Setback.** Does the proposed full infiltration BMP meet both the following? • The full infiltration BMP is located at least 250 feet away from an ephemeral stream; **AND** • The bottom surface of the full infiltration BMP is at a depth 20 feet or greater from seasonally high groundwater tables. ☐ Yes; Answer "Yes" to Criteria 2 Result. ☐ No; Continue to Step 2B.
2B	**Mitigation Measures.** Can site layout changes be proposed to support full infiltration BMPs? ☐ Yes; the site can be reconfigured to mitigate potential water balance issues. Answer "Yes" to Criteria 2 Result. ☐ No; the site cannot be reconfigured to mitigate potential water balance issues. Continue to Step 2C and provide discussion.
2C	**Additional studies.** Do additional studies support full infiltration BMPs? In the event that water balance effects are used to reject full infiltration (anticipated to be rare), additional analysis shall be completed and documented by a qualified professional indicating the site-specific information evaluated and the technical basis for this finding. ☐ Yes; Answer "Yes" to Criteria 2 Result. ☐ No; Answer "No" to Criteria 2 Result.
Criteria 2 Result	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? ☐ Yes; Continue to Part 1 Result. ☐ No; Continue to Part 1 Result.

Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions	Worksheet C.4-2: Form I-8B[15]
Summarize potential water balance effects. Documentation should focus on mapping and soil data regarding proximity to ephemeral streams and groundwater depth.	

Part 1 – Full Infiltration Groundwater and Water Balance Screening Result[16]	Result
If answers to Criteria 1 and 2 are "Yes", a full infiltration design is potentially feasible. The feasibility screening category is Full Infiltration based on groundwater conditions. If answer to Criteria 1 or Criteria 2 is "No", infiltration may be possible to some extent but would not generally be feasible or desirable to achieve a "full infiltration" design based on groundwater conditions. Proceed to Part 2.	☐ Full Infiltration ☐ Complete Part 2

[16] To be completed using gathered site information and best professional judgement considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by City Engineer to substantiate findings.

Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions	Worksheet C.4-2: Form I-8B[15]
Part 2 – Partial vs. No Infiltration Feasibility Screening Criteria	
DMA(s) Being Analyzed:	Project Phase:
Criteria 3: Groundwater Screening	
Contaminated Soil/Groundwater. Are partial infiltration BMPs proposed at least 100 feet away from contaminated soil or groundwater sites? This can be confirmed using GeoTracker (geotracker.waterboards.ca.gov) to identify open contaminated sites. This criterion is intentionally a smaller radius than full infiltration, as the potential quantity of infiltration from partial infiltration BMPs is smaller. ☐ Yes; Answer "Yes" to Criteria 3 Result. ☐ No; However, site layout changes can be proposed to avoid contaminated soils or soils that lack adequate treatment capacity. Select "Yes" to Criteria 3 Result. It is a requirement for the SWQMP preparer to identify potential mitigation measures. ☐ No; Contaminated soils or soils that lack adequate treatment capacity cannot be avoided and partial infiltration BMPs are not feasible. Select "No" to Criteria 3 Result.	
Criteria 3 Result: Can infiltration of greater than or equal to 0.05 inches/hour and less than or equal to 0.5 inches/hour be allowed without increasing risk of groundwater contamination that cannot be reasonably mitigated to an acceptable level? ☐ Yes; Continue to Part 2, Criteria 4. ☐ No; Skip to Part 2 Result.	
Summarize findings and basis. Documentation should focus on mapped soil types and contaminated site locations.	

<table>
<tr><th>Categorization of Infiltration Feasibility Condition based on Groundwater and Water Balance Conditions</th><th colspan="2">Worksheet C.4-2: Form I-8B[15]</th></tr>
<tr><td colspan="3">Criteria 4: Water Balance Screening</td></tr>
<tr><td colspan="3">Additional studies. In the event that water balance effects are used to reject partial infiltration (anticipated to be rare), a qualified professional must provide an analysis of the incremental effects of partial infiltration BMPs on the water balance compared to incidental infiltration under a no infiltration scenario (e.g. precipitation, irrigation, etc.).</td></tr>
<tr><td colspan="3">Criteria 4 Result: Can infiltration of greater than or equal to 0.05 inches/hour and less than or equal to 0.5 inches/hour be allowed without causing potential water balance issues such as change of seasonality of ephemeral streams?
☐ Yes: Continue to Part 2 Result.
☐ No: Continue to Part 2 Result.</td></tr>
<tr><td colspan="3">Summarize potential water balance effects. Documentation should focus on mapping and soil data regarding proximity to ephemeral streams and groundwater depth.</td></tr>
<tr><td colspan="2">Part 2 – Partial Infiltration Groundwater and Water Balance Screening Result[17]</td><td>Result</td></tr>
<tr><td colspan="2">If answers to Criteria 3 and Criteria 4 are “Yes”, a partial infiltration design is potentially feasible. The feasibility screening category is Partial Infiltration based on groundwater and water balance conditions.

If answer to Criteria 3 or Criteria 4 is “No”, then infiltration of any volume is considered to be infeasible within the site. The feasibility screening category is No Infiltration based on groundwater or water balance condition.</td><td>☐ Partial Infiltration Condition
☐ No Infiltration Condition</td></tr>
</table>

[17] To be completed using gathered site information and best professional judgement considering the definition of MEP in the MS4 Permit. Additional testing and/or studies may be required by City Engineer to substantiate findings.

Worksheet C.4-3: Infiltration and Groundwater Protection for Full Infiltration BMPs

Infiltration and Groundwater Protection		Worksheet C.4-3	
Criteria	Question	Yes	No
1	Will the storm water runoff undergo pretreatment such as sedimentation or filtration prior to infiltration?	☐	☐
2	Are pollution prevention and source control BMPs implemented at a level appropriate to protect groundwater quality for areas draining to infiltration BMPs?	☐	☐
3	Is the vertical distance from the base of the full infiltration BMP to the seasonal high groundwater mark 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	☐	☐
4	Does the soil through which infiltration is to occur have physical and chemical characteristics that are adequate for proper infiltration durations and treatment of runoff for the protection of groundwater beneficial uses? Refer to Appendix C.3.1.	☐	☐
5	Is the following statement true? Full infiltration BMPs are not used for areas of industrial or light industrial activity, and other high threat to water quality land uses and activities, 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.	☐	☐
6	Is the full infiltration BMP located at a distance greater than 100 feet horizontally from any water supply well?	☐	☐
Basis and Documentation: All the answers for Criteria 1 to 6 must be "Yes" for acceptance of a full infiltration BMP.			

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C.4 Feasibility Screening Exhibits

Table C.4-1 lists the feasibility screening exhibits that were generated using readily available GIS data sets to assist the project applicant during planning phase.

Table C.4-1: Feasibility Screening Exhibits

Figures	Layer	Data Sources
C.1 Soils	Hydrologic Soil Group – A, B, C, D	NRCS Web Soil Survey http://websoilsurvey.sc.egov.usda.gov/
	Hydric Soils	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%	SanGIS http://www.sangis.org/
	Liquefaction Potential	SanGIS http://www.sangis.org/
	Landslide Potential	SanGIS Geologic Hazards layer. Subset of polygons with hazard codes related to landslides were selected. This data is limited to the City of San Diego Boundary. http://www.sangis.org/
C.3: Groundwater Table Elevations	Groundwater Depths	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	GeoTracker. Data downloaded for San Diego county and limited to active cleanup sites http://geotracker.waterboards.ca.gov/

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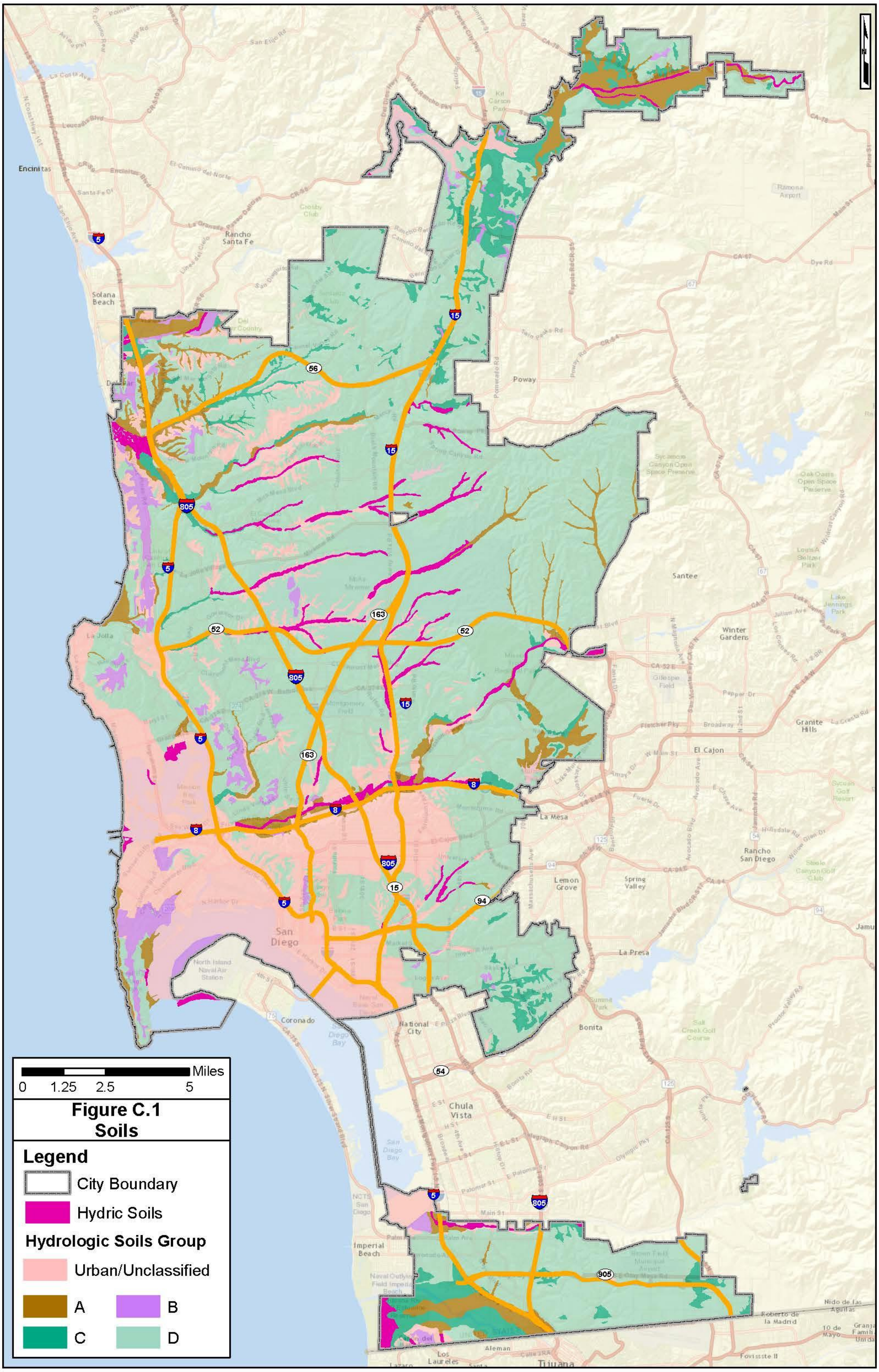

Figure C.4-1: Soils Exhibit

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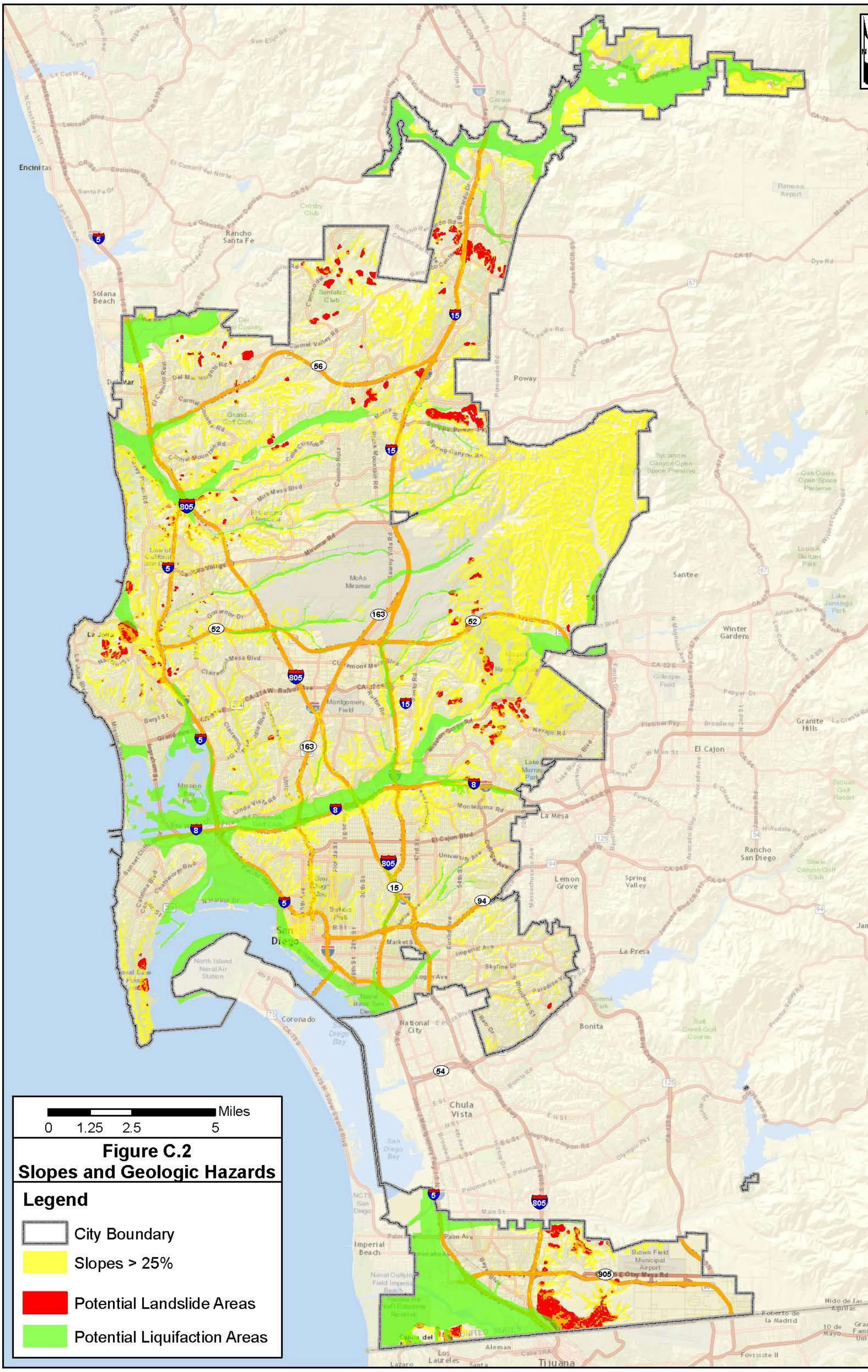

Figure C.4-2 : Slopes and Geologic Hazards Exhibit

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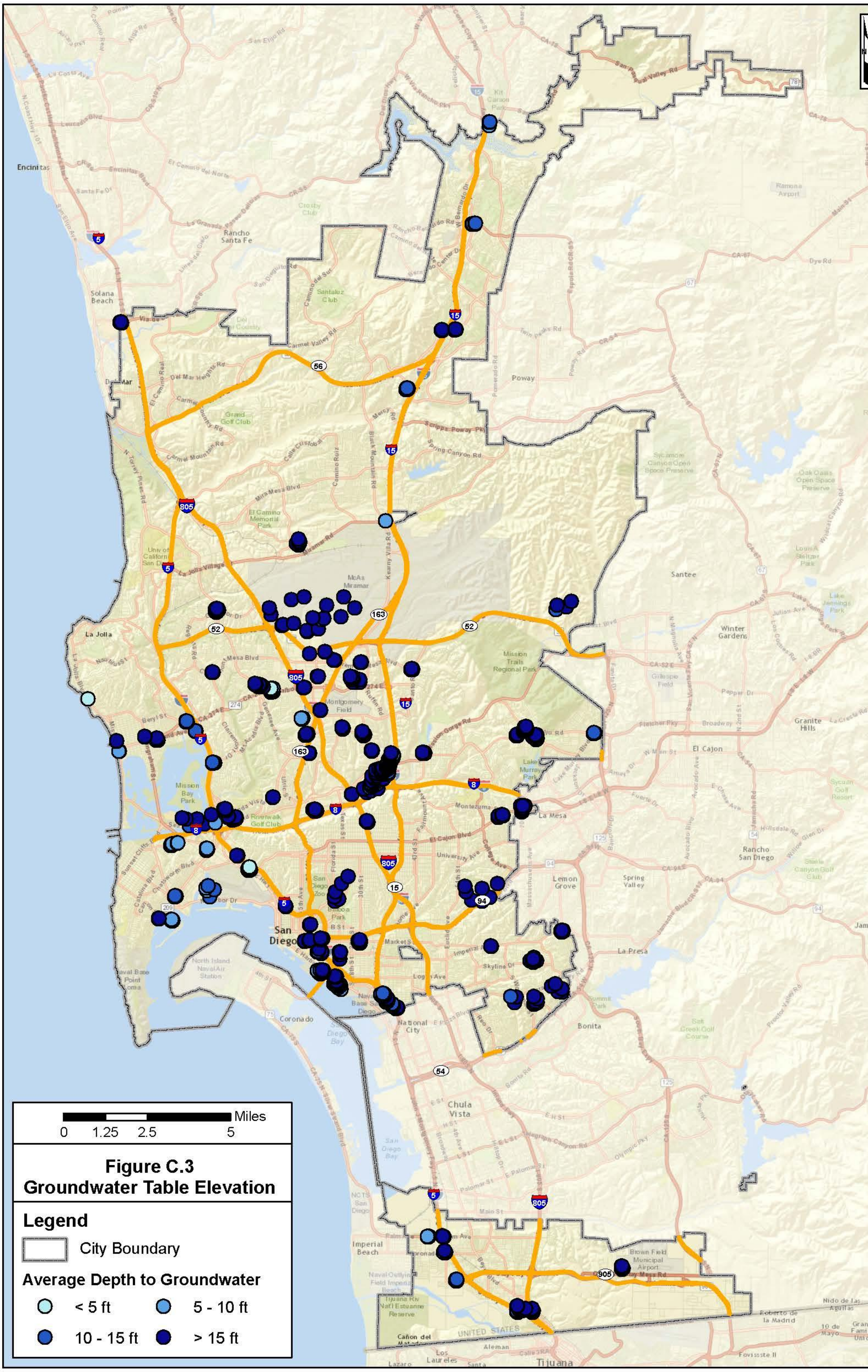

Figure C.4-3 : Groundwater Table Elevation Exhibit

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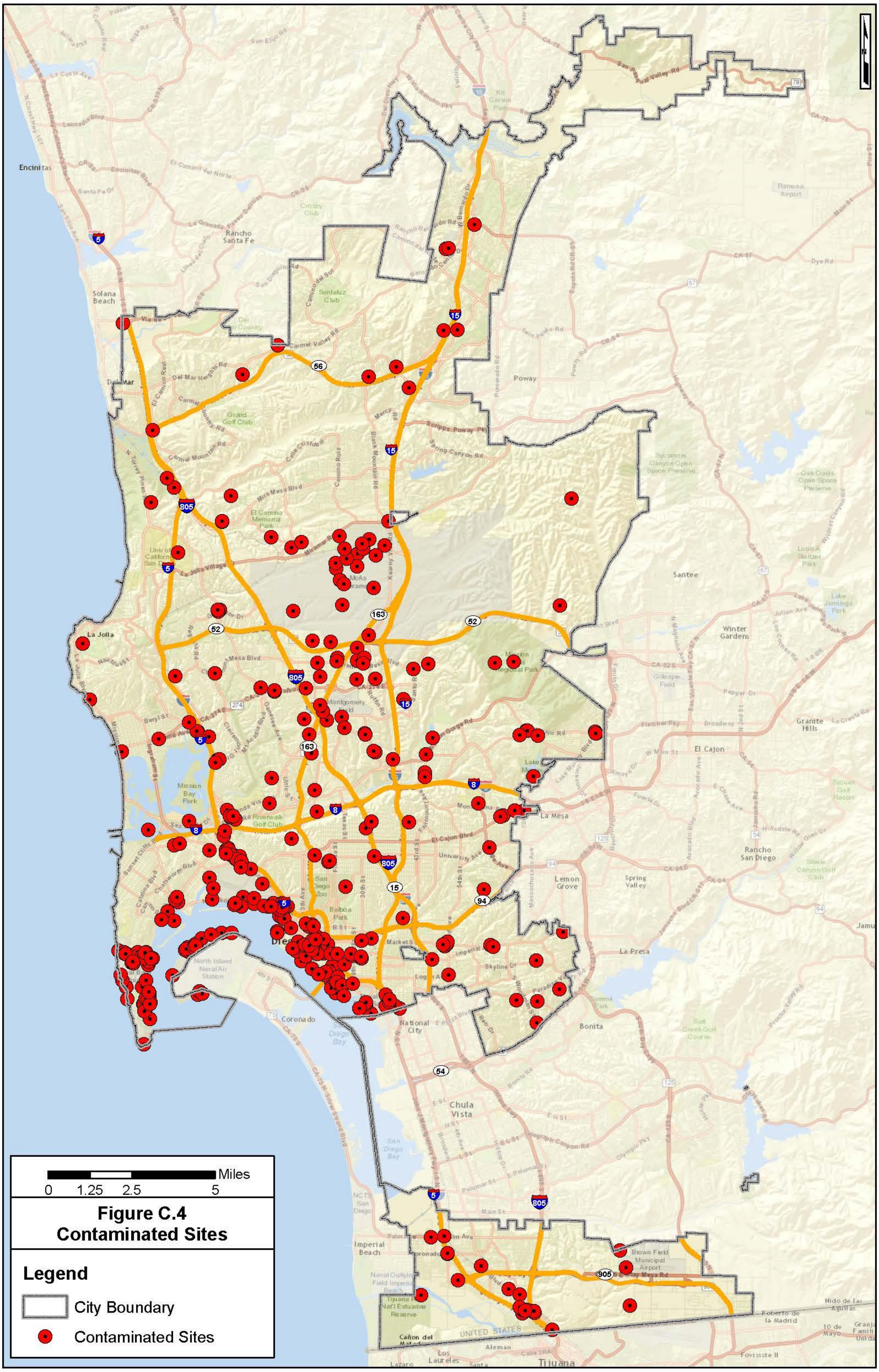

Figure C.4-4 : Contaminated Sites Exhibit

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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 reduces 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?**
   Appendix D.2 discusses the role of infiltration testing in different stages of project development and how to plan a phased investigation approach.
2. **What infiltration rate assessment methods are acceptable?**
   Appendix D.3 describes the acceptable infiltration rate assessment methods.
3. **What factors should be considered in selecting the most appropriate testing method for a project?**
   Appendix 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 for BMP selection and design?**
   Appendix D.5 provides guidance for selecting factor of safety.

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.

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 factor into project development, as summarized in Table D.2-1. When selecting infiltration testing methods, the geotechnical consultant should select methods applicable to the relevant project phase.

Table D.2-1 : Role of Infiltration Testing

Project Phase	Key Questions	General Assessment Strategies
Planning Phase	Where within the project area is infiltration potentially feasible? What volume reduction approaches are potentially suitable for my project?	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.
Design Phase	What infiltration rates should be used to design infiltration and biofiltration facilities? What factor of safety should be applied?	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 consultant should select appropriate testing methods for the site conditions, subject to the geotechnical consultant's discretion and approval of the City Engineer, that are adequate to evaluate applicability at each phase of the project (See Table D.3-1):

- At the planning phase, the testing 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. **Appendices 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. 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. **Alternative testing standards may be allowed with appropriate rationales and documentation.**

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 infiltration rate 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.

Submit the field test measurements and tabulated results for each location tested. Submit the calculated infiltration rate and method of calculation. For the purposes of this manual, saturated hydraulic conductivity and infiltration rate may be assumed to be equal.

Table D.3-1: Comparison of Infiltration Rate Estimation and Testing Methods[18]

Test	Suitability at Planning Phase	Suitability at Design Phase[19]
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.	Yes, for partial infiltration designs when mapped soils are corroborated with soil samples collected during investigation activities. No, for full infiltration designs.
Grain Size Analysis	Not preferred. Should only be used if a strong correlation has been developed between grain size analysis and measured infiltration rate testing results of site soils.	No
Cone Penetrometer Test (CPT)	Not preferred. Should only be used if a strong correlation has been developed between CPT results and measured infiltration rate 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
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	Yes
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 boring log should be recorded and used to interpret test; should be confirmed with a more direct measurement

[18] Percolation rates measured in pit tests and borehole percolation tests should be converted to infiltration rates using the Porchet method (Appendix D.3.4).

[19] Design phase confirmation of infiltration rate is only required if full infiltration BMPs are proposed. Partial infiltration BMPs are not as sensitive to infiltration rate and do not warrant design phase verification.

Test	Suitability at Planning Phase	Suitability at Design Phase[19]
		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.

Table D.3-2 provides recommendations for number of tests, based on test method, needed to provide adequate characterization of the design phase infiltration rate. Testing must be done at the location and elevation of proposed infiltration BMPs. **This guidance is only applicable for full infiltration BMPs at the design phase. It is not applicable for planning phase investigations or for design of partial infiltration BMPs.** The "low" and "medium" concerns relate to the factor of safety presented in Appendix D.5.

Table D.3-2. Recommended Replicates and Levels of Concern for Design Phase Infiltration Testing for Full Infiltration Designs

Test Method Category	Small BMPs (BMP area < 250 ft²)	Medium BMPs (BMP area < 2,000 ft²)	Large BMPs (BMP area > 2,000 ft²)
Pit Testing Methods: Large-scale PIT Smaller-scale PIT	2 tests = **Low Concern**	2+ tests = **Low Concern**	2 tests per 5,000 ft² = **Medium Concern** 3+ tests per 5,000 ft² = **Low Concern**
Surface Infiltrometer Tests and Smaller Pit Testing Methods: Simple Open Pit Open Pit Falling Head Single Ring Double ring Other surface infiltrometer methods	2 tests = **Medium Concern** 3+ tests = **Low Concern**	3 tests = **Medium Concern** 4+ tests = **Low Concern**	3 tests per 5,000 ft² = **Medium Concern** 5+ tests per 5,000 ft² = **Low Concern**
Well and Borehole Permeameter Methods (must be **accompanied by bore logs to be suitable for design phase)**	2 tests = **Medium Concern** 3+ tests = **Low Concern**	3 tests = **Medium Concern** 4+ tests = **Low Concern**	3 tests per 5,000 ft² = **Medium Concern** 5+ tests per 5,000 ft² = **Low Concern**
Mapping or soil texture methods	Not Acceptable for Full Infiltration Design Phase		

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 planning feasibility determinations, mapped conditions must be supplemented with available data from the site (e.g., soil borings, observed soil textures, biological indicators). For planning feasibility, the presence of C or 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. For the purposes of this manual, saturated hydraulic conductivity and infiltration rate can be assumed to be equal.

D.3.1.3 Cone Penetrometer Testing and Correlations to Infiltration Rate

Hydraulic conductivity can also be estimated indirectly from cone penetrometer test (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. For the purposes of this manual, saturated hydraulic conductivity and infiltration rate can be assumed to be equal.

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 percolation rate. Measured percolation rate shall be converted to an infiltration rate using the Porchet method (Appendix D.3.4).

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 allowed to drain for one hour (2 hours for slower soils), while measuring the rate at which the water level drops. The test is then repeated until successive trials yield a result with less than a 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 infiltration rate 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, 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.

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 and the rate at which mounding dissipates (i.e., the capacity of the infiltration receptor). Finally, the added effort and cost of isolating the 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 technically 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 similar 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), 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 the 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 above 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. The 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 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 pilot infiltration test (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 (Appendix D.3.4) 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.

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 in 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 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 (Appendix D.3.4).

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.3.4 Percolation Rate Conversion Example

Measured percolation rate should be converted to an infiltration rate using the Porchet method (aka Inverse Borehole Method). See example below for the conversion.

Given:

- Time interval, Δt = 10 minutes
- Initial depth to water, D_o = 12.25 inches
- Final depth to water, D_f = 13.75 inches
- Total depth of test hole, D_T = 60 inches
- Test hole radius[1], r = 4 inches

Required:

- Determine the tested infiltration rate based on Porchet's method.

Solution:

1. Solve for the height of water at the beginning of the selected time interval, H_o:

$$H_o = D_T - D_o = 60 - 12.25 = 47.75\ inches$$

2. Solve for the height of water at the end of the selected time interval, H_f:

$$H_f = D_T - D_f = 60 - 13.75 = 46.25\ inches$$

3. Solve for the change in height of water over the selected time interval, ΔH:

$$\Delta H = H_o - H_f = 47.75 - 46.25 = 1.50\ inches$$

4. Calculate the average head over the selected time interval, H_{avg}:

$$H_{avg} = \frac{H_o + H_f}{2} = \frac{47.75 + 46.25}{2} = 47.00\ inches$$

5. Calculate the tested infiltration rate, I_t, using the following equation:

$$I_t = \frac{\Delta H(60r)}{\Delta t(r + 2H_{avg})} = \frac{(1.50\ in)\left(60\frac{min}{hr}\right)(4\ in)}{(10\ \text{min})\big((4\ \text{in}) + 2(47\ \text{in})\big)} = 0.37\ in/hr$$

Notes:

[1]The equivalent radius should be determined for rectangular holes based on the area of the rectangular test hole (i.e., $r=(A/\pi)^{0.5}$)

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 density. 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 is the downward entry of water into the soil. The velocity at which water enters the soil is infiltration rate. Infiltration rate is typically expressed in inches per hour. For the purposes of this manual, saturated hydraulic conductivity and infiltration rate can be assumed to be equal. 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

<u>Cut Conditions</u>***:*** 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, <u>how can the proposed infiltration surface be tested to establish a design infiltration rate prior to beginning excavation?</u> 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, and 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 apply higher factors of safety to borehole methods to account for the inherent uncertainty in these measurements and conversions.

Fill Conditions*:* Materials that are placed to construct grade are referred to as fill. Mechanically placed fill soil constructed in accordance with current standards is referred to as engineered compacted fill or structural fill. Per current standards, the placement and compaction of the fill soil is monitored and tested for quality assurance, and reported in an "as-graded" geotechnical report. Mechanically placed fill constructed prior to the current standards may or may not have been properly documented. Suitability of these fills for an intended use must be investigated by a geotechnical professional. Fill materials have also been placed locally that are not constructed in accordance with any standard and without any quality control. These fills soils are referred to as undocumented fill or as an uncontrolled embankment.

Infiltration rates and subsurface water flow pathways in fill soils can vary based on the soil properties, placement, and compaction of the fill. Select grading using soils with uniform properties can result in fills with predictable infiltration characteristics. More commonly, however, soils from different sources are mixed and/or stratified resulting in unpredictable infiltration characteristics and subsurface flow pathways.

If the bottom of a BMP (infiltration surface) is proposed to be located in a planned 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 5 feet of fill, how could one reasonably establish an infiltration rate prior to the fill being placed?

Where possible, infiltration BMPs on planned fill materials 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, placement of fill material with heavy equipment may 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 planned fill 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 or selective grading 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 shall be involved in decision making whenever infiltration is proposed in the vicinity of engineered compacted fill supporting structures or improvements so that potential impacts of infiltration can be evaluated. No full infiltration or partial infiltration BMPs shall be used in existing fills greater than 5 feet thick unless approved by the project geotechnical engineer. In fills 5 feet or less, full infiltration or partial infiltration may reasonably be achieved beneath fill. Full or partial Infiltration BMPs proposed within fills 5 feet or less must be evaluated by a geotechnical professional.

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 conduct 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:

Equation D.4-1: Measured Infiltration Adjustment

$$K_{Typical} = K_{Test} \times \left(\frac{\mu_{Test}}{\mu_{Typical}} \right)$$

where:

$K_{Typical}$	=	the typical infiltration rate expected at typical temperatures when rainfall occurs
K_{Test}	=	the infiltration rate measured or estimated under the conditions of the test
$\mu_{Typical}$	=	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 for full infiltration BMPs:

- For the design phase, in situ infiltration testing shall be conducted at a minimum of two locations within 50-feet of each proposed storm water infiltration BMP.
- In situ infiltration testing shall be conducted using an approved method listed in Table D.3-1
- For the design phase, 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

Should I use a factor of safety for design infiltration rate?

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 required for full infiltration. This section presents a recommended thought process for selecting a safety factor for full infiltration systems. 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. 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 (Form I-9), 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 for design phase for full infiltration BMPs. A factor of safety of 2 must be used for partial infiltration BMPs. Tables D.5-1 and D.5-2 assign point values to design considerations; the values are entered into Worksheet D.5-1 (Form I-9), 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 for full infiltration BMPs during the design phase. 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 the first factor in Table D.5-2 by 0.5, the remaining two factors in Table D.5-2 by 0.25 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:

- 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 – sites 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 Full Infiltration Facility Safety Factors

Consideration	High Concern – 3 points	Medium Concern – 2 points	Low Concern – 1 point
Assessment methods	Refer to Table D.3-2 for guidance related to selecting levels of concern based on testing methods, test replicates, and infiltration BMP size.		
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

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 on 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
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 for full infiltration systems 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. It is also possible that some facilities that were deemed feasible during full infiltration screening (Affirmative response to Criteria 1 in Worksheet C.4-1) may be deemed infeasible during design phase investigations. Clearly, numbers toward the upper end of this range will make all but the best locations prohibitive in land area, cost, and feasibility.

In order to make full infiltration 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 through 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.

Partial infiltration BMPs shall use a factor of safety of 2 for both the feasibility screening and design phase rather than a factor of safety determined using the method below. Partial infiltration BMPs are less sensitive and more resilient to uncertainties in true infiltration because water that does not infiltrate into underlying soils is discharged after being treated through bioretention soil media.

Summary of factor of safety selection:

- **During Planning Phase**: A factor of safety of 2.0 must be used to estimate the infiltration rate to categorize the infiltration feasibility condition of the DMA (when completing Worksheet C.4-1: Form I-8) and to estimate the percentage of volume reduction required when the DMA is classified as “Partial Infiltration Condition”.
- **During Design Phase**: During the design phase, Worksheet D.5-1: Form I-9 must be used to calculate the factor of safety and design infiltration rate to design full infiltration BMPs. If the calculated combined factor of safety is less than 2, then a safety factor of 2 must be used to calculate the design infiltration rate. Partial infiltration BMP designs shall use a factor of safety of 2 for the design phase.

Note: If the observed infiltration rate is greater than or equal to 1 inches/hr. and the design infiltration rate calculated using Worksheet D.5-1 is less than or equal to 0.5 inches/hr. then the applicant may choose to implement partial infiltration BMPs.

Worksheet D.5-1: Factor of Safety and Design Infiltration Rate Worksheet for Full Infiltration Designs

Factor of Safety and Design Infiltration Rate Worksheet			Worksheet D.5-1: Form I-9		
Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) p = w x 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, $S_{total} = S_A \times S_B$ [Minimum of 2 and Maximum of 9]					
Observed Infiltration Rate, inch/hr., $K_{observed}$ (corrected for test-specific bias) Note: This worksheet is only applicable when the observed infiltration rate is greater than or equal to 1 inch/hr.					
Design Infiltration Rate, in/hr., $K_{design} = K_{observed} / S_{total}$ Note: If the estimated design infiltration rate is less than or equal to 0.5 inch/hr. then the applicant may choose to implement partial infiltration BMPs.					
Supporting Data					
Briefly describe infiltration test and provide reference to test forms:					

Note: Worksheet D.5-1: Form I-9 is only applicable to design BMPs in "full infiltration condition". This form is not applicable for categorization of infiltration feasibility (Worksheet C.4-1: Form I-8) and/or for designing BMPs in "partial infiltration condition" or "no infiltration condition".

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Appendix E

BMP Design Fact Sheets

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 SC-6A: Large Trash Generating Facilities SC-6B: Animal Facilities SC-6C: Plant Nurseries and Garden Centers SC-6D: Automotive-related Uses
Site Design	Site Design	SD-A: Trees SD-B: Impervious Area Dispersion SD-C: Green Roofs SD-D: Permeable Pavement (Site Design BMP) SD-E: Rain Barrels SD-F: Amended Soils
Retention	Harvest and Use	HU-1: Cistern
	Infiltration	INF-1: Infiltration Basins INF-2: Bioretention INF-3: Permeable Pavement (Pollutant Control) INF-4: Dry Wells
	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 for Bioretention/Biofiltration BMPs

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E.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.

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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
❑ **SC-A.** Onsite storm drain inlets ❑ Not Applicable	❑ Locations of inlets.	❑ Mark all inlets with the words "No Dumping! Flows to Bay" or similar.	❑ Maintain and periodically repaint or replace inlet markings. ❑ Provide storm water pollution prevention information to new site owners, lessees, or operators. ❑ See applicable operational BMPs in Fact Sheet SC-44, "Drainage System Maintenance," in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com. ❑ Include the following in lease agreements: "Tenant shall not allow anyone to discharge anything to storm drains or to store or deposit materials so as to create a potential discharge to storm drains."

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
❑ **SC-B**. Interior floor drains and elevator shaft sump pumps ❑ Not Applicable		❑ State that interior floor drains and elevator shaft sump pumps will be plumbed to sanitary sewer.	❑ Inspect and maintain drains to prevent blockages and overflow.
❑ **SC-C**. Interior parking garages ❑ Not Applicable		❑ State that parking garage floor drains will be plumbed to the sanitary sewer.	❑ Inspect and maintain drains to prevent blockages and overflow.
❑ **SC-D1**. Need for future indoor & structural pest control ❑ Not Applicable		❑ Note building design features that discourage entry of pests.	❑ Provide Integrated Pest Management information to owners, lessees, 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
❑ **SC-D2**. Landscape/ Outdoor Pesticide Use ❑ Not Applicable	❑ Show locations of existing trees or areas of shrubs and ground cover to be undisturbed and retained. ❑ Show self-retaining landscape areas, if any. ❑ Show storm water treatment facilities.	❑ State that final landscape plans will accomplish all of the following. ❑ Preserve existing drought tolerant trees, shrubs, and ground cover to the maximum extent possible. ❑ 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. ❑ Where landscaped areas are used to retain or detain storm water, specify plants that are tolerant of periodic saturated soil conditions. ❑ Consider using pest-resistant plants, especially adjacent to hardscape. ❑ To ensure successful establishment, select plants appropriate to site soils, slopes, climate, sun, wind, rain, land use, air movement, ecological consistency, and plant interactions.	❑ Maintain landscaping using minimum or no pesticides. ❑ See applicable operational BMPs in Fact Sheet SC-41, "Building and Grounds Maintenance," in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com. ❑ Provide IPM information to new owners, lessees 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
❑ **SC-E**. Pools, spas, ponds, decorative fountains, and other water features. ❑ Not Applicable	❑ Show location of water feature and a sanitary sewer cleanout in an accessible area within 10 feet.	❑ 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.	❑ See applicable operational BMPs in Fact Sheet SC-72, "Fountain and Pool Maintenance," in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com.
❑ **SC-F**. Food service ❑ Not Applicable	❑ 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. ❑ On the drawing, show a note that this drain will be connected to a grease interceptor before discharging to the sanitary sewer.	❑ Describe the location and features of the designated cleaning area. ❑ 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
❑ **SC-G**. Refuse areas ❑ Not Applicable	❑ 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. ❑ 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. ❑ Any drains from dumpsters, compactors, and tallow bin areas shall be connected to a grease removal device before discharge to sanitary sewer.	❑ State how site refuse will be handled and provide supporting detail to what is shown on plans. ❑ State that signs will be posted on or near dumpsters with the words "Do not dump hazardous materials here" or similar.	❑ 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
❑ **SC-H**. Industrial processes. ❑ Not Applicable	❑ Show process area.	❑ 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."	❑ See Fact Sheet SC-10, "Non-Stormwater Discharges" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com.
❑ **SC-I**. Outdoor storage of equipment or materials. (See rows J and K for source control measures for vehicle cleaning, repair, and maintenance.) ❑ Not Applicable	❑ 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. ❑ 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. ❑ 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.	❑ 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: ▪ 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	❑ 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
❑ **SC-J**. Vehicle and Equipment Cleaning ❑ Not Applicable	❑ Show on drawings as appropriate: (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. (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). (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. (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.	❑ If a car wash area is not provided, describe measures taken to discourage onsite car washing and explain how these will be enforced.	Describe operational measures to implement the following (if applicable): ❑ Washwater from vehicle and equipment washing operations shall not be discharged to the storm drain system. ❑ Car dealerships and similar may rinse cars with water only. ❑ 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
❑ **SC-K**. Vehicle/Equipment Repair and Maintenance ❑ Not Applicable	❑ 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. ❑ 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. ❑ 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.	❑ State that no vehicle repair or maintenance will be done outdoors, or else describe the required features of the outdoor work area. ❑ 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. ❑ 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.	In the report, note that all of the following restrictions apply to use the site: ❑ 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. ❑ 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. ❑ 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
❑ **SC-L**. Fuel Dispensing Areas ❑ Not Applicable	❑ 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. ❑ 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 area1.] The canopy [or cover] shall not drain onto the fueling area.		❑ The property owner shall dry sweep the fueling area routinely. ❑ See the Business Guide Sheet, "Automotive Service—Service Stations" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com.

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
SC-M. Loading Docks ❑ Not Applicable	❑ 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. ❑ 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. ❑ Provide a roof overhang over the loading area or install door skirts (cowling) at each bay that enclose the end of the trailer.		❑ Move loaded and unloaded items indoors as soon as possible. ❑ 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
❑ **SC-N**. Fire Sprinkler Test Water ❑ Not Applicable		❑ Provide a means to drain fire sprinkler test water to the sanitary sewer.	❑ See the note in Fact Sheet SC-41, "Building and Grounds Maintenance," in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com.
SC-O. Miscellaneous Drain or Wash Water ❑ Boiler drain lines ❑ Condensate drain lines ❑ Rooftop equipment ❑ Drainage sumps ❑ Roofing, gutters, and trim ❑ Not Applicable		❑ Boiler drain lines shall be directly or indirectly connected to the sanitary sewer system and may not discharge to the storm drain system. ❑ 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. ❑ Rooftop mounted equipment with potential to produce pollutants shall be roofed and/or have secondary containment. ❑ Any drainage sumps onsite shall feature a sediment sump to reduce the quantity of sediment in pumped water. ❑ 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
❑ **SC-P**. Plazas, sidewalks, and parking lots. ❑ Not Applicable			❑ 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 SC-6A Large Trash Generating Facilities

MS4 Permit Category
Source Control

BMP Manual Category
Source Control

Applicable Performance Standard
Source Control

Primary Benefits
Source Control

Description

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 to nearby storm drain inlets, channels, and/or creeks. Trash generating facilities that generate large amounts of trash require special attention to protect trash storage areas from rainfall, run-on, runoff, and wind dispersal. Large trash generating, or trash build-up areas, include but are not limited to restaurants, supermarkets, "big box" retail stores serving food, and pet stores. The City Engineer may designate additional facilities if they are likely to generate or accumulate large quantities of trash.

Design Adaptations for Project Goals

Source control BMPs reduce the amount of pollutants that are generated. This fact sheet contains details on the additional measures required to prevent or reduce pollutants in storm water runoff associated with trash storage and handling for large trash generating facilities. The requirements presented here are in addition to the requirements of Chapter 4.2.5 which requires all development projects to protect trash storage areas from rainfall, run-on, runoff, and wind dispersal:

- **Areas where trash containers are stored must be enclosed on four sides to prevent off-site transport of trash**. Four-sided trash enclosures typically consist of three walled sides and one gated side. Trash enclosures limit the potential for trash to pollute storm water runoff by limiting mobilization mechanisms (runoff, run-on, and wind dispersal).
- **Trash enclosures must be covered to minimize direct precipitation and prevent rainfall from entering enclosures.** Structural overhead covers are required as container lids are often left open.
- **Enclosures must be hydraulically isolated from surrounding areas.** Slabs shall be sloped such that any leaked materials will be contained within the enclosure. Drains must be

provided that capture and direct potential leaks to the sanitary sewer or appropriate BMPs. Divert runoff from surrounding areas away from the enclosure to prevent contamination and dispersion of collected materials.

- **Owner must provide BMP storm water training to employees.** Employee participation is required to ensure that enclosures are properly maintained and kept clean.

Design Guidelines

All trash shall be stored in weather-protected receptacles/bins and recyclable materials shall be protected against adverse weather conditions, which might render the collected materials unmarketable. Trash enclosure dimensions will vary based on projected usage and the following information is offered as an aid in planning new projects. Businesses that use dumpsters must design the enclosure to accommodate three-yard containers at a minimum. The tenants may use any dumpster size that is appropriate for their needs, but the enclosure must be able to accommodate different tenants with varying waste production, including any recycling requirements. The design of the enclosure must be signed and sealed by a California licensed engineer. Substantiating structural calculations may be required. The location and design of the enclosure will require review and approval by the City Engineer. Building permits may be required.

The following recommendations for typical bin sizes are adopted from the City of Escondido trash enclosure guidelines. The following bin/container measurements are approximate (add 8" to width for side pockets):

Typical Trash Bin Sizes

Size	Width	Depth	Height (front)	Height (back)
3 cubic yard	72" bin, 81" plus lid	43"	42"	70"
4 cubic yard	72" bin, 81" plus lid	56"	72"	72"

Filled weight should not exceed 1,000 pounds.

Design Criteria

1. Enclosures shall be structurally strong and constructed of reinforced masonry block or wood panels/boards. Structural requirements for enclosures are detailed in the City of San Diego specifications for Wood and Masonry Fences. http://www.sandiego.gov/development-services/pdf/industry/infobulletin/ib223.pdf
2. The enclosure should be constructed to the following minimum inside dimensions to accommodate three cubic-yard dumpsters (larger enclosures may be necessary to accommodate additional trash bins, recycling bins, and accessibility):

No. of Bins	Loading	Width	Depth	Height
One	Front	8'	6'	6'
One	Side	7.5'	8'	6'
Two	Front	16'	6'	6'
Two	Side	8'	16'	6'

3. The enclosure slab should be designed to keep storm water drainage out of the enclosure area, typically sloped at 0.5%. Slab construction specifications will vary according to methods of construction, but should be at least 4 inches of reinforced concrete.

4. Sturdy gates/doors shall be installed on all enclosures. Gates should not be mounted directly onto the block wall or inside of enclosure. The enclosure should include hardware to secure the gate's doors both open and closed (i.e., cane bolt w/sleeve and latch between doors and sleeve in pavement).
5. To prevent trash enclosures from contributing to storm water runoff pollution, all enclosures must be fitted with a roof deigned to drain into on-site landscape areas (where necessary) and/or to appropriate BMPs. The roof must provide sufficient clearance to allow the dumpster lid to open to the 90 degree position.
6. Enclosure roofs not conforming to City specifications for Patio Covers may require a building permit. Generally roofs not more than 12 feet in height above grade and constructed with conventional light-frame wood construction are considered acceptable. The use of metal roofs is not recommended as they can act as a source of pollutants.
   http://www.sandiego.gov/development-services/pdf/industry/infobulletin/ib206.pdf
7. Dumpsters associated with food establishments shall be sized per County Health Department requirements for wash down. Drains shall be connected to the business grease interceptor.

Example isometric view and plan view of an allowable trash enclosure facility is presented below. The project applicant may be allowed to use an alternative trash enclosure design that might be more appropriate for a project site if the alternative design is approved by the City Engineer.

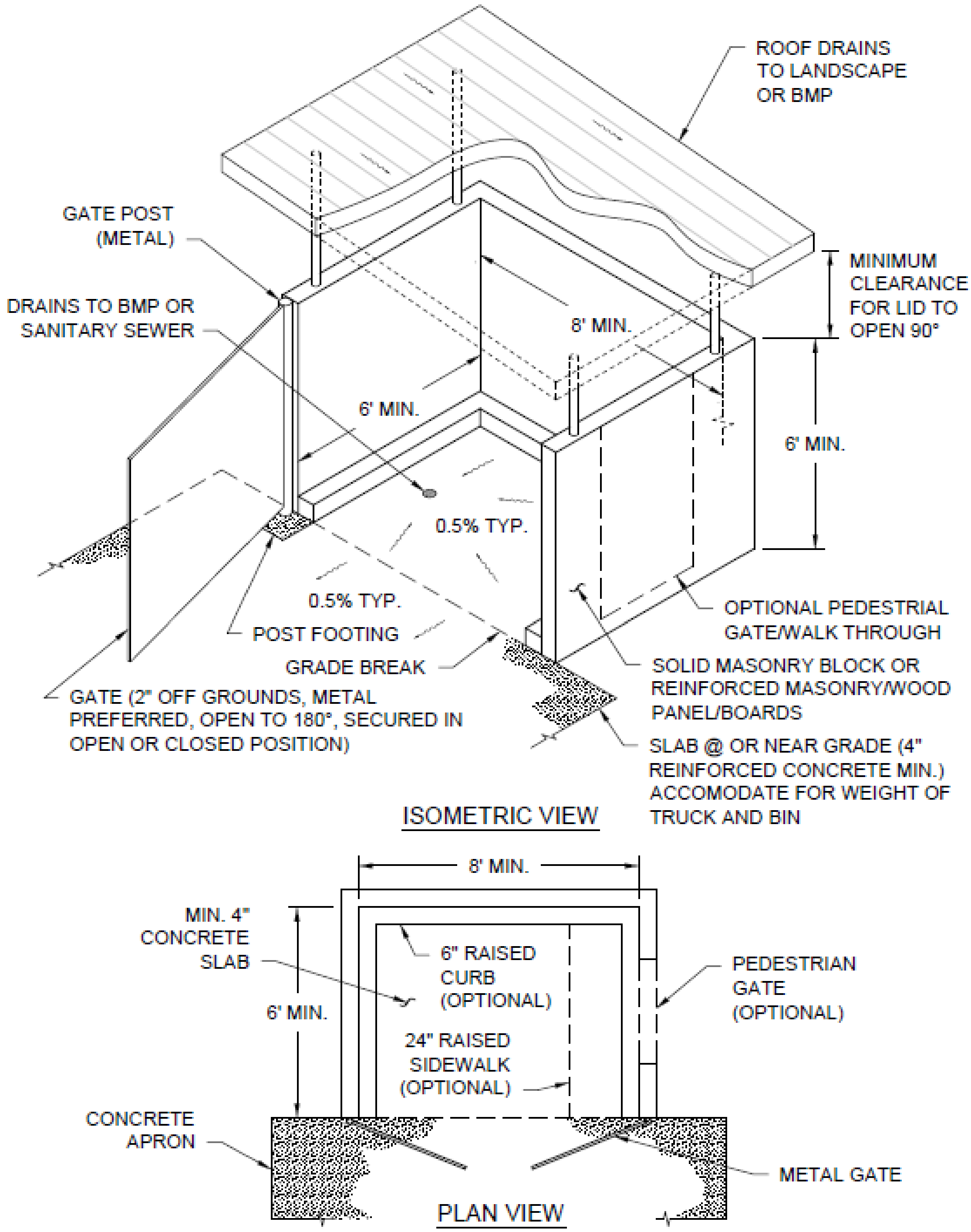

Figure E.2-1 : Typical Isometric and Plan View of a Trash Enclosure BMP

E.3 SC-6B Animal Facilities

MS4 Permit Category
Source Control

BMP Manual Category
Source Control
Applicable Performance Standard
Source Control
Primary Benefits
Source Control

Description

Animal facilities have an elevated potential for bacterial loading. If animal fecal material comes into contact with storm water, the storm water can become polluted. Animal facilities include but are not limited to animal shelters, dog daycare centers, veterinary clinics, groomers, pet care stores, and breeding, boarding, and training facilities. The City Engineer may designate additional facilities where animal fecal material is likely to be found.

Design Adaptations for Project Goals

Source control BMPs reduce the amount of pollutants that are generated. This fact sheet contains details on the additional measures required to prevent or reduce pollutants in storm water runoff associated with animal facilities. The requirements presented here are in addition to the source control requirements for all projects:

- **Dry weather runoff must be controlled**. Dry weather runoff from hosed off areas as part of animal facility operations must not drain to the MS4. Dry weather flows should be retained on-site through implementation of BMPs or collected and discharged to the sanitary sewer.
- **Outdoor activity areas must be identified on site plans.** Plan reviewers must be able to ensure that runoff from these areas is either diverted to the sanitary sewer or directed to appropriate treatment BMPs. On-site inspection of facilities, grading, and drainage may be required.
- **Trash enclosures within animal facilities must be covered to minimize direct precipitation and prevent rainfall from entering enclosures.** Structural overhead covers are required as container lids are often left open.

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E.4 SC-6C Plant Nurseries and Garden Centers

MS4 Permit Category
Source Control
BMP Manual Category
Source Control
Applicable Performance Standard
Source Control
Primary Benefits
Source Control

Description

Storm water runoff from plant nurseries and garden centers has an elevated risk of being polluted by organics, nutrients, and/or pesticides. Nurseries and garden centers require special attention to protect against these elevated risks. Plant nurseries and garden centers include but are not limited to commercial facilities that grow, distribute, sell, or store plants and plant material. The City Engineer may designate additional facilities if they are likely to be a source of organics, nutrients or pesticides.

Design Adaptations for Project Goals

Source control BMPs reduce the amount of pollutants that are generated. This fact sheet contains details on the additional measures required to prevent or reduce pollutants in storm water runoff associated with plant nurseries or garden center facilities. The requirements presented here are in addition to the requirements of Chapter 4.2 which require all development projects to avoid and reduce pollutants in storm water runoff:

- **Owner must provide BMP storm water training to appropriate employees**. Employee participation is required to ensure that source controls are properly maintained and behavioral BMPs are followed.
- **Eliminate overwatering and overspraying of plant**s. Overwatering and overspraying of plants increases dry weather flows and pollutant loading, and wastes water. Delivery systems and schedules should account for different plant types and containers.
- **Discharges from outdoor watering areas must be controlled**. Regular runoff from outdoor watering can contribute un-authorized dry weather flows to the MS4 (e.g., runoff from watering the plants at garden centers). Runoff water is also likely to be polluted by potting soil mixes and plants that contain fertilizers and/or pesticides. So, regular runoff should be treated and/or retained on-site through BMPs or discharged to the sanitary sewer.

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E.5 SC-6D Automotive Facilities

MS4 Permit Category

Source Control

BMP Manual Category

Source Control

Applicable Performance Standard

Source Control

Primary Benefits

Source Control

Description

Storm water runoff from automotive facilities can pollute storm water runoff with oils and grease, metals, and other pollutants. Pollutants sources can include maintenance and repair activities, outside storage areas, liquid material storage, and others. Automotive facilities require additional measures because of the potential impact of pollutants. Automotive facilities include but are not limited to facilities that perform maintenance or repair of vehicles, vehicle washing facilities, and retail gasoline outlets. The City Engineer may designate additional facilities if they are likely sources of storm water pollutants.

Design Adaptations for Project Goals

Source control BMPs reduce the amount of pollutants that are generated. This fact sheet contains details on the additional measures required to prevent or reduce pollutants in storm water runoff associated with automotive facilities. The requirements presented here are in addition to the requirements of Chapter 4.2 which require all development projects avoid and reduce pollutants in storm water runoff:

- **Auto repair, maintenance activities, fueling, and vehicle washing must be conducted in covered areas**. Activity areas must be protected from precipitation by permanent canopy or roof structures. Covers 10 feet high or less should have a minimum overhang of 3 feet on each side, covers higher than 10 feet should have a minimum overhang of 5 feet on each side. Overhang should be measured from the perimeter of the hydraulically isolated activity area.
- **Hydraulically isolate activity areas**. Activity areas should be protected from run-on that can mobilize pollutants and pollute uncontaminated storm water through the use of grading, berms, or drains. Direct drainage from the hydraulically isolated area to an approved sanitary sewer or a BMP.
- **Pave activity areas with hydraulic concrete or appropriately sealed asphalt cement**. Unpaved activity areas could contaminate ground water. So all activity area, including area for

fueling vehicles or equipment shall be paved with hydraulic concrete. If the area is already paved with asphalt, apply an asphalt sealant to the pavement surface. Maintain the paved surface to prevent gaps and cracks.

- **Provide sedimentation manhole with outlet**. Automotive facilities discharging to the sanitary sewer must follow standards set by the City Industrial Wastewater Control Program for the outlet design. See Appendix S: Sump/Clarifier Maintenance Standards found here for the outlet design:
    - http://www.sandiego.gov/mwwd/environment/iwcp/other.shtml
- **Provide appropriate oil controls**. All equipment and vehicle washing activity areas should include oil controls. On-site wash recycling systems may be used for oil control if they meet applicable effluent discharge limits for the sanitary sewer.
- **Identify auto-related usage areas on site plans and describe activities and drainage**. Plan checkers must be satisfied that grading and drainage will prevent contact between pollutants and storm water. Drains within the facilities must be connected to the sanitary sewer or a BMP. Verification may be required.
- **Owner must provide BMP storm water training to employees**. Employee participation is required to ensure that activity areas are properly maintained and kept clean.

E.6 SD-A Tree

Source: County of San Diego LID Manual

MS4 Permit Category
Site Design

Manual Category
Site Design

Applicable Performance Standard
Site Design

Primary Benefits
Volume Reduction

Description

Trees planted to intercept rainfall and runoff can be used as storm water management measure that provide additional benefits beyond those typically associated with trees, (i.e. 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 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
- Staking and planting requirements (see Standard Drawing: SDL-101)

- Optional suspended pavement design to provide structural support for adjacent pavement without requiring compaction of underlying layers
- As needed root barrier devices; 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 damage.
- Optional tree grates; maximize available space for pedestrian circulation and protect tree roots from compaction.
- Optional shallow surface depression for ponding of excess runoff
- Optional planter box drain

Design Adaptations for Project Goals

Storm water volume credits are only allowed for new trees implemented within the project footprint.

Site design BMP to provide incidental treatment. Trees primarily functions as site design BMPs for incidental treatment. Benefits from trees as a site design BMP are accounted by adjustment factors presented in **Appendix B.2.2**. 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 ft^3).

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 ft^3 from a single tree). For this option to be approved by the City Engineer, applicant is required to do infiltration feasibility screening (Worksheet C.4-1/Form I-8) and provide calculations supporting the amount of credit claimed from implementing trees within the project footprint. The City Engineer 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 ft^3 from a single tree).

Design Criteria and Considerations

Trees must meet the following design criteria and considerations and the requirements of Standard Drawing SDL-101 where applicable. Deviations from the below criteria may be approved at the discretion of the City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
□	Tree species is appropriately chosen for the development (private or public). For public rights-of-ways, local planning guidelines and zoning provisions for the permissible species and placement of trees are consulted.	Proper tree placement and species selection minimizes problems such as pavement damage by surface roots and poor growth.

<table>
<tr><th></th><th>Siting and Design</th><th>Intent/Rationale</th></tr>
<tr><td>□</td><td>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.
Unless exemption is granted by the City Engineer the following minimum tree separation distance (from the tree trunk) is followed
<table>
<tr><th>Improvement</th><th>Minimum distance to Tree</th></tr>
<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>
</table></td><td>Roadway safety for both vehicular and pedestrian traffic is a key consideration for placement along public streets.</td></tr>
<tr><td>□</td><td>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.</td><td>Tree growth can damage utilities and overhead wires resulting in service interruptions. Protecting utilities routed through the planter prevents damage and service interruptions.</td></tr>
<tr><td>□</td><td>Suspended pavement design was developed where appropriate to minimize soil compaction and improve infiltration and filtration capabilities.
Suspended pavement was constructed with an approved structural cell.</td><td>Suspended pavement designs provide structural support without compaction of the underlying layers, thereby promoting tree growth.
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.</td></tr>
<tr><td>□</td><td>A minimum soil volume of 2 cubic feet per square foot of canopy projection area is provided for each tree. Canopy projection area is the ground area beneath the tree, measured at the mature tree drip line.

Applicant uses soil amendments (SD-F), as necessary. Soil amendments result in healthier plant growth, reduced irrigation demands, and reduced need for fertilization and maintenance</td><td>The minimum soil volume is required to support a healthy tree.

A lower amount of soil volume may be allowed if certified by a landscape architect or agronomist that the installed soil volume will be adequate for health tree growth. The retention credit from the tree must be directly proportional to the soil volume installed for the tree.</td></tr>
</table>

	Siting and Design	Intent/Rationale
☐	DCV from the tributary area draining to the tree is equal to or greater than the tree credit volume	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.
☐	Inlet opening to the tree that is at least 18 inches wide. A minimum 2 inch drop in grade from the inlet to the finish grade of the tree. Grated inlets are allowed for pedestrian circulation. Grates need to be ADA compliant and have sufficient slip resistance.	Design requirement to ensure that the runoff from the tributary area is not bypassed. Different inlet openings and drops in grade may be allowed at the discretion of the City Engineer 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 volume must be reduced proportionately.

Conceptual Design and Sizing Approach for Site Design and Storm Water Pollutant Control

- Determine the areas where trees can be used in the site design to achieve incidental treatment. Trees reduce runoff volumes from the site. Refer to **Appendix B.2.2**. Document the proposed tree locations in the SWQMP.
- 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:
    - Delineate the DMA (tributary area) to the tree and calculate the associated DCV.
    - 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.
        - For example, 0.5 acre drains to the tree and the associated DCV is 820 ft^3. The required diversion flow rate is 0.10 ft^3/s, but only an inlet that can divert 0.05 ft^3/s could be installed.
        - Then the effective DCV draining to the tree = 820 ft^3 * (0.05/0.10) = 420 ft^3
    - Estimate the amount of storm water treated by the tree by summing the following:
        - Evapotranspiration credit of 0.1 * amount of soil volume installed; and
        - Infiltration credit calculated using sizing procedures in **Appendix B.4**.

E.7 SD-B Impervious Area Dispersion

Photo Credit: Orange County Technical Guidance Document

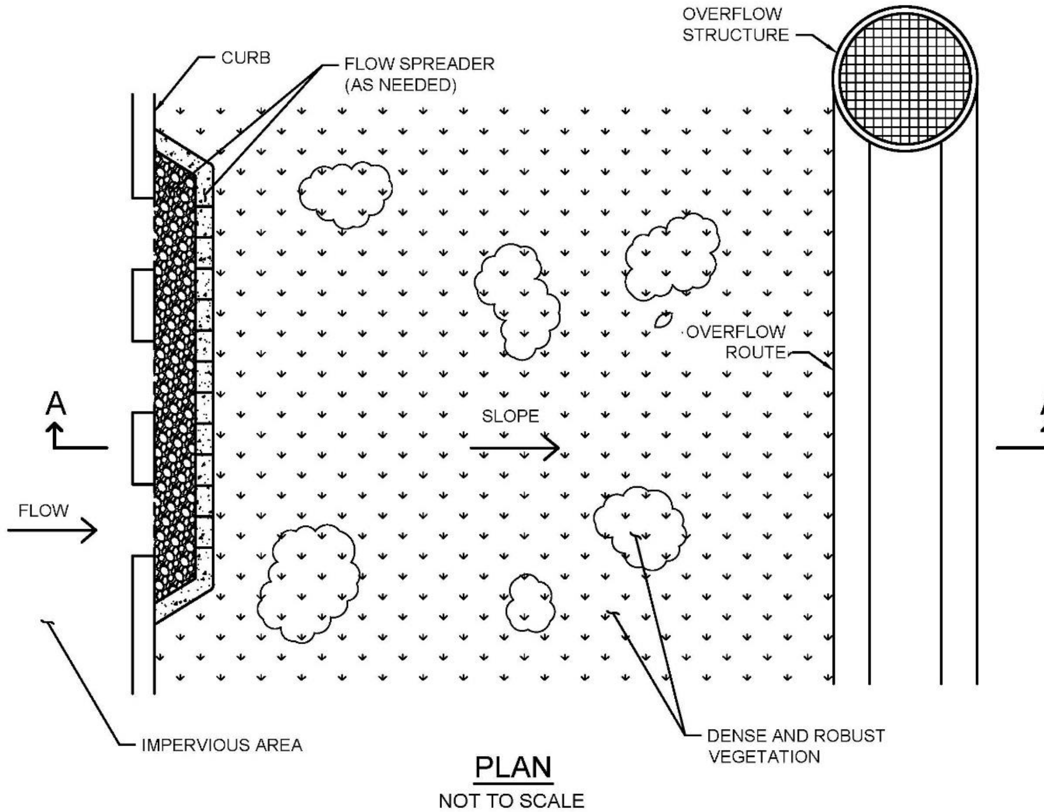
MS4 Permit Category
Site Design
Manual Category
Site Design
Applicable Performance Criteria
Site Design
Primary Benefits
Volume Reduction Peak Flow Attenuation

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 (SD-F fact sheet) 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



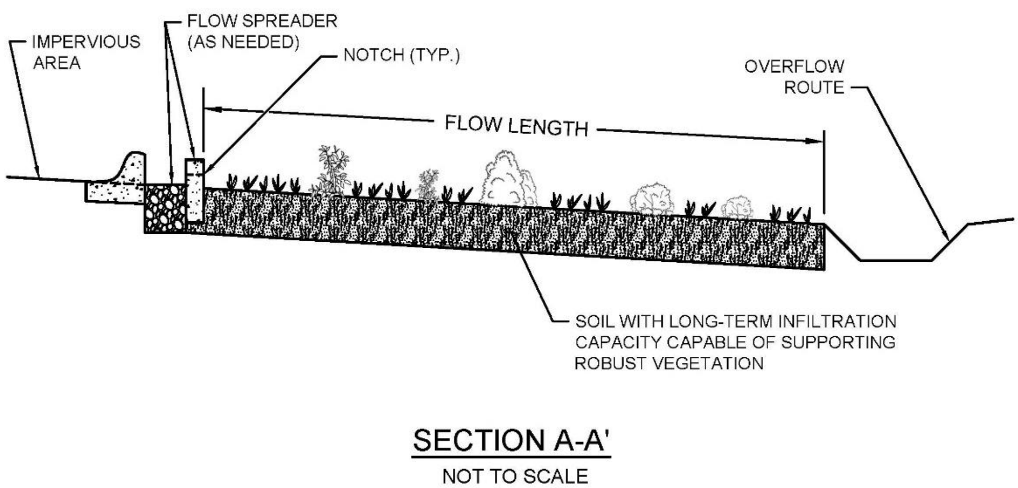


Figure E.7-1 : Typical Plan and Section view of an Impervious Area Dispersion BMP

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	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.
☐	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.
☐	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.
Inflow velocities		
☐	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.
Dedication		
☐	Dispersion areas must be owned by the project owner and 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.
Vegetation		
☐	Dispersion typically requires dense and robust vegetation for proper function. Drought tolerant species should be selected to minimize irrigation needs.	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”. DMA is 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
4. If the top 12 inches uses amended soils in accordance with SD-F, the runoff coefficient (c-factor) for the amended area is 0.1

Conceptual Design and Sizing Approach for Storm Water Pollutant Treatment and Flow Control

DMA is considered to meet both pollutant control and hydromodification flow control requirements if **ALL** of the following criteria are met:

1. All the impervious area within the DMA discharges to the pervious area before the runoff discharges from the DMA.
2. At a minimum, the top 11 inches of the pervious area uses amended soils in accordance with SD-F fact sheet and the pervious area also meets the requirements for dispersion (e.g. slope, inflow velocities, etc.) in SD-B fact sheet.
3. The impervious to pervious area ratio is 1:1.

E.8 SD-C Green Roofs

Location: County of San Diego Operations Center, San Diego, California

MS4 Permit Category
Site Design
Manual Category
Site Design
Applicable Performance Standard
Site Design
Primary Benefits
Volume Reduction Peak Flow Attenuation

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

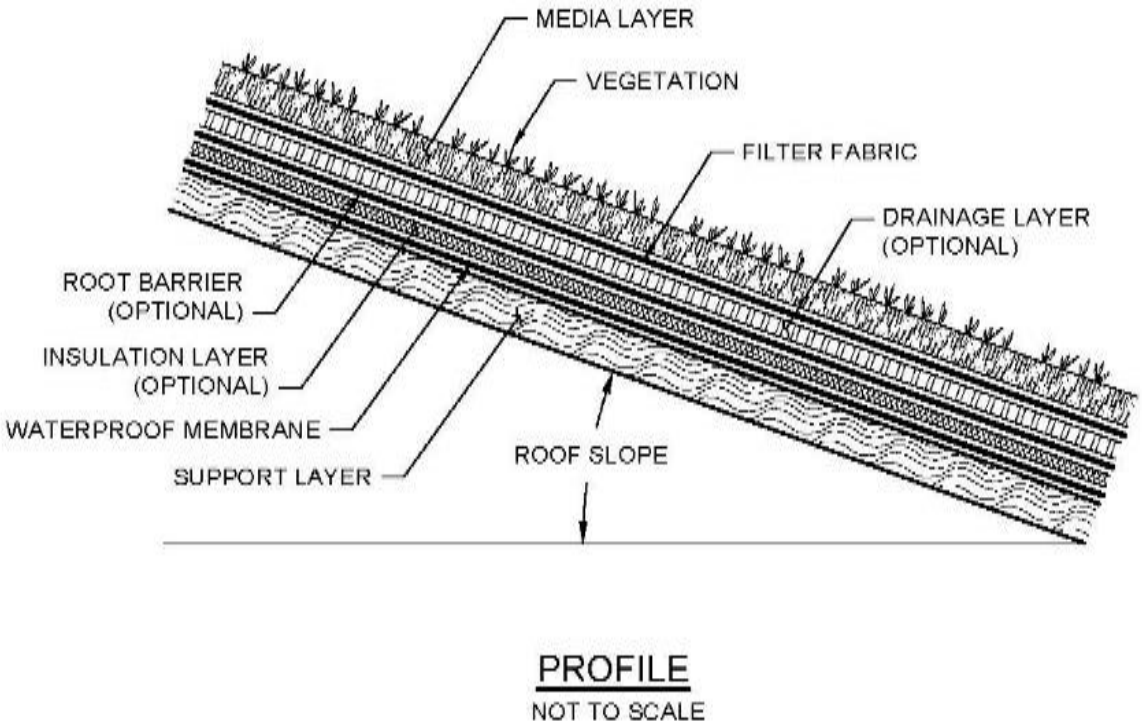


Figure E.8-1 : Typical Profile of a Green Roof BMP

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	Roof slope is ≤ 40% (Roofs that are ≤ 20% are preferred).	Steep roof slopes increase project complexity and requires supplemental anchoring.
☐	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.
☐	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.

	Siting and Design	Intent/Rationale
☐	Green roof location and extent must meet fire safety provisions.	Green roof design must not negatively impact fire safety.
☐	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.
Vegetation		
☐	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.
☐	Vegetation is capable of covering ≥ 90% the roof surface.	Benefits of green roofs are greater with more surface vegetation.
☐	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.
☐	Vegetation is fire resistant.	Vegetation that will not burn easily decreases the chance for fire and harm to the building and occupants.
☐	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.
☐	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.
☐	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.
☐	A filter fabric is used to prevent migration of media fines through the system.	Migration of media can cause clogging of the drainage layer.
☐	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.
☐	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.

	Siting and Design	Intent/Rationale
☐	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.
☐	A waterproof membrane is used to prevent the roof runoff from vertically migrating and damaging the roofing material. A root barrier may be required to prevent roots from compromising the integrity of the membrane.	Water-damaged roof materials increase the risk of harm to the building and occupants.

Conceptual Design and Sizing Approach for Site Design

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. If a DMA only contains a green roof that is designed in accordance with this fact sheet, then it can be considered as a self-retaining DMA that meets the storm water pollutant control obligations.
3. If a green roof receives runon, then calculate the DCV for the DMA using **Appendix B.2**.

E.9 SD-D 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, or with storage greater than the 85th percentile depth below the 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.

Permeable pavements, when proposed as a site design BMP to reduce impervious area and/or DCV must meet the following conditions:

- Must not have an impermeable liner; and
- Slope must be less than or equal to 5%.

Conceptual Design and Sizing Approach for Site Design

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.

- Calculate the DCV per **Appendix B.2**, taking into account reduced runoff from permeable pavement areas.

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E.10 SD-E 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.

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

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.

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.

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E.11 SD-F Amended Soils

Photo Credit: Orange County Technical Guidance Document

MS4 Permit Category
Site Design
Manual Category
Site Design
Applicable Performance Standard
Site Design
Primary Benefits
Volume Reduction Peak Flow Attenuation

Description

Amended soils are soils whose physical, chemical, and biological characteristics have been altered from the natural condition to promote beneficial storm water characteristics. Amended soils shall be used as part of SD-B Impervious Area Dispersion, where applicable. Typical storm water management benefits associated with amended soils include:

- **Improved hydrologic characteristics**—amended soils can promote infiltration, decrease runoff rates and volumes, and more effectively filter pollutants from storm water runoff
- **Improved vegetation health**—amended soils provide greater moisture retention, and altered chemical and biological characteristics that can result in healthier plant growth, reduced irrigation demands, and reduced need for fertilization and maintenance
- **Reduced erosion**—amended soils produce healthier plant growth and reduced runoff which results in reduced soil erosion

Design Adaptations for Project Goals

Varying categories of soil amendments have different benefits and applications. Mulch is a soil amendment that is added at grade, rather than mixed into the soil. Mulch reduces evaporation and improves retention. Shavings and compost are common soil amendments that improve biological and chemical properties of the soil. Sand can be used as an amendment to improve the drainage rates of amended soils. Native soil samples may need to be analyzed by a lab to determine the specific soil amendments needed to achieve the desired infiltration, retention, and/or filtration rates.

Important Considerations

Maintenance: Annual maintenance may be required to determine reapplication requirements of amended soils. Amended soils should be regularly inspected for signs of compaction, waterlogging, and unhealthy vegetation.

Limitations: Not all amended soils have the same storm water benefits, the soil amendment used should be suited for the design purpose and design period of the amended area.

Design Criteria and Considerations

Soil amendments must meet the following design criteria and considerations. Deviations from the below criteria may be approved at the discretion of the City Engineer if appropriate:

	Siting and Design	Intent/Rationale
☐	When mulch is used as an amendment, it is applied at grade over all planting areas to a depth of 3".	Mulch should be applied on top and not mixed into underlying soils
☐	When shavings or compost is used as an amendment, it is rototilled into the native soil to a minimum depth of 6" (12 inches preferred).	If soil is not completely mixed the overall benefit will be reduced.
☐	Compost meets the criteria in Appendix F.3.1.2	If poor quality compost is used, it will have negative impact to water quality.
☐	Soil amendments are free of stones, stumps, roots, glass, plastic, metal, and other deleterious materials.	Large debris in amended soils can cause localized erosion. Trash/harmful materials can result in personal injury or contamination.
☐	Mixing of soils are done prior to planting	Soil mixing before planting results in a more homogeneous mixing and will reduce the stress on plants.
☐	Care is taken around existing trees and shrubs to prevent root damage during construction and soil amendment application.	Preservation of existing established vegetation is an important part of site design and erosion control.
☐	Soil amendments are applied at the end of construction	Soil amendments applied too soon in the construction process may become over compacted reducing effectiveness.
☐	Soil amendments are compatible with planned vegetation	The soil amendments impact the pH and salinity of the soil. Some plants have sensitive pH and/or salinity tolerance ranges.

Conceptual Design and Sizing Approach for Site Design

- When soil amendments are used a runoff factor of 0.1 can be used for DCV calculation for the amended area.
- Amended soils should be used as part of SD-B Impervious Area Dispersion, and to increase the retention volume in infiltration and biofiltration BMPs.

E.12 HU-1 Cistern

Photo Credit: Water Environment Research Foundation: WERF.org

MS4 Permit Category

Retention

Manual Category

Harvest and Use

Applicable Performance Standards

Pollutant Control
Flow Control

Primary Benefits

Volume Reduction
Peak Flow Attenuation

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

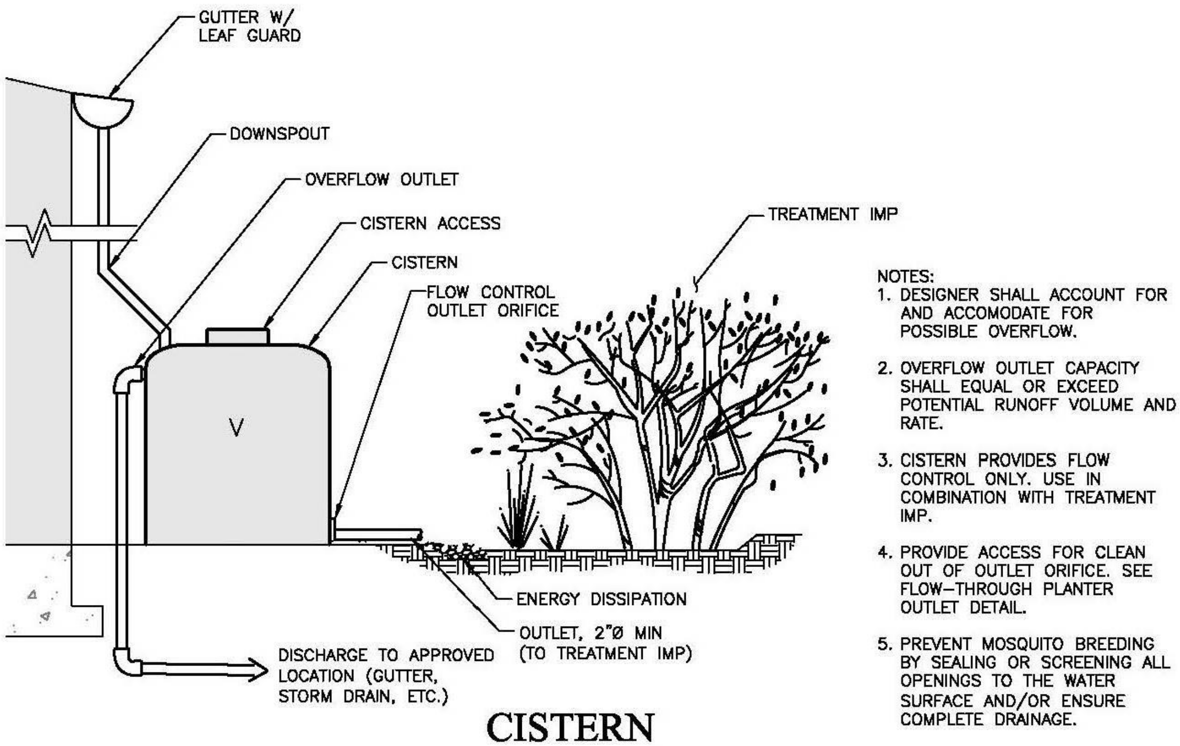

Figure E.12-1 : Typical Section View of a Cistern BMP

Source: 2012 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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	Cisterns are sized to detain the full DCV of contributing area and empty within 36 hours.	Draining the cistern makes the storage volume available to capture the next storm. The applicant has an option to use a different drawdown time if the volume of the facility is adjusted using the percent capture method in Appendix B.4.2. Drawdown time greater than 96 hours may require a vector management plan.
☐	Cisterns are fitted with a flow control device such as an orifice or a valve to limit outflow in accordance with drawdown time requirements.	Flow control provides flow attenuation benefits and limits cistern discharge to downstream facilities during storm events.
☐	Cisterns are designed to drain completely, leaving no standing water, and all entry points are fitted with traps or screens, or sealed.	Complete drainage and restricted entry prevents mosquito habitat.
☐	Leaf guards and/or screens are provided to prevent debris from accumulating in the cistern.	Leaves and organic debris can clog the outlet of the cistern.
☐	Access is provided for maintenance and the cistern outlets are accessible and designed to allow easy cleaning.	Properly functioning outlets are needed to maintain proper flow control in accordance with drawdown time requirements.
☐	Cisterns must be designed and sited such that overflow will be conveyed safely overland to the storm drain system or discharge point.	Safe overflow conveyance prevents flooding and damage of property.

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 drawdown/storage meets the pollutant control requirement. Refer to Appendix B for guidance.
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.13 INF-1 Infiltration Basin

Photo Credit:
http://www.stormwaterpartners.com/facilities/basin.html

MS4 Permit Category
Retention
Manual Category
Infiltration
Applicable Performance Standard
Pollutant Control Flow Control
Primary Benefits
Volume Reduction Peak Flow Attenuation

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

Recommended Siting Criteria

Siting Criteria	Intent/Rationale
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.

Siting Criteria	Intent/Rationale
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. Applicant must complete Worksheet C.4-1/Form I-8A; Worksheet C.4-2/Form I-8B and Worksheet C.4-3.

Example Schematic Design – Plan and Section View

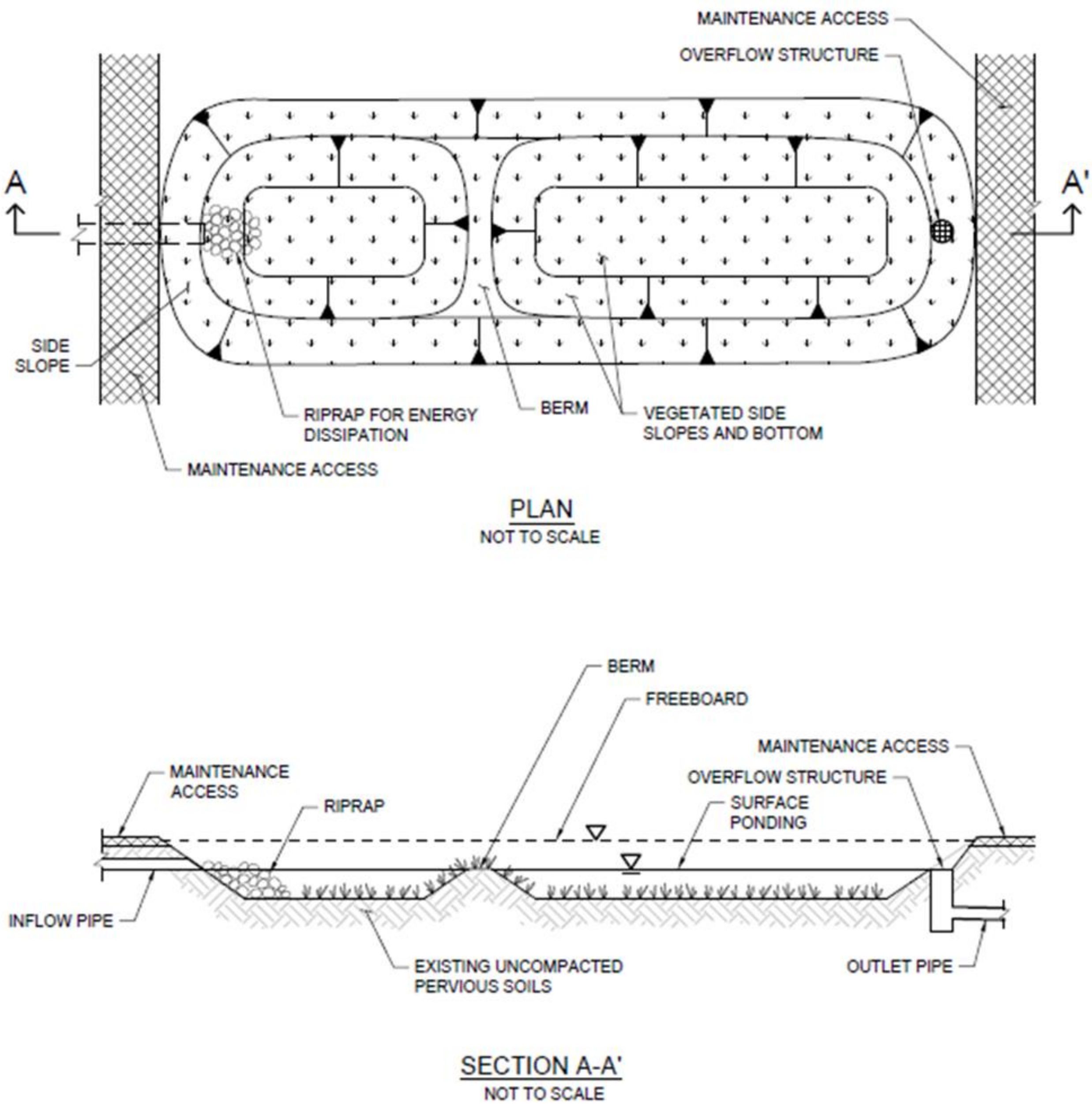

Figure E.13-1 : Typical Plan and Section View of an Infiltration BMP

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Freeboard	≥ 2 inches	Freeboard minimizes risk of uncontrolled surface discharge.
Ponding Area Side Slopes	3H:1V or shallower	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
Settling Forebay Volume	≥ 25% of facility volume	A forebay to trap sediment can decrease frequency of required maintenance. Equivalent pretreatment BMPs upstream of the infiltration BMP are allowed.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

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 City Engineer if it is determined to be appropriate:

	Design Criteria	Intent/Rationale
☐	Finish grade of the facility is ≤ 2% (0% recommended).	Flatter surfaces reduce erosion and channelization with the facility.
☐	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. A drawdown time greater than 96 hours maybe allowed with implementation of an vector management plan.
Inflow and Overflow Structures		
☐	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.

	Design Criteria	Intent/Rationale
□	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.
□	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.14 INF-2 Bioretention

Photo Credit: Ventura County Technical Guidance Document

MS4 Permit Category
Retention
Manual Category
Infiltration
Applicable Performance Standard
Pollutant Control Flow Control
Primary Benefits
Volume Reduction Treatment Peak Flow Attenuation

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 in ground 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.

Recommended Siting Criteria

	Siting Criteria	Intent/Rationale
☐	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.
☐	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.
☐	Contributing tributary area is ≤ 5 acres (≤ 1 acre preferred).	Bigger BMPs require additional design features for proper performance. Contributing tributary area greater than 5 acres may be allowed at the discretion of the City Engineer 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 City Engineer for proper performance of the regional BMP.
☐	Finish grade of the facility is ≤ 2%. In long bioretention facilities where the potential for internal erosion and channelization exists, the use of check dams is required.	Flatter surfaces reduce erosion and channelization within the facility. Internal check dams reduce velocity and dissipate energy.

Example Schematic Design – Plan and Section View

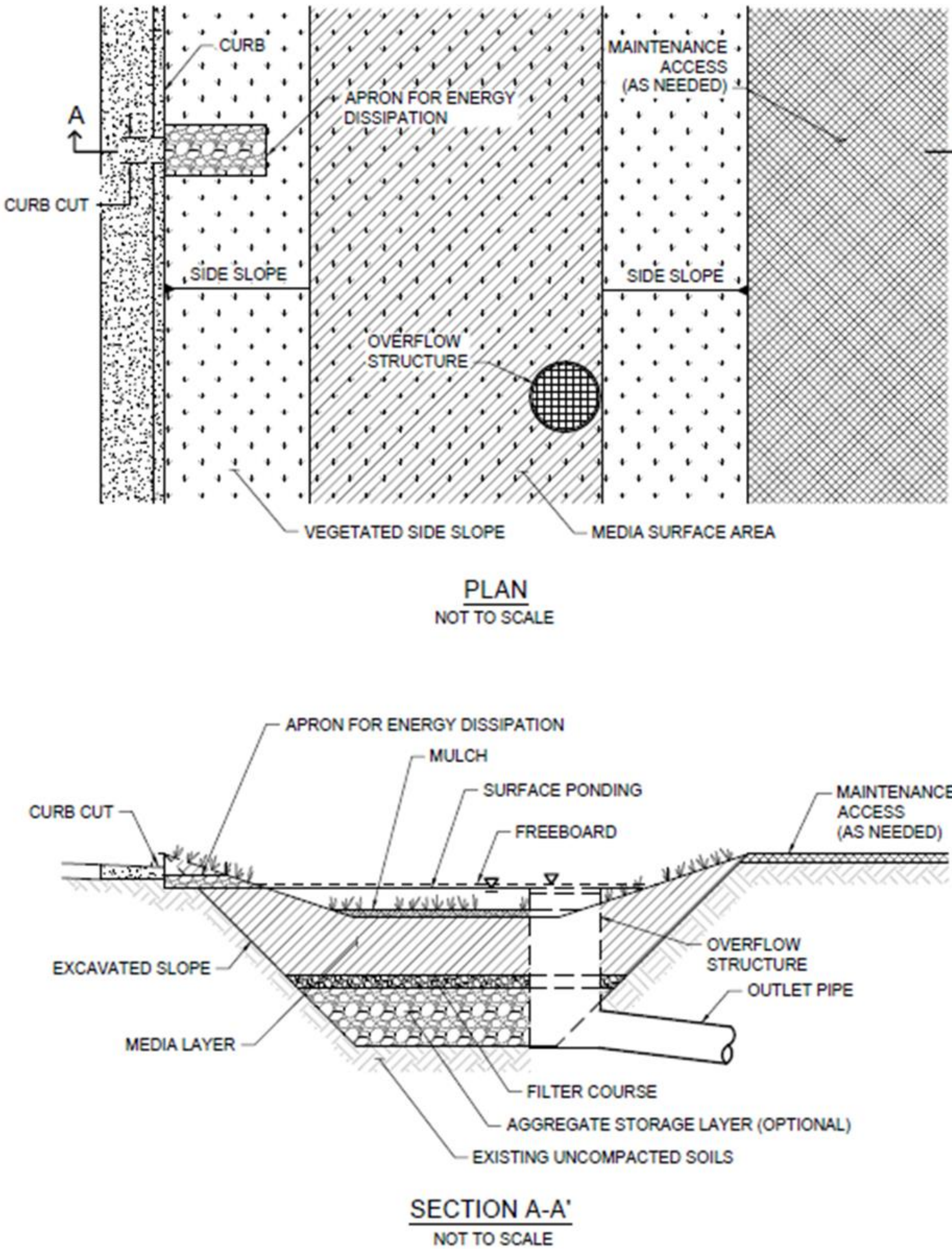

Figure E.14-1 : Typical Plan and Section View of a Bioretention BMP

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Freeboard	≥ 2 inches	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
Surface Ponding	≥ 6 and ≤ 12 inches	The minimum ponding depth is required so that the runoff is uniformly spread throughout the basin (minimizes the likelihood of short circuiting). Deep surface ponding raises safety concerns. When the BMP is adjoining walkways the minimum surface ponding depth can be reduced to 4 inches. 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 City Engineer 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 3) potential for elevated clogging risk is evaluated (Worksheet B.5.4).
Ponding Area Side Slopes	3H:1V or shallower	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
Mulch	≥ 3 inches	Mulch will suppress weeds and maintain moisture for plant growth.
Media Layer	≥ 18 inches	A deep media layer provides additional filtration and supports plants with deeper roots. Where the minimum of 18 inches is used, only shallow-rooted species shall be planted. A minimum 24-inch media layer depth is recommended to support vegetation, with a minimum 36-inch media layer depth recommended for trees.
Filter Course	6 inches	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone. This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

Design Criteria and Considerations

Bioretention must meet the following design criteria. Deviations from the below criteria may be approved at the discretion of the City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
Surface Ponding		
□	Surface ponding is limited to a 24-hour drawdown time.	24-hour drawdown time is recommended for plant health. 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.
Vegetation		
□	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.26.	Plants suited to the climate and ponding depth are more likely to survive.
□	An irrigation system with a connection to water supply is provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
Mulch		
□	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 beneficial microbes to multiply.
Media Layer		
□	Media maintains a minimum filtration rate of 5 in/hr over lifetime of facility. Additional Criteria for media hydraulic conductivity described in the bioretention soil media model specification (Appendix F.3)	A high filtration rate through the soil mix minimizes clogging potential and allows flows to quickly enter the aggregate storage layer, thereby minimizing bypass.
□	Media is a minimum 18 inches deep, meeting the following media specifications: Model bioretention soil media specification provided in Appendix F.3 <u>or</u> County of San Diego Low Impact Development Handbook: Appendix G - Bioretention Soil Specification (June 2014, unless superseded by more recent edition).	A deep media layer provides additional filtration and supports plants with deeper roots. Standard specifications shall be followed.
□	Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in Appendix F.3 or the County LID Manual, the media meets the pollutant treatment performance criteria in Section F.1.	For non-standard or proprietary designs, compliance with F.1 ensures that adequate treatment performance will be provided.

	Siting and Design	Intent/Rationale
□	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%.	Greater surface area to tributary area ratios decrease loading rates per square foot and therefore increase longevity. 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. Use Worksheet B.5.4 to estimate the Alternative Minimum Sizing Factor.
Filter Course Layer		
□	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.
□	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
□	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone	This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.
Aggregate Storage Layer (Optional)		
□	ASTM #57 open graded stone is used for the storage layer and a two layer filter course (detailed above) is used above this layer	This layer provides additional storage capacity. ASTM #8 stone provides an acceptable choking/bridging interface with the particles in ASTM #57 stone.
Inflow and Overflow Structures		
□	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.
□	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.
□	Curb cut inlets are at least 18 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.
□	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.

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.

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E.15 INF-3 Permeable Pavement (Pollutant Control)

Location: Kellogg Park, San Diego, California

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

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-D). Pollutant control is provided via infiltration, filtration, sorption, sedimentation, and biodegradation processes. **Permeable pavements proposed as a retention or partial retention BMP should not have an impermeable liner**.

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

Design Adaptations for Project Goals

Site design BMP to reduce impervious area and DCV. See site design option SD-D.

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.

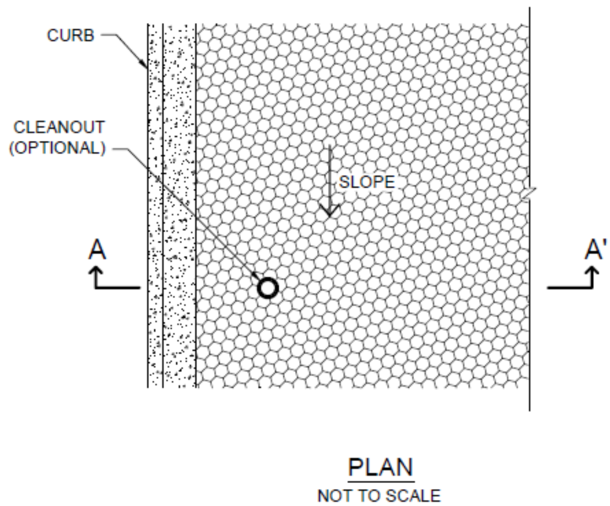
Integrated storm water flow control and pollutant control configuration. With any of the above configurations, the system can be designed to provide flow rate and duration control. This may include having a deeper aggregate storage layer that allows for significant detention storage above the underdrain, which can be further controlled via inclusion of an outlet structure at the downstream end of the underdrain.

Recommended Siting Design

	Siting Criteria	Intent/Rationale
☐	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.
☐	Selection must be based on infiltration feasibility criteria (Appendix C and D).	Full or partial infiltration designs must be supported by drainage area feasibility findings.
☐	Permeable pavement is not placed in an area with significant overhanging trees or other vegetation.	Leaves and organic debris can clog the pavement surface.
☐	Minimum depth to groundwater and bedrock ≥ 10 ft.	A minimum separation facilitates infiltration and lessens the risk of negative groundwater impacts.

	Siting Criteria	Intent/Rationale
☐	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.
☐	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.

Example Schematic Design – Plan and Section View



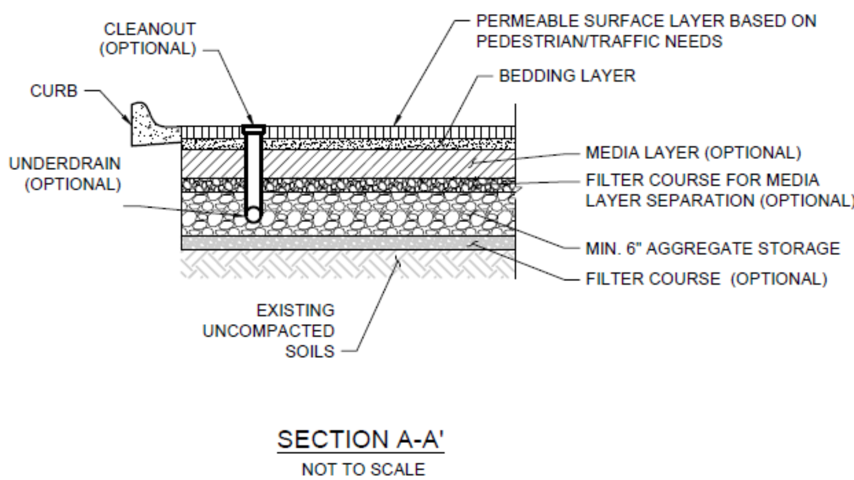


Figure E.15-1 : Typical Plan and Section View of a Permeable Pavement BMP

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.

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Bedding Layer	1-2 inches (typical)	Bedding (e.g., sand, aggregate) provided to stabilize and level the surface.
Media Layer (Optional)	≥ 18 inches	Provides effective pollutant removal.
Filter Course for Media Layer Separation (Optional)	4-6 inches	Typically made up of 2 to 3 inches of coarse sand and 2 to 3 inches of pea gravel, both washed. Thinner layers are less effective and may be more challenging to accurately construct.
Aggregate Storage	≥ 6 inches	A minimum depth of aggregate provides structural stability for expected pavement loads.
Bottom Filter Course (Optional)	≥ 6 inches	Provides filtering of fine sediment prior to infiltration into subsurface soils
Underdrain Diameter (Optional)	≥ 8 inches	Minimum diameter required for maintenance by City crew's. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
Cleanout Diameter (Optional)	≥ 8 inches	Facilitates simpler cleaning, when needed. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

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 City Engineer if it is determined to be appropriate:

	Design Criteria	Intent/Rationale
☐	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.
☐	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.
☐	Finish grade of the permeable pavement has a slope ≤ 5%.	Flatter surfaces facilitate increased runoff capture.

	Design Criteria	Intent/Rationale
Permeable Surface Layer		
☐	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.
☐	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.
Bedding Layer for Permeable Surface		
☐	Bedding thickness and material is appropriate for the chosen permeable surface layer type.	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. Pervious concrete also requires an aggregate course of clean gravel or crushed stone with a minimum amount of fines. Permeable Interlocking Concrete Paver requires 1 or 2 inches of sand or No. 8 aggregate to allow for leveling of the paver blocks. Similar to Permeable Interlocking Concrete Paver, plastic grid systems also require a 1- to 2-inch bedding course of either gravel or sand. 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.
☐	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.
Media Layer (Optional) –used between bedding layer and aggregate storage layer to provide pollutant treatment control		
☐	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.
☐	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.

	Design Criteria	Intent/Rationale
☐	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.
☐	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.
Aggregate Storage Layer		
☐	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.
☐	Minimum layer depth is 6 inches.	A minimum depth of aggregate provides structural stability for expected pavement loads.
Underdrain and Outflow Structures		
☐	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.
☐	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.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
☐	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.
Filter Course (Optional)		
☐	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).

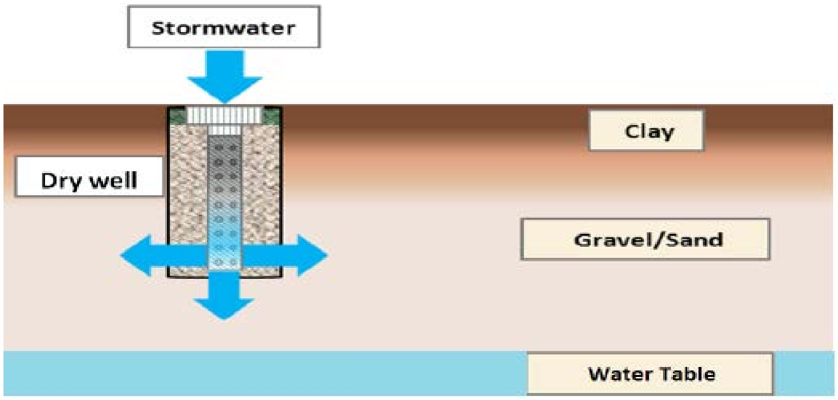
Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable

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 achieving 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.16 INF-4 Dry Wells



Source: Cal/EPA Fact Sheet on Dry Wells

MS4 Permit Category
Retention
BMP Manual Category
Infiltration
Applicable Performance Standard
Pollutant Control Flow Control
Primary Benefits
Volume Reduction

Purpose

The purpose of this fact sheet is to help explain the potential role of dry wells in meeting infiltration requirements. This fact sheet does not describe design criteria like the other fact sheets in this manual. The City Engineer may develop design criteria and include in this fact sheet at a future time.

Description

A dry well typically consists of a gravity-fed pit, deeper than it is long or wide, lined with perforated casing and often backfilled with gravel or stone. Dry wells penetrate layers of poorly infiltrating soils, such as clays, allowing infiltration into deeper permeable layers. Dry wells reduce storm water runoff while increasing groundwater recharge. Dry wells require pretreatment. Pretreatment effectiveness is contingent upon proper maintenance pretreatment devices.

Criteria for Use of a Dry Well as an Infiltration BMP

A dry well may be acceptable as an "infiltration BMP" if it meets **ALL** the following criteria:

- The BMP meets the minimum geotechnical and groundwater investigation requirements listed in **Appendix C**; and
- The BMP is evaluated by approved infiltration rate assessment methods presented in **Appendix D**; and
- Implements an appropriate pretreatment BMP (refer to **Appendix B.6.2** for selection); and
- Dry wells serving lots other than single-family homes are **registered with the US EPA**.

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E.17 PR-1 Biofiltration with Partial Retention

Location: 805 and Bonita Road, Chula Vista, CA.

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 (aka choking 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

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.

Recommended Siting Criteria

	Siting Criteria	Intent/Rationale
☐	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.
☐	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.
☐	Contributing tributary area shall be ≤ 5 acres (≤ 1 acre preferred).	Bigger BMPs require additional design features for proper performance. Contributing tributary area greater than 5 acres may be allowed at the discretion of the City Engineer 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 City Engineer for proper performance of the regional BMP.
☐	Finish grade of the facility is ≤ 2%.	Flatter surfaces reduce erosion and channelization within the facility.

Example Schematic Design – Plan and Section View

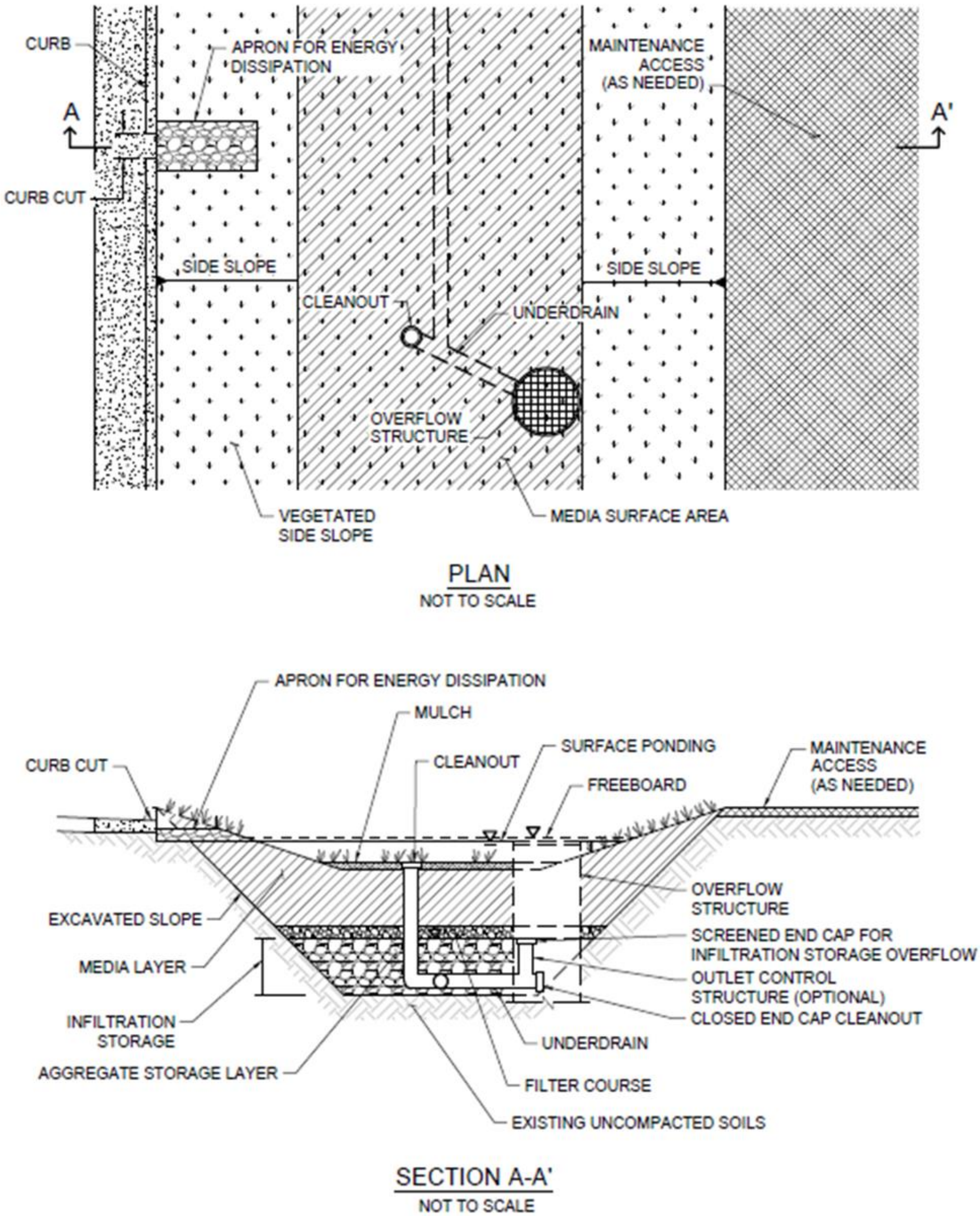

Figure E.17-1 : Typical Plan and Section View of a Biofiltration with Partial Retention BMP

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Freeboard	≥ 2 inches	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
Surface Ponding	≥ 6 and ≤ 12 inches	The minimum ponding depth is required so that the runoff is uniformly spread throughout the basin (minimizes the likelihood of short circuiting). Deep surface ponding raises safety concerns. When the BMP is adjoining walkways the minimum surface ponding depth can be reduced to 4 inches. 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 City Engineer 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 3) potential for elevated clogging risk is evaluated (Worksheet B.5.4).
Ponding Area Side Slopes	3H:1V or shallower	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
Mulch	≥3 inches	Mulch will suppress weeds and maintain moisture for plant growth.
Media Layer	≥ 18 inches	A deep media layer provides additional filtration and supports plants with deeper roots. Where the minimum of 18 inches is used, only shallow-rooted species shall be planted. A minimum 24-inch media layer depth is recommended to support vegetation, with a minimum 36-inch media layer depth recommended for trees.
Filter Course	6 inches	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4). This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.
Underdrain Diameter	≥ 8 inches	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
Cleanout Diameter	≥ 8 inches	Facilitates simpler cleaning, when needed. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

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 City Engineer if it is determined to be appropriate:

	Design Criteria	Intent/Rationale
Surface Ponding		
☐	Surface ponding is limited to a 24-hour drawdown time.	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 City Engineer if certified by a landscape architect or agronomist.
Vegetation		
☐	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.26	Plants suited to the climate and ponding depth are more likely to survive.
☐	An irrigation system with a connection to water supply should be provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
Mulch		
☐	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.
Media Layer		
☐	Media maintains a minimum filtration rate of 5 in/hr over lifetime of facility. Additional Criteria for media hydraulic conductivity described in the bioretention soil media model specification (Appendix F.3)	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.

	Design Criteria	Intent/Rationale
☐	Media shall be a minimum 18 inches deep for filtration purposes, with a minimum 24-inch media layer depth recommended to support vegetation and a minimum 36-inch media layer depth recommended for trees. Media shall meet the following specifications: Model bioretention soil media specification provided in Appendix F.3 or County of San Diego Low Impact Development Handbook: Appendix G - Bioretention Soil Specification (June 2014, unless superseded by more recent edition). Alternatively, for proprietary designs and custom media mixes not meeting the media specifications, the media meets the pollutant treatment performance criteria in Section F.1.	A deep media layer provides additional filtration and supports plants with deeper roots. Standard specifications shall be followed. For non-standard or proprietary designs, compliance with Appendix F.1 ensures that adequate treatment performance will be provided.
☐	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%.	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. 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. Refer to Appendix B.5 for guidance to support use of smaller than 3% footprint.
☐	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).	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.
Filter Course Layer		
☐	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 and can result in poor water quality performance for turbidity and suspended solids. Filter fabric is more likely to clog.
☐	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility
☐	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4)	This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.

	Design Criteria	Intent/Rationale
Aggregate Storage Layer		
☐	ASTM #57 open graded stone is used for the storage layer and a two layer filter course (detailed above) is used above this layer	This layer provides additional storage capacity. ASTM #8 stone provides an acceptable choking/bridging interface with the particles in ASTM #57 stone.
Inflow, Underdrain, and Outflow Structures		
☐	Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
☐	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.
☐	Curb cut inlets are at least 18 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.
☐	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.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
☐	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.
☐	An underdrain cleanout with a minimum 8-inch diameter and lockable cap is placed every 50 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.
☐	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 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. 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.

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.18 BF-1 Biofiltration

Location: 43rd Street and Logan Avenue, San Diego, California

MS4 Permit Category
Biofiltration
Manual Category
Biofiltration
Applicable Performance Standard
Pollutant Control Flow Control
Primary Benefits
Treatment Volume Reduction (Incidental) Peak Flow Attenuation (Optional)

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 (aka choking 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

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.

Recommended Siting Criteria

	Siting Criteria	Intent/Rationale
☐	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.
☐	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.
☐	Contributing tributary area shall be ≤ 5 acres (≤ 1 acre preferred).	Bigger BMPs require additional design features for proper performance. Contributing tributary area greater than 5 acres may be allowed at the discretion of the City Engineer 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 City Engineer for proper performance of the regional BMP.
☐	Finish grade of the facility is ≤ 2%.	Flatter surfaces reduce erosion and channelization within the facility.

Example Schematic Design – Plan and Section View

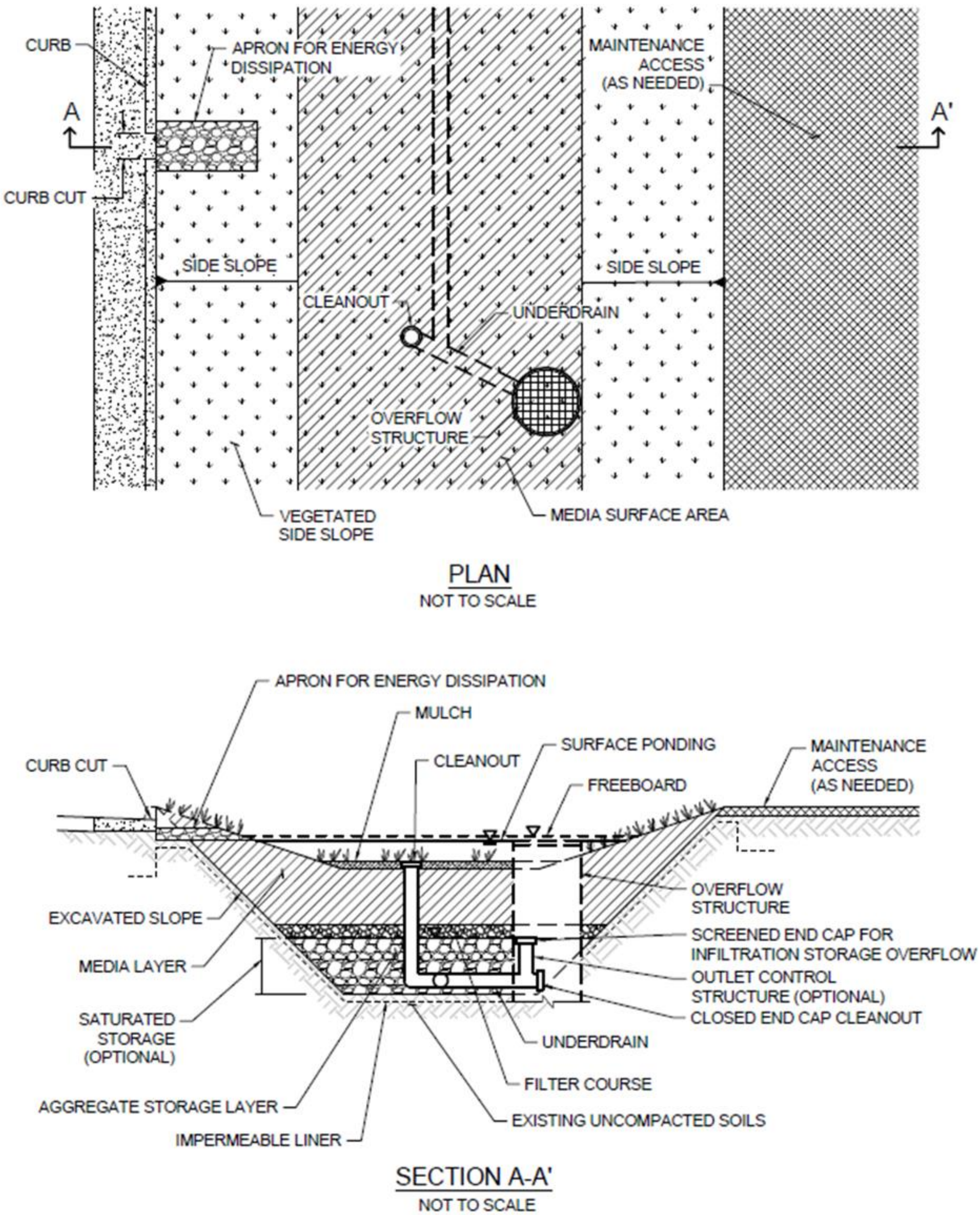

Figure E.18-1 : Typical Plan and Section View of a Biofiltration BMP

Recommended BMP Component Dimensions

BMP Component	Dimension	Intent/Rationale
Freeboard	≥ 2 inches	Freeboard provides room for head over overflow structures and minimizes risk of uncontrolled surface discharge.
Surface Ponding	≥ 6 and ≤ 12 inches	The minimum ponding depth is required so that the runoff is uniformly spread throughout the basin (minimizes the likelihood of short circuiting). Deep surface ponding raises safety concerns. When the BMP is adjoining walkways the minimum surface ponding depth can be reduced to 4 inches. 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 City Engineer 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 3) potential for elevated clogging risk is evaluated (Worksheet B.5.4).
Ponding Area Side Slopes	3H:1V or shallower	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
Mulch	≥ 3 inches	Mulch will suppress weeds and maintain moisture for plant growth.
Media Layer	≥ 18 inches	A deep media layer provides additional filtration and supports plants with deeper roots. Where the minimum depth of 18 inches is used, only shallow-rooted species shall be planted. A minimum 24-inch media layer shall typically be required to support vegetation, with a minimum 36-inch media layer depth required for trees.
Filter Course	6 inches	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4). This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.
Underdrain Diameter	≥ 8 inches	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
Cleanout Diameter	≥ 8 inches	Facilitates simpler cleaning, when needed. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.

Deviations to the recommended BMP component dimensions may be approved at the discretion of the City Engineer if it is determined to be appropriate.

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 City Engineer if it is determined to be appropriate:

	Design Criteria	Intent/Rationale
Surface Ponding		
□	Surface ponding is limited to a 24-hour drawdown time.	Surface ponding limited to 24 hour for plant health. 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.
Vegetation		
□	Plantings are suitable for the climate and expected ponding depth. A plant list to aid in selection can be found in Appendix E.26.	Plants suited to the climate and ponding depth are more likely to survive.
□	An irrigation system with a connection to water supply should be provided as needed.	Seasonal irrigation might be needed to keep plants healthy.
Mulch		
□	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.
Media Layer		
□	Media maintains a minimum filtration rate of 5 in/hr. over lifetime of facility. Additional Criteria for media hydraulic conductivity described in the bioretention soil media model specification (Appendix F.3)	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.

	Design Criteria	Intent/Rationale
☐	Media shall be a minimum 18 inches deep for filtration purposes, with a minimum 24-inch media layer depth typically required to support vegetation and a minimum 36-inch media layer depth required for trees. Media shall meet the following specifications. Model bioretention soil media specification provided in Appendix F.3 or County of San Diego Low Impact Development Handbook: Appendix G - Bioretention Soil Specification (June 2014, unless superseded by more recent edition). Alternatively, for proprietary designs and custom media mixes not meeting the media specifications, the media meets the pollutant treatment performance criteria in Section F.1.	A deep media layer provides additional filtration and supports plants with deeper roots. Standard specifications shall be followed. For non-standard or proprietary designs, compliance with Appendix F.1 ensures that adequate treatment performance will be provided.
☐	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%.	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. 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. Refer to Appendix B.5 for guidance to support use of smaller than 3% footprint..
☐	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).	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.
Filter Course Layer		
☐	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 and can result in poor water quality performance for turbidity and suspended solids. Filter fabric is more likely to clog.
☐	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
☐	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4).	This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.

	Design Criteria	Intent/Rationale
Aggregate Storage Layer		
☐	ASTM #57 open graded stone is used for the storage layer and a two layer filter course (detailed above) is used above this layer	This layer provides additional storage capacity. ASTM #8 stone provides an acceptable choking/bridging interface with the particles in ASTM #57 stone.
☐	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.
Inflow, Underdrain, and Outflow Structures		
☐	Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
☐	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.
☐	Curb cut inlets are at least 18 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.
☐	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.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
☐	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.
☐	An underdrain cleanout with a minimum 8-inch diameter and lockable cap is placed every 50 feet as required based on underdrain length.	Properly spaced cleanouts will facilitate underdrain maintenance. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.
☐	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 biofiltration 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 biofiltration 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.19 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 **Appendix F.3** and the County of San Diego Low Impact Development Handbook: Appendix G -Bioretention Soil Specification (June 2014, 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.

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.

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E.20 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 selection criteria and pollutant treatment performance standard in **Appendix F.1**;
2. The BMP meets the performance standard for compact BMPs in **Table B.5-1** in **Appendix B.5**;
3. The BMP is designed and maintained in a manner consistent with its performance certifications (See explanation in **Appendix F.2**); and
4. The BMP is acceptable at the discretion of the City Engineer. In determining the acceptability of a BMP, the City Engineer 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 City Engineer, 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 B.5** and **Appendix F.2**.

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E.21 FT-1 Vegetated Swales

Location: Eastlake Business Center, Chula Vista, California; Photo Credit: Eric Mosolgo

MS4 Permit Category

Flow-thru Treatment Control

Manual Category

Flow-thru Treatment Control

Applicable Performance Standard

Pollutant Control

Primary Benefits

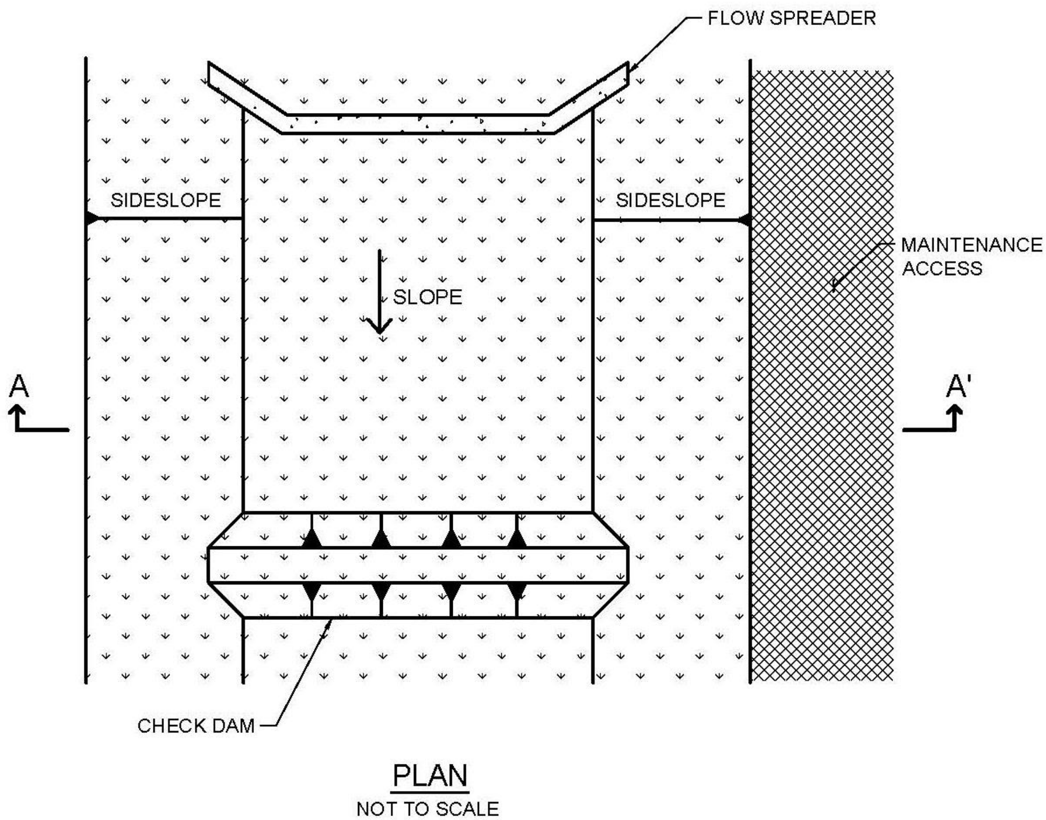
Treatment
Volume Reduction (Incidental)
Peak Flow Attenuation

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)



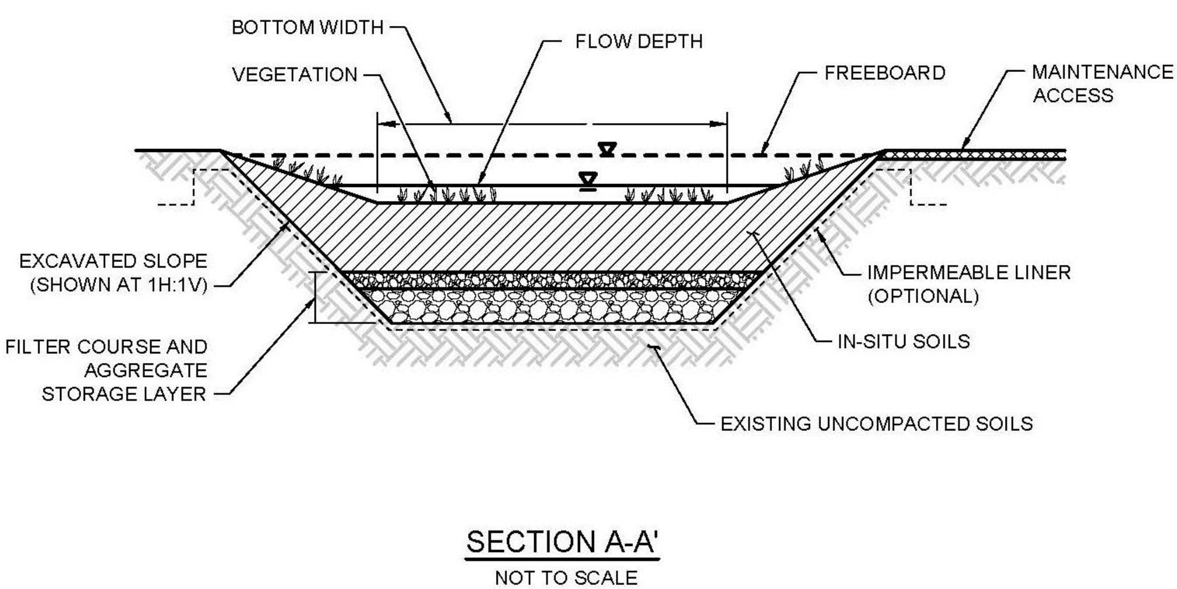


Figure E.21-1 : Typical Plan and Section View of a Vegetated Swale BMP

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
□	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.
□	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.
□	Contributing tributary area ≤ 2 acres.	Higher ratios increase the potential for clogging but may be acceptable for relatively clean tributary areas.
□	Longitudinal slope is ≥ 1.5% and ≤ 6%.	Flatter swales facilitate increased water quality treatment while minimum slopes prevent ponding.
□	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.
Surface Flow		
□	Maximum flow depth is ≤ 6 inches or ≤ $^{2}/_{3}$ 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 2 inches of freeboard is provided.	Freeboard minimizes risk of uncontrolled surface discharge.

	Siting and Design	Intent/Rationale
□	Minimum 100 foot flow length.	Longer flow lengths provide increased pollutant removal via filtration and greater incidental infiltration.
□	Cross sectional shape is trapezoidal or parabolic with side slopes ≥ 3H:1V.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
□	Bottom width is ≥ 2 feet and ≤ 8 feet.	A minimum of 2 feet minimizes erosion. A maximum of 8 feet prevents channel braiding.
□	Minimum hydraulic residence time ≥ 10 minutes.	Longer hydraulic residence time increases pollutant removal.
□	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.
□	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.
Vegetated Surface Layer (amendment with media is Optional)		
□	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: BSM specification in Appendix F.3; 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.
□	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.
Check Dams		
□	Check dams are provided at 50-foot increments for slopes ≥ 2.5%.	Check dams prevent erosion and increase the hydraulic residence time by lowering flow velocities and providing ponding opportunities.
Filter Course Layer (For Underdrain Design)		
□	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.

	Siting and Design	Intent/Rationale
☐	Filter course is washed and free of fines.	Washing aggregate will help eliminate fines that could clog the facility and impede infiltration.
☐	To reduce clogging potential, a two-layer filter course (aka choking stone system) is used consisting of one 3" layer of clean and washed ASTM 33 Fine Aggregate Sand overlying a 3" layer of ASTM No 8 Stone (Appendix F.4).	This specification has been developed to maintain permeability while limiting the migration of media material into the stone reservoir and underdrain system.
Aggregate Storage Layer (For Underdrain Design)		
☐	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.
☐	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.
Inflow and Underdrain Structures		
☐	Inflow and underdrains are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
☐	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.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.
☐	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.
☐	An underdrain cleanout with a minimum 8-inch diameter and lockable cap is placed, at the farthest, every 300 feet as required based on underdrain length (50 feet is recommended).	Properly spaced cleanouts will facilitate underdrain maintenance. For privately maintained BMPs, cleanout diameter of 6 inches is allowed.

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.22 FT-2 Media Filters


Photo Credit: Contech Stormwater Solutions

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)

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	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.
☐	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.
☐	Vault storage drawdown time ≤96 hours.	Provides vector control.
☐	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.
Inflow and Outflow Structures		
☐	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.

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:
   (k) Divide the vault volume by the filter surface area.
   (l) Divide the result (a) by the design filter rate.

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E.23 FT-3 Sand Filters

Photo Credit: City of San Diego LID Manual

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)

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

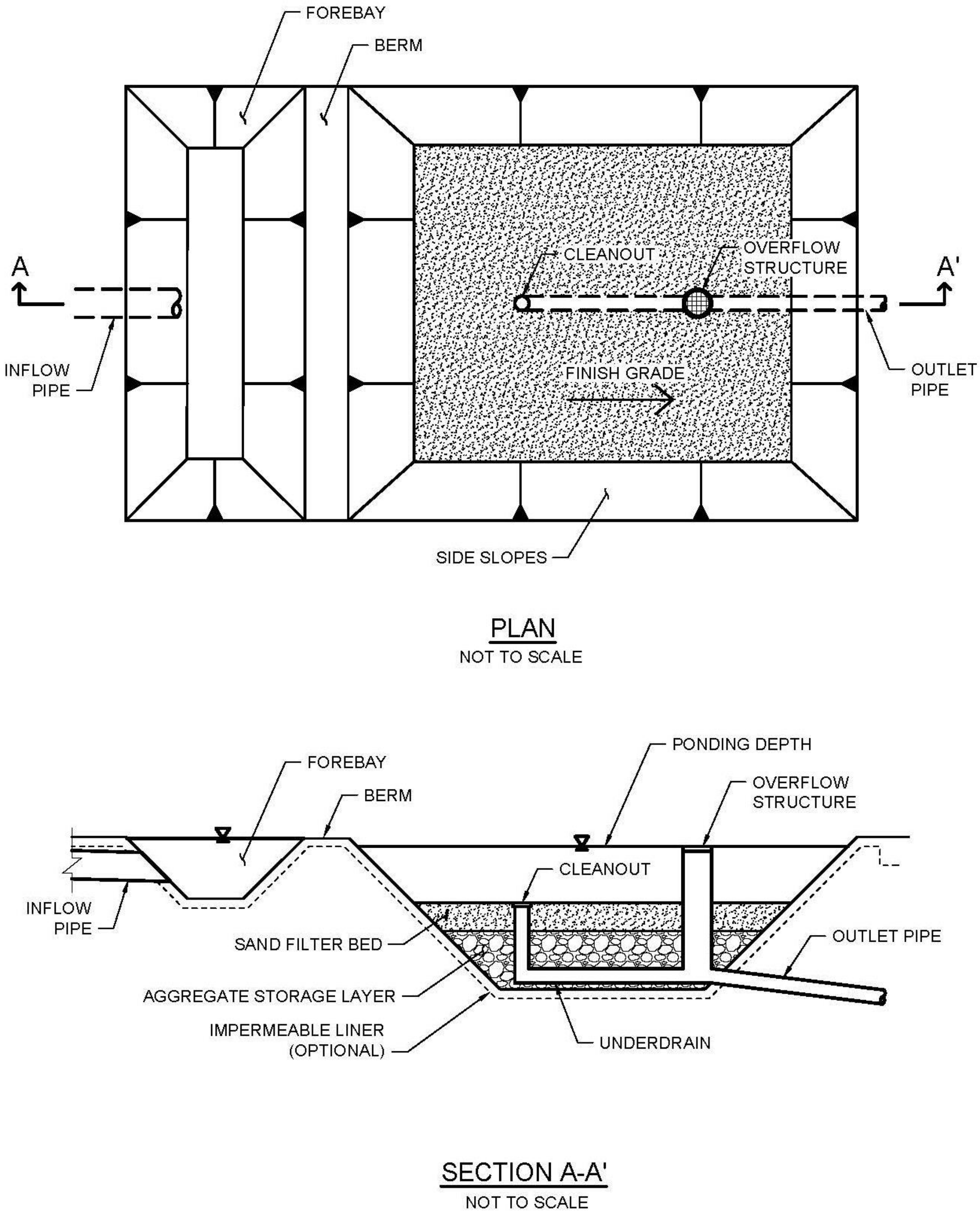

Figure E.23-1 : Typical Plan and Section View of a Sand Filter BMP

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	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.
☐	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.
☐	Contributing tributary area (≤ 5 acres).	Bigger BMPs require additional design features for proper performance. Contributing tributary area greater than 5 acres may be allowed at the discretion of the City Engineer 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 City Engineer for proper performance of the regional BMP.
☐	Finish grade of facility is < 6%.	Flatter surfaces reduce erosion and channelization within the facility.
☐	Earthen side slopes are ≥ 3H:1V.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.

	Siting and Design	Intent/Rationale
☐	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.
☐	Surface ponding is limited to a 96-hour drawdown time.	Prolonged surface ponding can create a vector hazard.
☐	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.
☐	Sand filter bed consists of clean washed concrete or masonry sand (passing ¼ 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.
☐	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.
☐	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.
☐	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.
☐	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.
☐	Inflow, underdrains and outflow structures are accessible for inspection and maintenance.	Maintenance will prevent clogging and ensure proper operation of the flow control structures.
☐	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.
☐	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.
☐	Minimum underdrain diameter is 8 inches.	Minimum diameter required for maintenance by City crews. For privately maintained BMPs, a minimum underdrain diameter of 6 inches is allowed.

	Siting and Design	Intent/Rationale
☐	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.
☐	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.

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E.24 FT-4 Dry Extended Detention Basin

Location: Rolling Hills Ranch, Chula Vista, California; Photo Credit: Eric Mosolgo

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

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

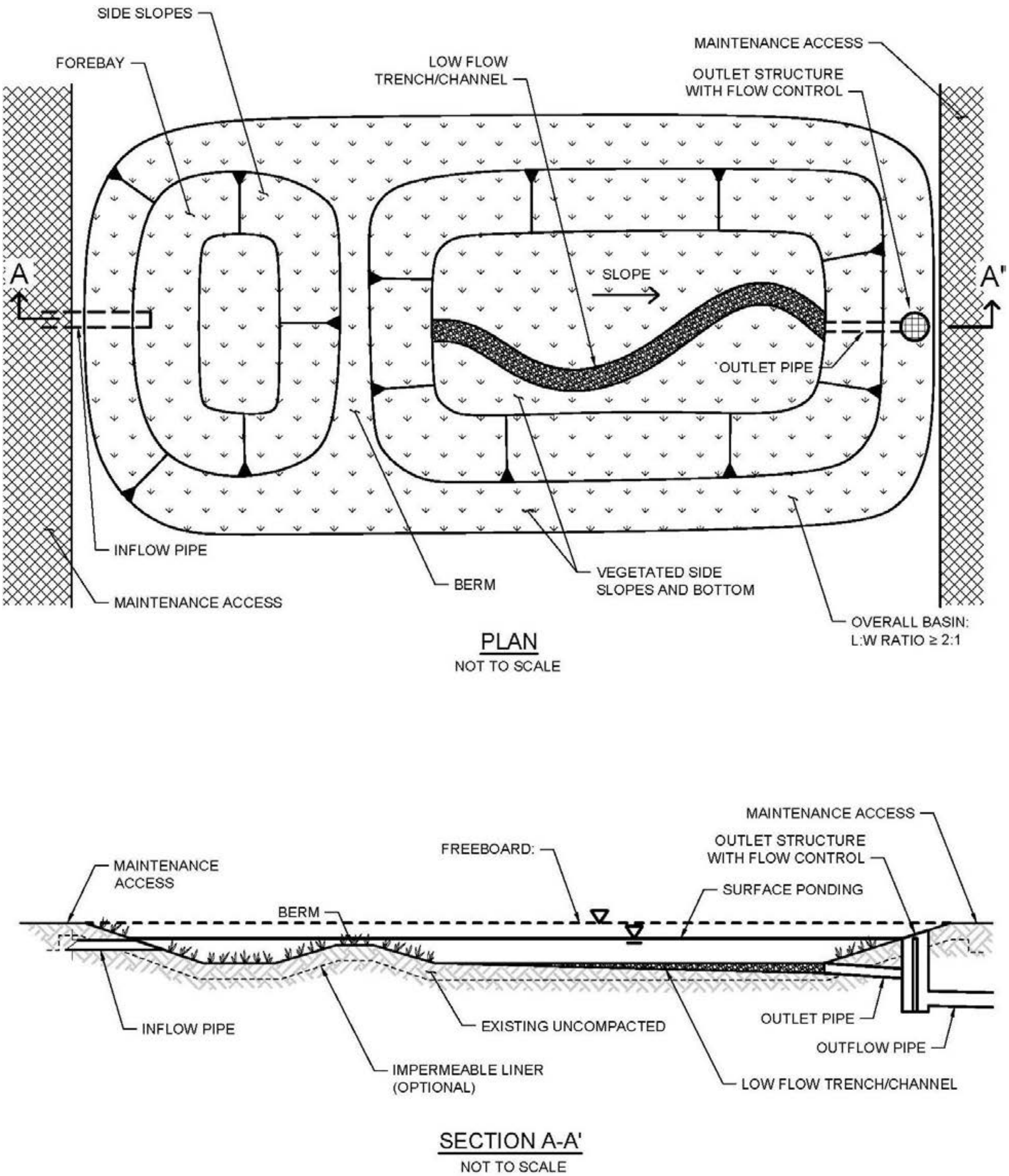

Figure E.24-1 : Typical plan and Section view of a Dry Extended Detention Basin BMP

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 City Engineer if it is determined to be appropriate:

	Siting and Design	Intent/Rationale
☐	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.
☐	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.
☐	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.
☐	Longitudinal basin bottom slope is 0 - 2%.	Flatter slopes promote ponding and settling of particles.
☐	Basin length to width ratio is ≥ 2:1 (L:W).	A larger length to width ratio provides a longer flow path to promote settling.
☐	Forebay is included that encompasses 20 - 30% of the basin volume.	A forebay to trap sediment can decrease frequency of required maintenance.
☐	Side slopes are ≥ 3H:1V.	Gentler side slopes are safer, less prone to erosion, able to establish vegetation more quickly and easier to maintain.
☐	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.
☐	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.
☐	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.

	Siting and Design	Intent/Rationale
□	A low flow channel or trench with a ≥ 2% slope is provided. A gravel infiltration trench is provided where infiltration is allowable.	Aids in draining or infiltrating dry weather flows.
□	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.
□	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.

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.25 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 City Engineer. In determining the acceptability of a BMP, the City Engineer 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 City Engineer, 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**.

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E.26 PL Plant List for Bioretention/Biofiltration BMPs

The following Plant List was developed to aid in the selection of plant material for BMPs in the City. Due to the wide range of species that thrive in San Diego, the designer may have knowledge of additional species that will function well in specific BMPs. In using this plant list as a starting point for selection of plant material, the designer should also consider the requirements of the individual site and its microclimatic conditions before making final plant selections.

The Plant List contains approved species of:

1. Trees, and
2. Shrubs/Groundcover

Trees(2)

Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Unlined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
Latin Name	Common Name	Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray)(1)	Basin Bottom	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 Unlined Facilities Only (Bioretention Only)	YES Can Use in Lined or Unlined Facility (Flow-Through Planter OR Bioretention)
Platanus racemosa	California Sycamore	X		X	X	X	X	X	X	X	
Sambucus mexicana	Blue Elderberry	X			X	X	X	X	X	X	
Agonis flexuosa	Peppermint Tree		X	X	X	X	X	X	X	X	
Arbutus 'Marina'	Strawberry Tree		X	X	X	X	X	X	X		X
Cassia leptophylla	Gold Medallion Tree		X		X	X	X				X
Cercis canadensis 'Forest Pansy'	Eastern Redbud		X	X	X	X	X	X	X		X
Cercis occidentalis	Western Redbud		X	X	X	X	X	X	X		X
Feijoa sellowiana	Pineapple Guava		X	X		X	X	X	X		X
Hymenosporum flavum	Sweet Shade		X	X		X	X	X	X		X
Koelreuteria paniculata	Golden Raintree		X	X		X	X	X	X	X	
Lagerstroemia indica	Crape Myrtle		X	X	X	X	X	X	X		X
Magnolia grandiflora 'Little Gem'	Little Gem Magnolia		X	X	X	X	X				X
Metrosideros excelsa	New Zealand Christmas Tree		X	X	X	X	X	X	X		X
Olea europaea	Olive	X	X		X	X	X				X
Olneya tesota	Desert Ironwood		X	X	X	X	X	X	X	X	

Trees(2)											
Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Unlined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
Latin Name	Common Name	Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray)(1)	Basin Bottom	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 Unlined Facilities Only (Bioretention Only)	YES Can Use in Lined or Unlined Facility (Flow-Through Planter OR Bioretention)
Parkinsonia (Cercidium) X 'Desert Museum'	Desert Museum Palo Verde	X		X		X	X	X	X	X	
Prosopis spp.	Mesquite	X		X	X	X	X	X	X	X	
Quercus agrifolia	Coast Live Oak	X	X	X	X	X	X	X	X	X	
Rhus lancea	African Sumac		X	X	X	X	X	X	X	X	
Senegalia (Acacia) greggii	Catclaw	X		X	X	X	X	X	X	X	
Umbellularia californica	California Bay	X	X	X	X	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.

3. Suitable species for minimum 18-inch soil media depth.

Shrubs/Groundcover

Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Unlined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
Latin Name	Common Name	Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray)[1]	Basin Bottom	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 Unlined Facilities Only (Bioretention Only)	YES Can Use in Lined or Unlined Facility (Flow-Through Planter OR Bioretention)
Achillea millefolium[3]	Yarrow	X			X	X	X				X
Agrostis pallens[3]	Thingrass	X			X	X	X	X	X		X
Anemopsis californica[3]	Yerba Manza	X			X	X	X	X	X		X
Carex praegracillis[3]	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
Eleocharis macrostachya	Pale Spike Rush	X	X	X		X	X	X	X		X
Festuca rubra[3]	Red Fescue	X	X	X	X	X	X				X
Festuca californica[3]	California Fescue	X	X		X	X	X				X
Iva hayesiana	Hayes Iva	X			X	X	X				X
Juncus Mexicana[3]	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[3]	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[3]	Low Bullrush	X	X	X		X	X	X	X		X
Sisyrinchium bellum[3]	Blue-eyed Grass	X			X	X	X				X
Acacia redolens	Prostrate Acacia	X	X	X	X	X	X	X	X		X
Aloe spp. [3]	Aloe	X	X		X	X	X				X
Anigozanthus flavidus [3]	Kangaroo Paws		X	X	X	X	X	X	X		X
Aristida purpurea [3]	Purple three-awn	X	X	X	X	X	X	X	X		X

Shrubs/Groundcover											
Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Unlined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
Latin Name	Common Name	Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray)[1]	Basin Bottom	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 Unlined Facilities Only (Bioretention Only)	YES Can Use in Lined or Unlined Facility (Flow-Through Planter OR Bioretention)
Baccharis pilularis 'Pigeon Point'	Dwarf Coyote Bush	X	X	X	X	X	X				X
Carex pansa	Dune Sedge		X	X	X	X	X	X	X		X
Carissa macrocarpa	Natal Plum		X		X	X	X				X
Carpenteria californica	Bush Anemone		X		X	X	X				X
Chondropetalum tectorum	Small Cape Rush		X	X	X	X	X	X	X		X
Cistus spp.	Rockrose	X	X		X	X	X				X
Coprosma repens	Mirror Plant		X	X	X	X	X	X	X		X
Delosperma 'Alba'	Disney White Ice Plant		X	X	X	X	X	X	X		X
Dietes iridioides	White Fortnight Lily		X	X	X	X	X	X	X		X
Dodonaea viscosa 'Purpurea'	Purple Hopbush		X	X	X	X	X				X
Drosanthemum floribundum	Rosea Ice Plant		X	X	X	X	X	X	X		X
Echeveria spp	Echeveria	X	X		X	X	X				X
Epilobium canum [3]	California Fuschia		X	X	X	X	X	X	X		X
Eriogonum fasciculatum [3]	California Buckwheat	X	X	X	X	X	X	X	X		X
Eriogonum grande rubescens [3]	San Miguel Island Buckwheat	X	X	X	X	X	X	X	X		X
Grevillea spp.			X	X	X	X	X	X	X		X
Hakea laurina	Pin-cushion Hakea		X	X	X	X	X	X	X		X
Heteromeles arbutifolia	Toyon	X	X	X	X	X	X	X	X		X
Iris douglasiana	Douglas Iris		X	X	X	X	X	X	X		X
Lantana spp.	Lantana	X	X	X	X	X	X	X	X		X
Myoporum parvifolium	Creeping Myoporum	X	X	X	X	X	X	X	X		X
Myrica californica	Pacific Wax Myrtle	X	X	X	X	X	X	X	X		X
Phormium spp.	New Zealand Flax		X	X	X	X	X	X	X		X

Shrubs/Groundcover											
Plant Name		Irrigation Requirements		Preferred Location in Basin		Applicable Bioretention Sections (Unlined Facilities)				Applicability to Flow-Through Planter? (Lined Facility)	
Latin Name	Common Name	Temporary Irrigation during Plant Establishment Period	Permanent Irrigation (Drip / Spray)[1]	Basin Bottom	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 Unlined Facilities Only (Bioretention Only)	YES Can Use in Lined or Unlined Facility (Flow-Through Planter OR Bioretention)
Rhaphiolepis indica	India Hawthorn	X	X	X	X	X	X	X	X		X
Romneya coulteri	Matilija Poppy		X	X	X	X	X	X	X		X
Rosmarinus officinalis	Rosemary	X	X	X	X	X	X	X	X		X
Solidago californica	California Goldenrod	X	X	X	X	X	X				X
Sphaeralcea ambigua	Desert Mallow	X	X	X	X	X	X	X	X		X
Stipa pulchra [3]	Purple Needle Grass	X	X	X	X	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.
3. Suitable species for minimum 18-inch soil media depth.

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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 <u>and</u> 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.

Other biofiltration BMP designs[20] (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,

[20] 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.

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 City Engineer. 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 considerations to provide for continued effectiveness of pollutant and flow control functions.

Biofiltration Criteria Checklist

The applicant must 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.	
☐	The project applicant has demonstrated that it is not technically feasible to retain the full DCV onsite.	Document feasibility analysis and findings in the PDP SWQMP. Applicant must include harvest and use feasibility and infiltration feasibility in the PDP SWQMP
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.	
☐	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 (such as results derived from continuous simulation calculations of treatment volume, retention, etc.) with the PDP 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.	
☐	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.	Document site planning and feasibility analyses in PDP SWQMP per Section 5.4.
☐	The biofiltration BMP meets the volume retention performance standard specified in Table B.5-1 in Appendix B.5.	Included documentation in the PDP SWQMP using worksheets in Appendix B.5 that show that the volume retention performance standard is met. Note, retention depth profiles that are too shallow or too deep may not be acceptable.

☐	An impermeable liner or other hydraulic restriction layer on the bottom of the BMP 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.
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.	
☐	Media selected for the biofiltration BMP meets minimum quality and material specifications per Appendix F.3 or County LID Manual, including the maximum allowable design filtration rate and minimum thickness of media. OR Alternatively, for proprietary designs and custom media mixes not meeting the media specifications contained in Appendix F.3 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 that media meets the specifications in Appendix F.3 or County LID Manual. Provide documentation of performance information as described in Section F.1.
☐	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.
☐	Surface ponding is limited to 24 hours from the end of storm event flow to preserve plant health and promote healthy soil structure.	Include calculations to demonstrate that drawdown rate is adequate. 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.
☐	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.
☐	Media gradation calculations demonstrate that migration of media between layers will be prevented and permeability will be preserved.	Follow specification for choking layer 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.** Intent: Biological processes are an important element of biofiltration performance and longevity.	
☐	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.26.
☐	Plants have been selected to minimize irrigation requirements.	Provide documentation describing irrigation requirements for establishment and long term operation.
☐	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.26.
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.	
☐	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.
☐	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.
☐	For proprietary BMPs, the BMP is used in a manner consistent with manufacturer guidelines and conditions of its third-party certification[21] (i.e., maximum tributary area, maximum inflow velocities, etc., as applicable).	Provide copy of manufacturer recommendations and conditions of third-party certification.

[21]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

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.	
☐	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.
☐	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.
☐	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 the 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 City Engineer 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 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:
    (m) 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.
    (n) 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.

(o) 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.

(p) 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:

(q) 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 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.

(r) 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).

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 be 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.

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	≥ 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 ≥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	≥ 50% TSS removal

F.2 Guidance on Sizing and Design of Non-Standard Biofiltration BMPs

This section explains the general process for design and sizing of non-standard biofiltration BMPs. 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 Compact Biofiltration BMPs

This sizing method is only available when the BMP meets the pollutant treatment performance standard in Appendix F.1.

Compact (i.e. high rate) biofiltration BMPs are typically designed as a flow-based BMPs (i.e., a constant treatment capacity with negligible storage volume). The applicable sizing method for compact biofiltration BMPs is therefore reduced to: <u>**Treat 1.5 times the DCV**</u>.

The following steps must 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), <u>**or**</u>
    - Conduct a continuous simulation analysis to compute the size required to capture and treat 80 percent of average annual runoff; for small catchments with a time of concentration smaller than 15 minutes, 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 supplemental retention BMP/site design feature that will meet the volume retention performance standard in Table B.5-1 in Appendix B.5.

F.3 Bioretention Soil Media (BSM)

F.3.1 General

Bioretention Soil Media (BSM) is a formulated soil mixture that is intended to filter storm water and support plant growth while minimizing the leaching of chemicals found in the BSM itself. BSM consists of 70% to 85% by volume washed sand and 15% to 30% by volume compost or alternative organic amendment. Alternative proportions may be justified under certain conditions. BSM shall be mixed thoroughly using a mechanical mixing system at the plant site prior to delivery. In order to reduce the potential for leaching of nutrients, the proportion of compost or alternative organic amendment shall be held to a minimum level that will support the proposed vegetation in the system.

F.3.1.1 Sand for Bioretention Soil Media.

The sand shall conform to ASTM C33 "fine aggregate concrete sand" requirements. A sieve analysis shall be performed in accordance with ASTM C 136, ASTM D 422, or approved equivalent method to demonstrate compliance with the gradation limits shown in Table F.3-1. The sand shall be thoroughly washed to remove fines, dust, and deleterious materials prior to delivery. Fines passing the No. 200 sieve shall be non-plastic.

Table F.3-1: Sand Gradation Limits

Sieve Size (ASTM D422)	Percent Passing (by weight)	
	Minimum	Maximum
3/8 inch	100	100
#4	95	100
#8	80	100
#16	50	85
#30	25	60
#50	5	30
#100	0	10
#200	0	5

Note: Coefficient of Uniformity (Cu = D60/D10) equal to or greater than 4).

F.3.1.2 Compost.

Compost shall be certified by the U.S. Composting Council's Seal of Testing Assurance Program or an approved equivalent program. Compost shall comply with the following requirements:

1. Organic Material Content shall be 35% to 75% by dry weight.
2. Carbon to nitrogen (C:N) ratio shall be between 15:1 and 40:1, preferably above 20:1 to reduce the potential for nitrogen leaching/washout.
3. Physical contaminants (manmade inert materials) shall not exceed 1% by dry weight.
4. pH shall be between 6.0 and 7.5.

5. Soluble Salt Concentration shall be less than 10 dS/m (Method TMECC 4.10-A, USDA and U.S. Composting Council).
6. Maturity (seed emergence and seedling vigor) shall be greater than 80% relative to positive control (Method TMECC 5.05-A, USDA and U.S. Composting Council)
7. Stability (Carbon Dioxide evolution rate) shall be less than 2.5 mg CO2-C per g compost organic matter (OM) per day or less than 5 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 6 or higher is acceptable.
8. Moisture shall be 25%-55% wet weight basis.
9. Select Pathogens shall pass US EPA Class A standard, 40 CFR Section 503.32(a).
10. Trace Metals shall pass US EPA Class A standard, 40 CFR Section 503.13, Tables 1 and 3.
11. Shall be within gradation limits in Table F.3-2 (ASTM D 422 sieve analysis or approved equivalent).

Table F.3-2: Compost Gradation Limits

Sieve Size	Percent Passing (by weight)
16 mm (5/8")	99 to 100
6.3 mm (1/4")	40 to 95
2 mm	40 to 90

F.3.1.3 Alternative Mix Components and Proportions.

Alternative mix components and proportions may be utilized, provided that the whole blended mix (Appendix F.3.2) conforms to agricultural, chemical, and hydraulic suitability criteria, as applicable. Alternative mix designs may include alternative proportions, alternative organic amendments and/or the use of natural soils. Alternative mixes are subject to approval by the City Engineer.

Alternative mixtures may be particularly applicable for systems with underdrains in areas where phosphorus is associated with a water quality impairment or a Total Maximum Daily Load (TMDL) in a downstream receiving water. BSM with 15% to 30% compost by volume (as specified in F.3.1.3) will likely contribute to increased phosphorus in effluent. Alternative organic amendments, such as coco coir pith, in place of compost should be considered in these areas. A sand or soil substrate with low plant available phosphorus (< 5 mg/kg) should also be considered. The use of compost in these mixes should be limited to the top three to six inches of soil and limited to the minimum level needed to augment fertility. Additionally, an activated alumina polishing layer can be considered to control phosphorus leaching.

Additional mix components, such as granular activated carbon, zeolite, and biochar may be considered to improve performance for other parameters.

F.3.2 Whole BSM Testing Requirements and Criteria.

The Contractor shall submit the following information to the City Engineer at least 30 days prior to ordering materials:

- Source/supplier of BSM,
- Location of source/supplier,
- A physical sample,
- Available supplier testing information,
- Whole BSM test results from a third party independent laboratory,
- Description of proposed methods and schedule for mixing, delivery, and placement of BSM.

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 agricultural suitability criteria (Appendix F.3.2.1), chemical suitability criteria (Appendix F.3.2.2), and hydraulic suitability criteria (Appendix F.3.2.3). 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 agricultural soil evaluation which indicates compliance stating that the tested material proposed source complies with these specifications. Third party independent laboratory tests shall be paid for by the Contractor.

F.3.2.1 BSM Agricultural Suitability

The BSM shall be suitable to sustain the growth of the plants specified and shall conform to the following requirements:

(a) pH range shall be between 6.0-7.5

(b) Salinity shall be less than 3.0 millimho/cm (as measured by electrical conductivity)

(c) Sodium adsorption ration (SAR) shall be less than 3.0

(d) Chloride shall be less than 150 ppm

The test results shall show the following information:

(a) Date of Testing

(b) Project Name

(c) The Contractor’s Name

(d) Source of Materials and Supplier’s Name

(e) pH

(f) E_C

(g) Total and plant available elements (mg/kg particle concentration): phosphorus, potassium, iron, manganese, zinc, copper, boron, calcium, magnesium, sodium, sulfur, molybdenum, nickel, aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, mercury, selenium, silver, strontium, tin, and vanadium. Plant available concentration shall be assessed based on weak acid extraction(ammonium Bicarbonate/DTPA soil analysis or similar)

(h) Soil adsorption ratio

(i) Carbon/nitrogen ratio

(j) Cation exchange capacity

(k) Moisture content

(l) Organic content

(m) An assessment of agricultural suitability based on test results

(n) Recommendations for adding amendments, chemical corrections, or both.

BSM which requires amending to comply with these specifications shall be uniformly blended and tested in its blended state prior to testing and delivery.

F.3.2.2 BSM Chemical Suitability

For systems with underdrains, the BSM shall exhibit limited potential for leaching of pollutants that are at levels of concern. Potential for pollutant leaching shall be assessed using either the Saturated Media Extract Method (aka, Saturation Extract) that is commonly performed by agricultural laboratories or the Synthetic Precipitation Leaching Procedure (SPLP) (EPA SW-846, Method 1312). The referenced tests express the criteria in terms of the pollutant concentration in water that is in contact with the media. In areas in which a pollutant or pollutants are associated with a water quality impairment or a TMDL, BSM in systems with underdrains shall conform to the following Saturation Extract or SPLP criteria for applicable pollutant(s):

(a) Nitrate < 3 mg/L

(b) Phosphorus < 1 mg/L[22]

(c) Zinc < 0.1 mg/L

(d) Copper < 0.025 mg/L

(e) Lead < 0.025 mg/L

(f) Arsenic < 0.02 mg/L

(g) Cadmium < 0.01 mg/L

(h) Mercury < 0.01 mg/L

[22] Alternative mixtures should be considered for systems with underdrains in areas where phosphorus is associated with a water quality impairment or a TMDL or where the BSM does not achieve the Saturation Extract or SPLP criteria of < 1 mg/L total phosphorus as specified in 800-4.2.2. Details regarding alternative mixtures requirements and potential components are included in Appendix F.3.1.3.

(i) Selenium < 0.01 mg/L

Criteria shall be met as stated where a pollutant is associated with a water quality impairment or Total Maximum Daily Load (TMDL) in any downstream receiving water. Criteria may be waived or modified, at the discretion of the City Engineer, where a pollutant does not have a nexus to a water quality impairment or TMDL of downstream receiving water(s). Criteria may also be modified at the discretion of the City Engineer 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.

Note that Saturation Extract and SPLP tests are expected to result in somewhat more leaching than would be experienced with real storm water; therefore, a direct comparison to water quality standards or effluent limitations is not relevant.

The chemical suitability criteria listed in this section do not apply to systems without underdrains, unless groundwater is impaired or susceptible to nutrients contamination.

F.3.2.3 BSM Hydraulic Suitability

The saturated hydraulic conductivity or infiltration rate of the whole BSM shall be measured by one of the following methods:

(a) Measurement of hydraulic conductivity (USDA Handbook 60, method 34b) (commonly available as part of standard agronomic soil evaluation), or

(b) ASTM D2434 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 (options describe below).

Systems with unrestricted underdrain system (i.e., media control). For systems with underdrains that are not restricted, the BSM shall have a minimum measured hydraulic conductivity of 8 inches per hour to ensure adequate flow rate through the BMP and longevity of the system. The BSM shall have a maximum measured hydraulic conductivity of no more than 20 inches per hour. BSM with higher measured hydraulic conductivity may be accepted at the discretion of the City Engineer. In all cases, an upturned elbow system on the underdrain, measuring 9 to 12 inches above the invert of the underdrain, shall be used to control velocities in the underdrain pipe and reduce potential for solid migration through the system.

Systems with restricted underdrain system (i.e., outlet control). For systems in which the flowrate 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 shall be at least 15 inches per hour and not more than 40 inches per hour. The outlet control device shall control the flowrate to between 5 and 12 inches per hour. This configuration reduces the sensitivity of system performance to the hydraulic conductivity 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.

Systems without underdrains. For systems without underdrains, the BSM shall have a hydraulic conductivity at least 4 times higher than the underlying soil infiltration rate, but shall not exceed 12 inches per hour.

F.3.3 Delivery, Storage and Handling

The Contractor shall not deliver or place soils in frozen, wet, or muddy conditions. The Contractor shall protect soils and mixes from absorbing excess water and from erosion at all times. 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 City Engineer before placement.

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. 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 shall not exceed 75 to 85% standard proctor within the designed depth of 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 City Engineer.

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.

The Engineer 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 (Appendix F.3.2.3). In the event that the infiltration rate of placed material does not meet applicable criteria, the City Engineer may require replacement and/or decompaction of materials.

F.3.4 Quality Control and Acceptance

Close adherence to the material quality controls herein are 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 City Engineer 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 Integration with Other Specifications

This specification includes, is related to, and may depend or have dependency on other specifications, including but not limited to:

- Plantings and Hydroseed
- Mulch
- Aggregate (choking stone, drainage stone, energy dissipation)
- Geotextiles
- Underdrains
- Outlet control structures
- Excavation

Execution of this specification requires review and understanding of related specifications. Where conflicts with other specifications exist or appear to exist, the Contractor shall consult with the City Engineer to determine which specifications prevail.

F.4 Aggregate Materials for BSM Drainage Layers

Drainage of BSM requires the use of specific aggregate materials for filter course (aka choking layer) materials and for an underlying drainage and storage layer.

F.4.1 Rock and Sand Products for Use in BSM Drainage

Size classifications detailed in Tables F.4-1 and F.4-2 shall apply with respect to BSM drainage materials. All sand and stone products used in BSM drainage layers shall be clean and thoroughly washed.

Table F.4-1: Crushed Rock and Stone Gradation Limits

Sieve Size	Percent Passing Sieves	
	AASHTO No. 57	ASTM No. 8(
3 in	–	–
2.5 in	–	–
2 in	–	–
1.5 in	100	–
1 in	95 – 100	–
0.75 in	–	–
0.5 in	25 – 60	100
0.375 in	–	85 – 100
No. 4	10 max.	10 – 30
No. 8	5 max.	0 – 10
No. 16		0 – 5
No. 50		–

Table F.4-2: Sand Gradation Limits

Sieve Size	Percent Passing Sieves
	Choker Sand - ASTM C33
0.375 in	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	5 – 30
No. 100	0 – 10
No. 200	0 – 3

F.4.2 Graded Aggregate Choker Stone

Graded aggregate choker material is installed as a filter course to separate BSM from the drainage rock reservoir layer. This ensures that no migration of sand or other fines occurs. The filter course consists of two layers of choking material increasing in particle size. The top layer of the filter course shall be constructed of thoroughly washed ASTM C33 fine aggregate sand material conforming to gradation limits contained in Table F.4-2. 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 F.4-1.

F.4.3 Open-Graded Aggregate Stone

Open-graded aggregate material is installed to provide drainage for overlying BSM and filter course layers, 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 F.4-1.

F.4.4 Spreading

Imported BSM drainage material shall be delivered to the BMP system installation site 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.

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.

The thickness of the aggregate storage layer (AASHTO No. 57) will depend on site specific design and shall be detailed in contract documents.

The bottom layer of the filter course (ASTM No.8) shall be installed to a thickness of 3 inches (75 mm). The layer shall be spread in one layer. The top layer of the filter course (ASTM C33) shall be installed to a thickness of 3 inches (75 mm). The layer shall be spread in one layer. Marker stakes shall be used to ensure uniform lift thickness.

F.4.5 Compacting

Filter course material and aggregate storage material shall be lightly compacted to approximately 80% standard proctor without the use of vibratory compaction.

F.4.6 Measurement and Payment

Quantities of graded aggregate choker material and open-graded 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.

Appendix G

Guidance for Continuous Simulation and Hydromodification 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:

- 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 XP-SWMM, InfoSWMM, MIKE Urban 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.

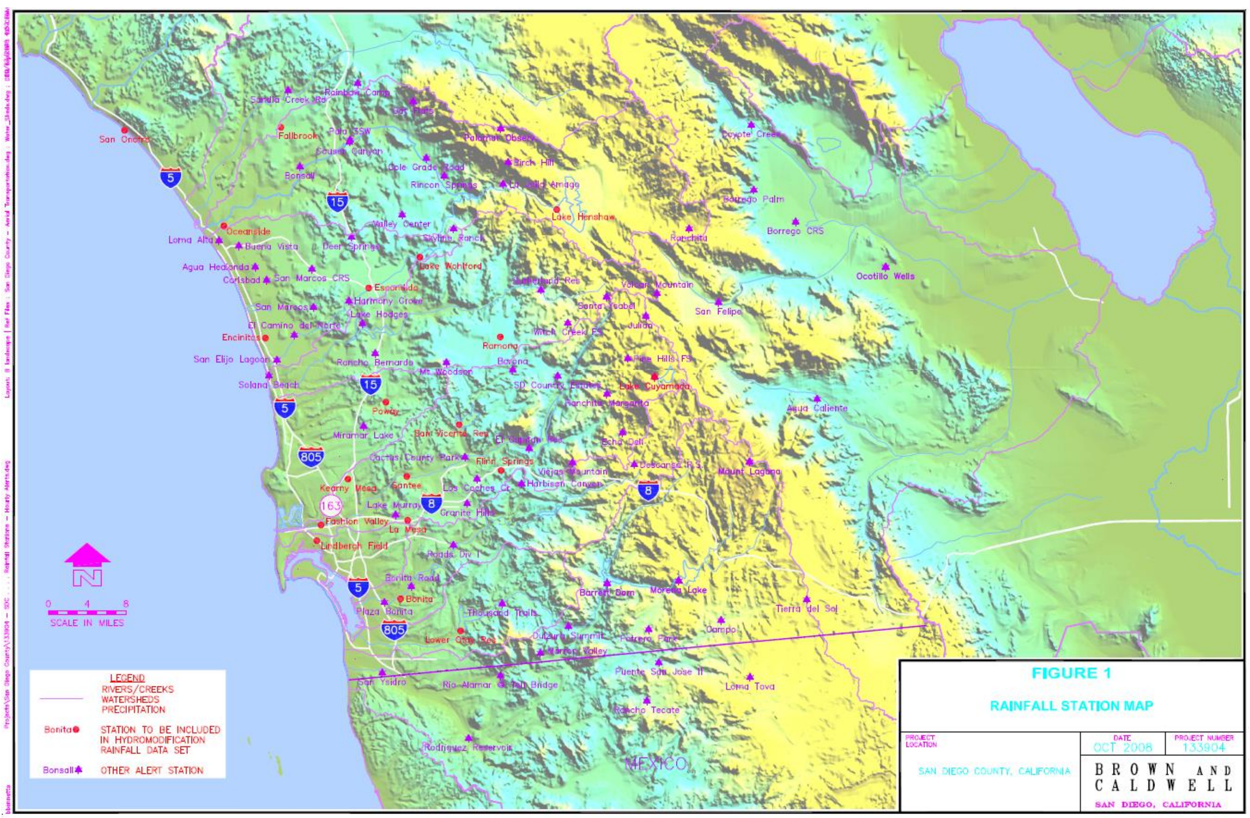

Figure G.1-1 : Rainfall Station Map

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 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.

Hydrologic water balance can be used to compare pre-development and post-project conditions, which can be defined by the following equation:

Precipitation = Evapotranspiration + Infiltration + Surface Storage+ Surface Runoff

Rainfall comprises the left side of the equation, however in some cases additional inputs from irrigation, groundwater discharge, or snowmelt may need to be considered. Each term on the right side of the equation is commonly referred to as a "rainfall loss" and is referenced as such in the Final HMP and throughout this document. Despite their name, these rainfall losses include dry weather processes that can significantly impact model results for long-term continuous simulation. Hydrologic losses can occur from standing water on subcatchment surfaces and from soil moisture beneath the ground surface. In SWMM, losses can also be simulated in the hydraulic model, from water traveling through open channels and from water held in surface storage units.

It is also worth noting that the "Surface Runoff" term in the equation includes the disposal of excess runoff generated from a subcatchment into the storm drain, receiving watercourse, or waterbody. Structural BMP designs that include consumptive use (e.g., rainwater harvesting systems) can capture a portion of the surface runoff volume and use it to meet non-potable water demands that don't require a high level of treatment.

G.1.3.2 Potential Evapotranspiration

The Evapotranspiration term in the water balance equation includes evaporation of surface waters and transpiration of soil moisture through vegetation. Climatology parameters characterize rates, as the actual amount of water evaporated or transpired depends on the amount of available water (i.e., either held in surface depressions or soil pores), temperature, wind velocity, relative humidity, and solar radiation. It is important to understand the source of measurements. Pan evaporation data are derived from measurements in stainless steel pans and therefore need to be adjusted to reflect actual site conditions by applying the appropriate set of pan coefficients. Likewise, evapotranspiration data may be derived from a specific crop or vegetation type and may need to be translated to the appropriate reference evapotranspiration (ETo). Pan coefficients can also be adjusted to reflect seasonal variations to distinguish growing/dormant periods or to account for excessive transpiration from heavy canopy/root systems.

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.

In SWMM, there are a number of options available for characterizing potential evaporation rates, including:

- Constant Value: This is not acceptable for hydromodification management studies
- Time Series: A user-defined set of values can be supplied with either a fixed recording interval (e.g., 15-minute or hourly) or variable recording interval
- Climate File: Daily evaporation rates can be read from an external climate file, and monthly pan coefficients can be specified
- Monthly Averages: A set of monthly average values is input by the user

- Temperatures: Daily evaporation rates can be computed based on daily air temperature time series data using the Hargreaves method

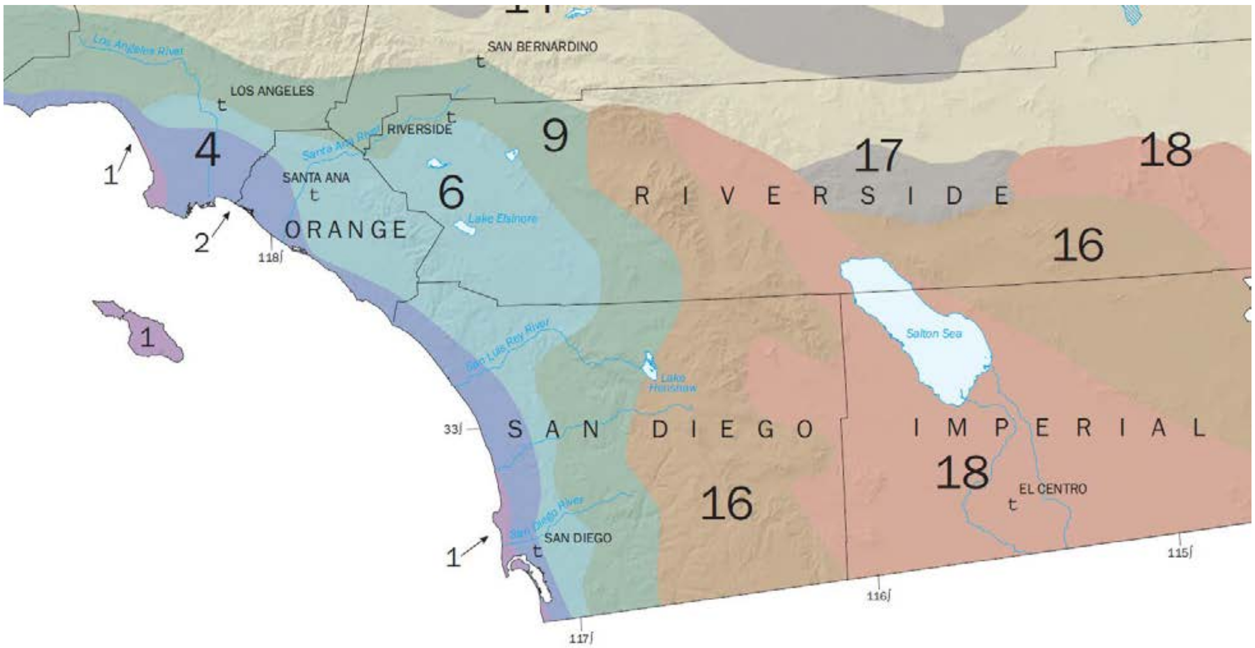

Figure G.1-2 : California Irrigation Management Information System "Reference Evapotranspiration Zones"

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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

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G.1.4 Land Characteristics and Loss Parameters

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 **Appendix 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 **Appendix 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

Name	Definition	Units	Range of Values				Function of ...	Comment
			Typical		Possible			
			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

Name	Definition	Units	Range of Values				Function of ...	Comment
			Typical		Possible			
			Min	Max	Min	Max		
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)								

Table G.1-3: HSPF PERLND/PWATER Parameters from BMP Sizing Calculator Methodology

	Units	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_PARM2													
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_PARM3													
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_PARM4													
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

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 and the LID manual where applicable. The latest version (SWMM 5.1.008, released April 2015) is available for download, along with detailed documentation and supporting information, at

http://www.epa.gov/nrmrl/wswrd/wq/models/swmm/

The SWMM Manual provides details regarding the hydrologic input parameters and summary tables of possible ranges of these parameters. For SWMM studies for hydromodification management in San Diego, hydrology parameters shall fall within the range provided in the SWMM Manual. The program help file is another source of information for typical values and additional guidance. Further, users should confirm that values are consistent within the acceptable range stated in the BMP Design 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 and infiltration parameters for use in hydromodification management studies in the San Diego region. The LID module requires an additional set of parameters and these are described below.

Table G.1-4: Subcatchment Parameters for SWMM Studies for Hydromodification Management in San Diego

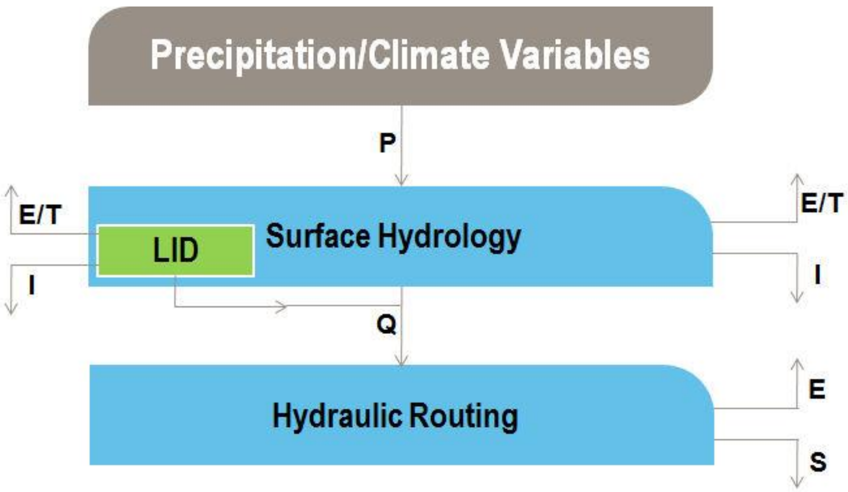
SWMM Parameter Name	Unit	Range	Use in San Diego
Name X-Coordinate Y-Coordinate Description Tag Rain Gage Outlet	N/A	N/A – project-specific	Project-specific
Area	acres (ac)	Project-specific	Project-specific
Width	feet (ft)	Project-specific	Project-specific
% Slope	percent (%)	Project-specific	Project-specific
% Imperv	percent (%)	Project-specific	Project-specific
N-imperv	--	0.011 – 0.024 presented in Table A.6 of SWMM Manual	default use 0.012, otherwise provide documentation supporting other value used
N-Perv	--	0.05 – 0.80 presented in Table A.6 of SWMM Manual	default use 0.10, otherwise provide documentation supporting other value used
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%

SWMM Parameter Name	Unit	Range	Use in San Diego
	(%)		
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
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: 0.33 Hydrologic Soil Group B: 0.32 Hydrologic Soil Group C: 0.31 Hydrologic Soil Group D: 0.30 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
Snow Pack Land Uses Initial Buildup Curb Length			Not applicable to hydromodification management studies

A schematic of the basic SWMM setup for hydromodification management studies is shown below, with the LID module is shown as a feature within the hydrology computational block. Surface water hydrology is distinguished from groundwater, however the groundwater module is not typically used in hydromodification management studies.

The rainfall and climatology input time series data are used to generate surface runoff which in turn is hydraulically routed through the collection system and storage/treatment facilities. The figure includes the following terms in the water balance equation:

- P = Precipitation
- E/T = Evaporation / Transpiration
- I/S = Infiltration / Seepage
- Q = Runoff



Evapotranspiration was previously addressed above; the remainder of this section discusses the other hydrologic losses and parameters.

<u>Soil and Infiltration Parameters</u>

Of the infiltration options available in SWMM, the Green-Ampt equation can best handle variable water content conditions in the shallow soil layers beneath the ground surface, which is critical for long-term continuous simulation of surface water hydrology. The Green-Ampt parameters suggested in Table G.1-4 are referenced according to hydrologic soil group. Green-Ampt parameters can also be determined by relating infiltration parameters to soil texture properties, as identified by in-situ geotechnical analysis results or published County soil survey information. Infiltration parameters include:

- Capillary Tension (Suction Head): a measure of how tightly water is held within the soil pore space;
- Saturated Hydraulic Conductivity: a measure of how quickly the water can be drained vertically; and
- Initial Moisture Deficit: a measure of the initial soilwater deficit, also known as porosity (i.e., the volumetric fraction of water within the soil pore space under initially dry conditions).

Note that when SWMM is used without the Groundwater module, there is no distinction between the upper and lower zone soil moisture storage as in HSPF/SDHM. The LID module does however distinguish several layers/zones within each facility, and these are described below.

Overland Flow Parameters

Overland flow parameters describe the slope and length characteristics of shallow surface runoff. These are determined by identifying representative overland flow paths for each subcatchment using available digital topographic data for pre-development conditions and the proposed grading plan for post-project conditions. Overland flow path lengths and slopes are measured directly from the available information. Generally, overland flow paths should be less than 1,000 feet in length, otherwise channelized flow is likely present and should be modeled hydraulically. Overland flow path widths are determined based on the subcatchment area divided by the corresponding flow path length for each subcatchment.

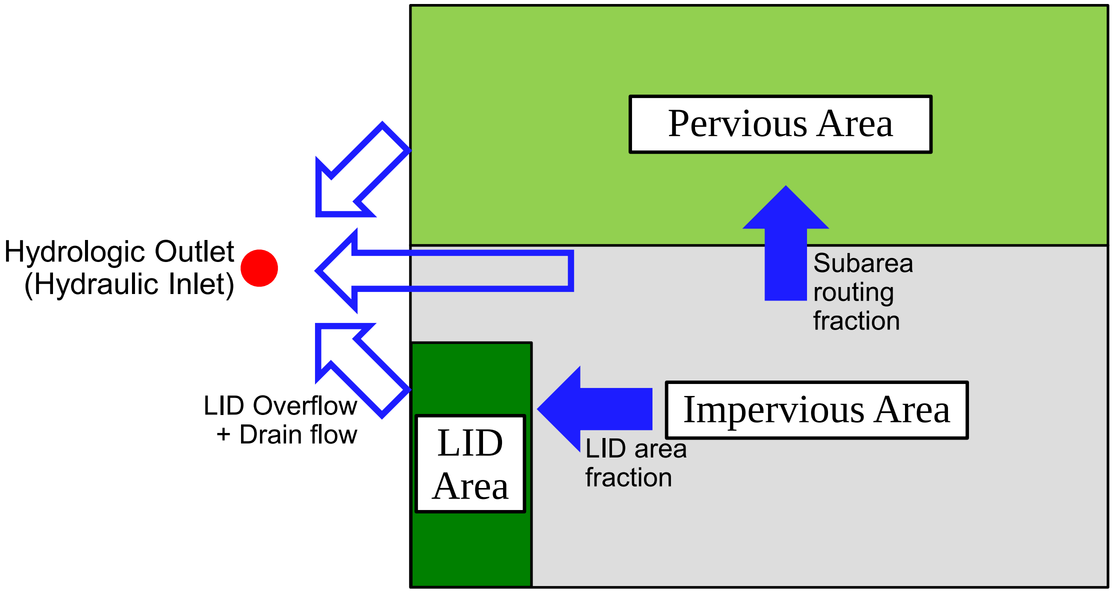
Although Surface Storage is not depicted in SWMM schematic, it is a component of the water balance equation and includes excess runoff that is held in both hydrologic depression storage and hydraulic storage units.

LID Module

There are two approaches for representing LID facilities in SWMM:

- **Modeling Approach No. 1**: Place LID controls within the appropriate subcatchment and then adjust parameters accordingly to reflect untreated areas within the parent subcatchment; and
- **Modeling Approach No. 2**: Create a new subcatchment for each LID control, allowing "run-on" from the treated portion of the parent subcatchment.

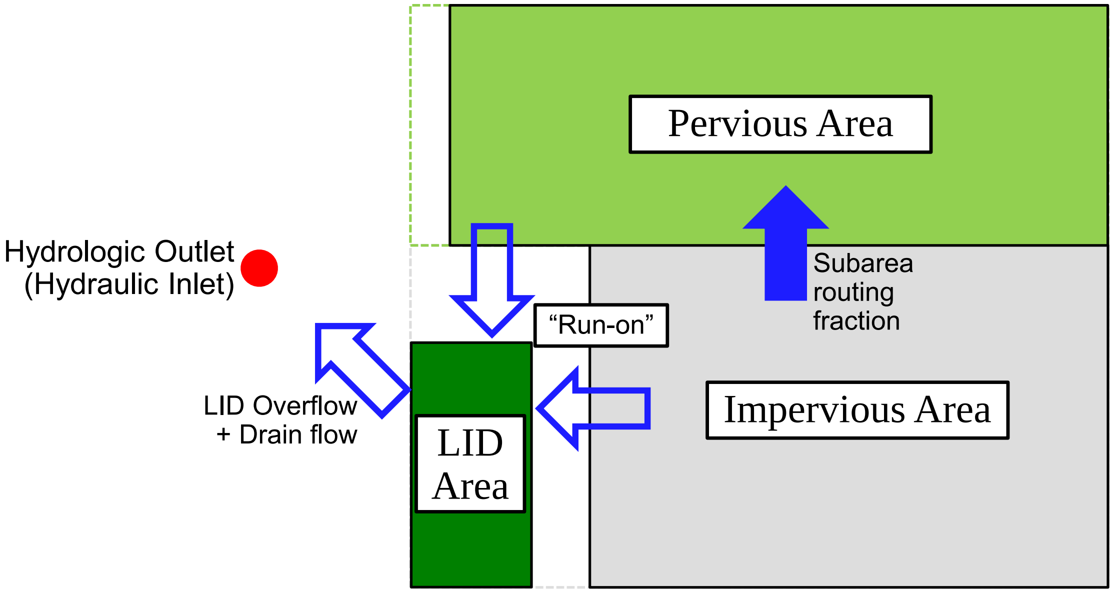
Modeling Approach No.1 schematic is presented below. As described above, a portion of the impervious subarea from a given subcatchment can be routed onto the pervious area for infiltration (see arrow denoting subarea routing fraction). When the LID module of SWMM is used, the portion of the impervious area that is captured and treated by an LID facility is specified (see arrow denoting LID area fraction). The remaining impervious area, if any, is routed directly to the outlet.



Modeling Approach No. 1 (LID within Parent Subcatchment)

The first approach is the easiest of the two for representing LID facilities in SWMM, as it allows a mix of controls to be placed within an existing subcatchment and each facility can capture and treat a different portion of the runoff generated from the parent subcatchment (i.e., outside of the LID footprint). A drawback of this approach is that it will not appropriately represent LID facilities in series (i.e., where the outflow from one LID control becomes the inflow to another LID control). No adjustments to the parent subcatchment hydrology parameters are needed if the cumulative LID area is small in comparison to the subcatchment area. However when the cumulative LID area is significant (e.g., greater than 10% of the subcatchment), at a minimum, the imperviousness and overland flow width values will need to be adjusted to compensate for the parent subcatchment area that was replaced with the cumulative LID footprint area.

Modeling Approach No.2 schematic is presented below. In this approach the LID facility is assigned to a new subcatchment and runoff from upstream subcatchments can be directed to this new subcatchment (i.e., “run-on”). In this way, LID controls can be modeled in series. Adjustments to the imperviousness and overland flow width values in the parent subcatchment will need to be made. For typical development or redevelopment sites that are evaluated in hydromodification management studies, LID capture areas often comprise a large portion of the parent subcatchments, and therefore this is the preferred approach.



Modeling Approach No. 2 (LID in New Subcatchment)

More details on the use and application of LID controls are provided in the SWMM Manual and program help file. Suggested parameter values for use with hydromodification management studies in San Diego are provided in **Appendix G.1.5.**

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 City Engineer 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.

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 simulated by including the various control structures such as the orifice, weir, gate, pump or other device directly in the hydraulic model. 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 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)

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, illustrate unsaturated soil and soil saturation, field capacity, and wilting point.

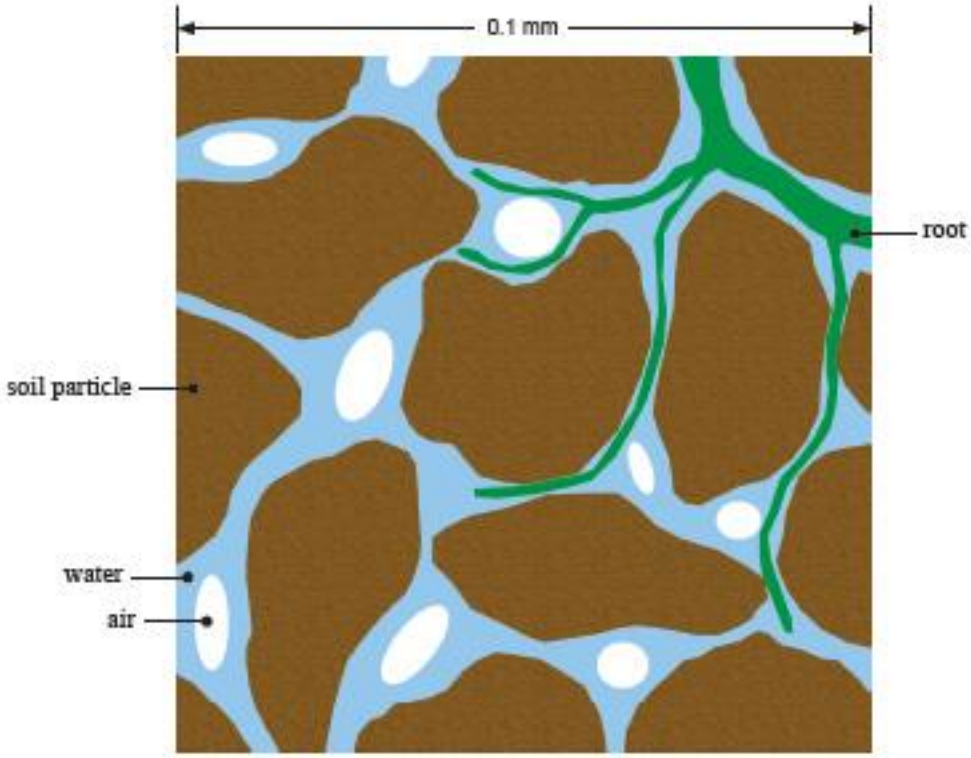


Figure G.1-3 : Unsaturated Soil Composition

Unsaturated soil is composed of solid particles, organic material and pores. The pore space will contain air and water.

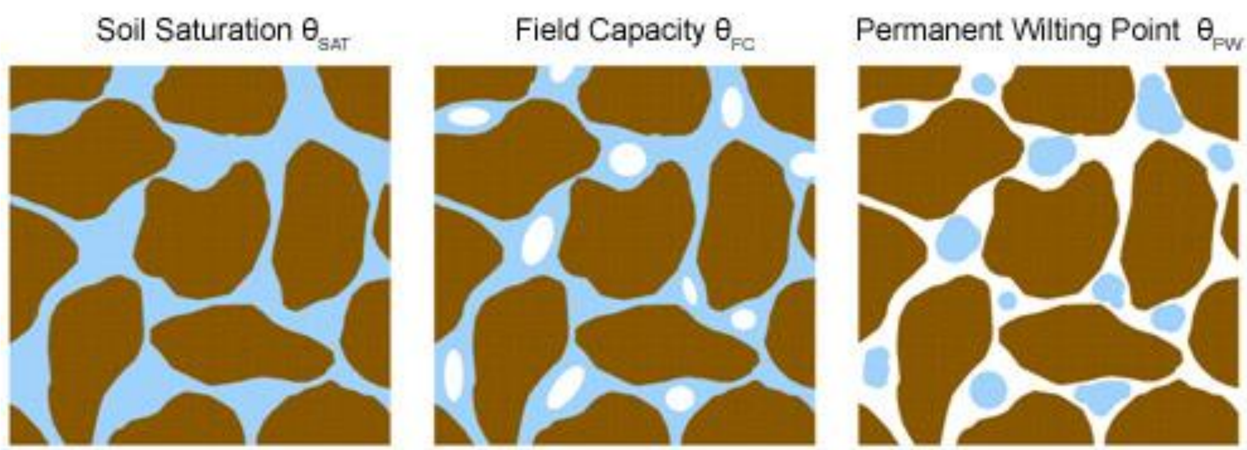


Figure G.1-4 : Soil saturation, field capacity, and wilting point

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 + void ratio).

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 **Appendix G.1.5.1**.

Additional Guidance for SWMM Users

The latest version of SWMM includes the following eight types of LID controls:

- Bio-Retention Cell: surface storage facility with vegetation in an engineered soil mixture placed above a gravel drainage bed.
- Rain Garden: same setup as bio-retention cell, but without an underlying gravel bed.
- Green Roof: bio-retention cell with shallow surface storage and soil layers, underlain by a drainage mat that conveys excess percolated rainfall to the regular roof drainage system.
- Infiltration Trench: drainage swale or narrow storage basin filled with gravel or other porous media designed to capture and infiltrate runoff to the native soil below.
- Permeable Pavement: continuous pavement systems with porous concrete, asphalt mix, or paver blocks above a sand or gravel drainage bed with gravel storage layer below.
- Rain Barrel: container (cistern) to collect roof runoff for later use (e.g., landscape irrigation) or release.
- Rooftop Disconnection: to simulate redirection of downspout discharge onto pervious landscaped areas and lawns instead of directly into storm drains.
- Vegetative Swale: grassed conveyance channel (drainage ditch or swale) with vegetation designed to slow down runoff to allow more time for infiltration into the native soil below.

The "bio-retention cell" LID control may be used to represent bioretention or biofiltration BMPs. For bio-retention cells, a number of LID process layers have been defined in SWMM and these are described below. 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" LID Control for Hydromodification Management Studies in San Diego

SWMM Parameter Name	Unit	Use in San Diego
Surface		
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)
Soil		
Thickness	inches	project-specific
Porosity	---	0.40
Field Capacity	---	0.2
Wilting Point	---	0.1
Conductivity	Inches/hour	5
Conductivity Slope	---	5
Suction Head	inches	1.5
Storage		
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
Underdrain		
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

Surface Layer

This process layer receives direct rainfall (and run-on from upstream subcatchments) and the resultant storm water is available for ponding, infiltration, evapotranspiration, or overflow to the outlet. The following parameters are used:

- Berm Height: This value is the maximum depth that water can pond above the ground surface before overflow occurs. In some cases, this volume may overlap with the hydraulic representation of existing surface storage or another proposed BMP facility. In any case, the user must avoid double-counting the physical storage volume.

- Vegetation Volume Fraction: This represents the surface storage volume that is occupied by the stems and leaves of vegetation within the bio-retention cell.

Soil Layer

This process layer is typically composed of an amended soil or compost mix. Water that infiltrates into this component is stored in the soil void space and is available for evapotranspiration via plant roots or can percolate into the storage layer below. The following parameters are used:

- Thickness: This parameter represents the depth of the amended soil layer.
- Porosity: Ratio of pore space volume to soil volume.
- Field Capacity: Pore water volume ratio after the soil has been drained.
- Wilting Point: Pore water volume ratio after the soil has been dried.
- Conductivity: This represents the saturated hydraulic conductivity.
- Conductivity Slope: Rate at which conductivity decreases with decreasing soil moisture content.
- Suction Head: This represents the capillary tension of water in the soil.

Porosity, conductivity and suction head values as a function of soil texture were included in Table G.1-5. The flow of water through partially saturated soil is less than under fully saturated conditions. The SWMM program accounts for this reduced hydraulic conductivity to predict the rate at which infiltrated water moves through a layer of unsaturated soil when modeling groundwater or LID controls. The conductivity slope is a dimensionless curve-fitting parameter that relates the partially saturated hydraulic conductivity to the soil moisture content.

Storage Layer

This process layer is typically composed of porous granular media such as crushed stone or gravel. Water that percolates into this component is stored in the void space and is available for infiltration into the native soil, or collected by an underdrain and discharged to the outlet. The following parameters are used:

- Thickness: This parameter represents the depth of the stone base.
- Void Ratio: Volume of void space relative to volume of solids. Note, by definition, Porosity = Void Ratio ÷ (1 + Void Ratio).
- Seepage Rate: Filtration rate from the granular media into the native soil below. A value of zero should be used if the facility has an impermeable bottom (e.g., concrete) or is underlain by an impermeable liner.
- Clogging Factor: This value is determined by the total volume of treated runoff to completely clog the bottom of the layer divided by the void volume of the layer.

Drain Layer

This process layer is used to characterize the discharge rate of an underdrain system to the outlet. The following parameters are used:

Flow Coefficient: This value (coupled with the flow exponent described below) characterizes the rate of discharge to the outlet as a function of the height of water stored in the bio-retention cell. The coefficient can be determined by the following equation:

$$C = c_g\left(\frac{605}{A_{LID}}\right)\left(\frac{\pi D^2}{8}\right)\sqrt{\frac{g}{6}}$$

where,

cg is the orifice discharge coefficient, typically 0.60-0.65 for thin walled plates and higher for thicker walls;
ALID is the cumulative footprint area (ft^2) of all LID controls;
D is the underdrain orifice diameter (in); and
g is the gravitational constant (32.2 ft/s^2).

- Flow Exponent: A value of 0.5 should be used to represent flow through an orifice.
- Offset Height: This represents the height of the underdrain above the bottom of the storage layer in the bio-retention cell.

G.1.6 Flow Duration Performance Standard

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 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 hydromodification management performance standards, peak flow frequency curves and 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 all, 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.
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 **Appendix G.1.6**).

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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 included here have been updated based on the requirements in the 2015 MS4 permit and are different than the sizing factors presented in previous manuals. These updated values replace the previous sizing factors which shall no longer be used for sizing of hydromodification flow control BMPs. A discussion of the rational for the update is included below.

The sizing factors included in previous edition was re-printed from the "San Diego BMP Sizing Calculator Methodology," dated January 2012, prepared by Brown and Caldwell (herein "BMP Sizing Calculator Methodology"). These sizing factors were linked to the specific details and descriptions that were presented in the BMP Sizing Calculator Methodology, which included certain assumptions and limited options for modifications. The sizing factors were developed based on the 2007 MS4 Permit. Some of the original sizing factors developed based on the 2007 MS4 Permit and presented in the BMP Sizing Calculator Methodology were not compatible with new requirements of the 2015 MS4 Permit, and therefore were not included in the February 2016 manual. Since publishing the 2016 Model Manual, the Copermittees have developed updated hydromodification factors that more accurately represent the BMP configurations specified in this model manual and account for the revised flow-duration performance standard of the 2015 MS4 Permit (110% exceedance allowance for entire flow-duration curve).

The updated sizing factors were generated using continuous simulation models in USEPA SWMM in accordance with the procedures, methodologies, and values presented in Appendix G.1. All sizing factors are in relation to the effective impervious area draining to the BMP.

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. When using the sizing factor methodology, the area fraction reported in the sizing tables represents the plan view area at the surface of the BMP before any ponding occurs. The BMP footprint as defined by this methodology is depicted in Figure G.2-1.

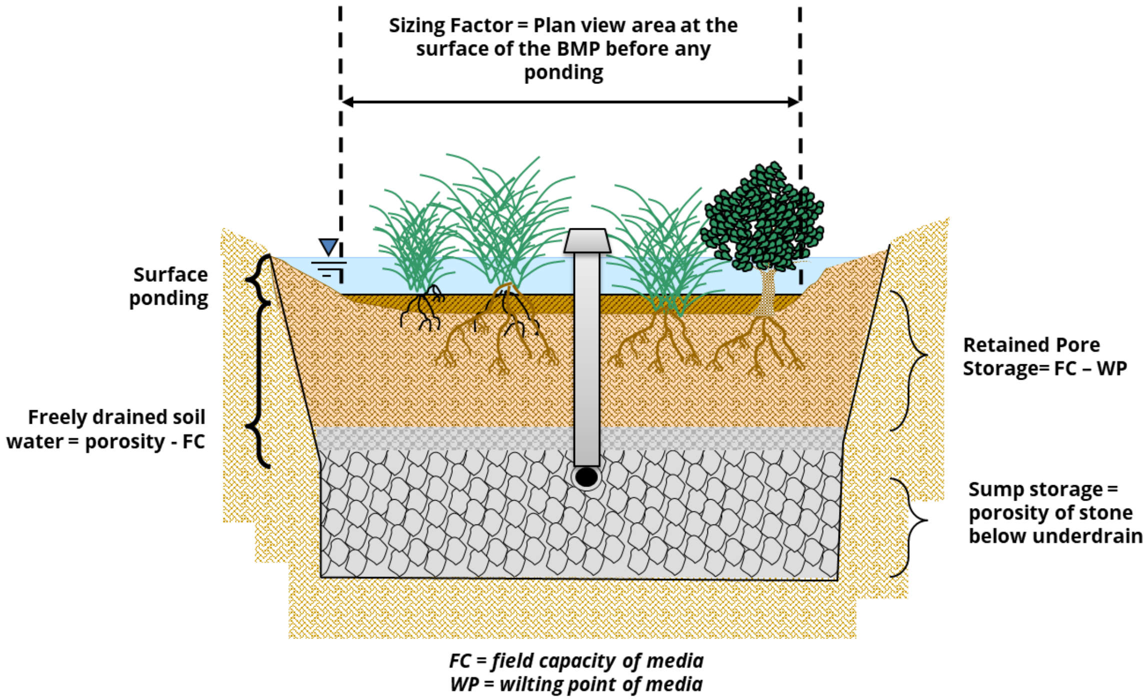

Figure G.2-1: Representation of BMP Footprint for use of Sizing Factors

Sizing factors are available for the following specific structural BMPs:

- **Full infiltration condition**:
  - **Infiltration**: Sizing factors available for A, B, C, and D soils represent surface and/or below-ground structures (infiltration vaults).
- **Partial infiltration condition:**
  - **Biofiltration with partial retention**: Sizing factors available for A, B, 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 and flow control orifice, with no impermeable liner.
- **No infiltration condition:**
  - **Biofiltration**: Sizing factors available for A, B, C and D soils represent a biofiltration system with engineered soil media and gravel storage layer, with an underdrain and flow control orifice, with gravel storage, with an impermeable liner (formerly known as flow-through planter and/or biofiltration with impermeable liner).
- **Other:**
  - **Cistern**: sizing factors available for A, B, C, or D soils represent a vessel with a flow control orifice outlet to meet the hydromodification management performance standard. For this BMP, the sizing factor result is a volume in cubic feet, not a surface footprint in square feet.

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.2-2, 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% – 10%, steep = >10%)
- 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 Q_2 to control (see Chapter 6.3.4)[23]

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.

[23] All updated sizing factors refer to the "High Susceptibility" threshold value of $0.1*Q_2$, where Q_2 is determined using the Weibull Plotting position and results of the SWMM model runs for unit pervious catchments (refer to Table G.2-2).

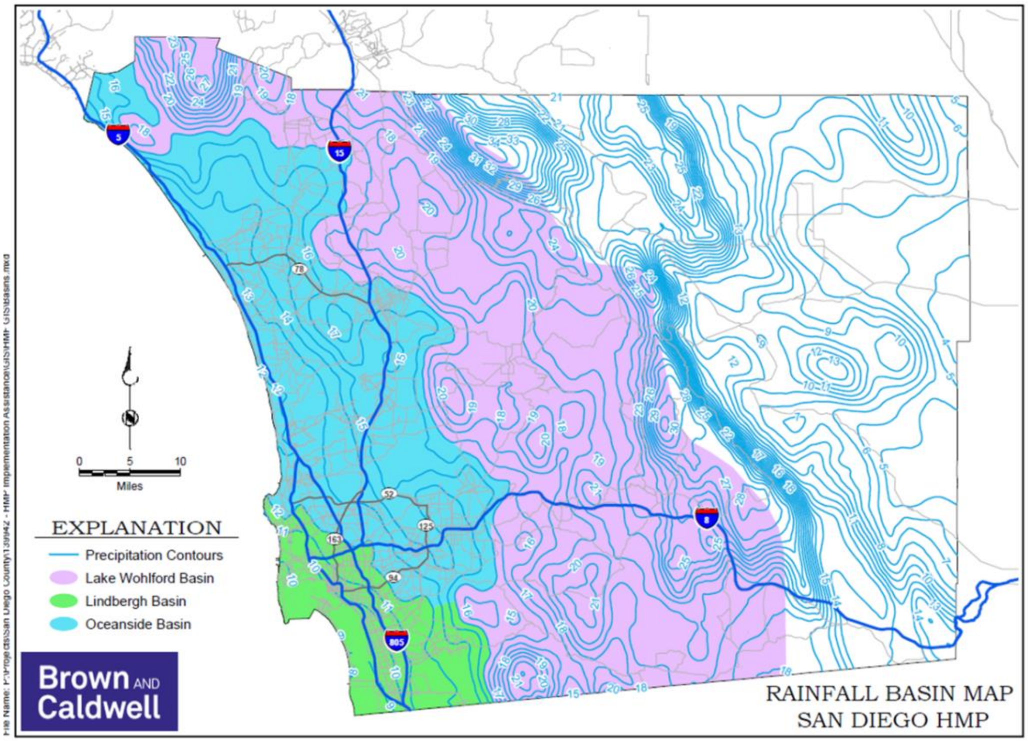

Figure G.2-2: Rainfall Basin Map

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

Worksheet G.2-1: Sizing Factors Worksheet

Site Information			
Project Name:		**Hydrologic Unit**	
Project Applicant:		**Rain Gauge:**	
Jurisdiction:		**Total Project Area:**	
Assessor's Parcel Number:		**Low Flow Threshold:**	$0.1Q_2$
BMP Name:		**BMP Type:**	

Areas Draining to BMP						Sizing Factors		Minimum BMP Size	
DMA Name	**Area (sf)**	**Soil Type**	**Slope**	**Post Project Surface Type**	**Runoff Factor (From Table G.2-1)**	**Surface Area**	**Volume**	**Surface Area (sf)**	**Volume (cf)**
Total DMA Area							**Minimum BMP Size***		
							Proposed BMP Size*		

***Minimum BMP Size = Total of rows above.**

***Proposed BMP Size ≥ Minimum BMP size.**

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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, or cistern BMPs. There is no low flow orifice in the infiltration BMP. The unit runoff ratios are updated from the previously reported BMP Sizing Calculator methodology ratios to account for changes in modeling methodologies. 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

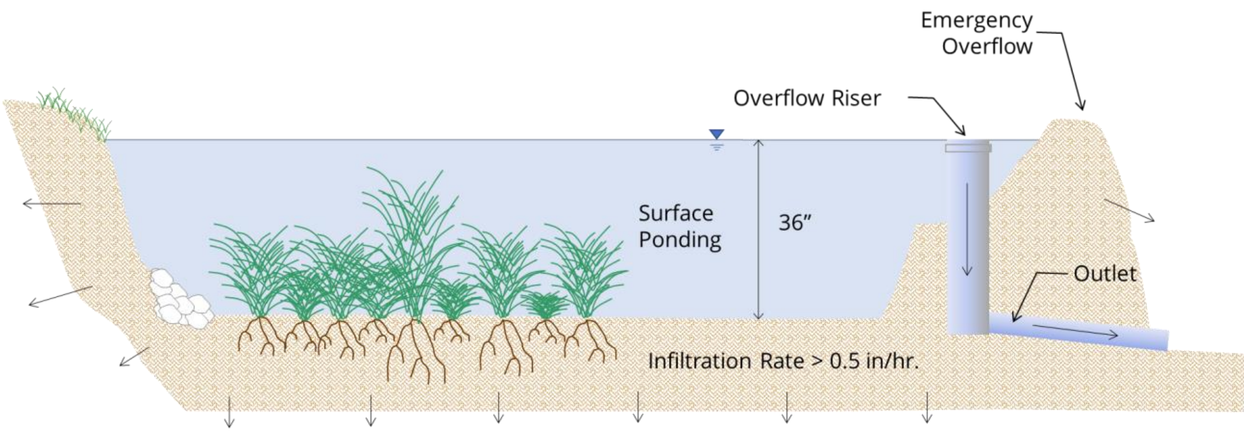
Rain Gauge	Soil	Slope	Q_2 (cfs/acre)	Q_{10} (cfs/ac)
Lake Wohlford	A	Low	0.256	0.518
Lake Wohlford	A	Moderate	0.275	0.528
Lake Wohlford	A	Steep	0.283	0.531
Lake Wohlford	B	Low	0.371	0.624
Lake Wohlford	B	Moderate	0.389	0.631
Lake Wohlford	B	Steep	0.393	0.633
Lake Wohlford	C	Low	0.490	0.729
Lake Wohlford	C	Moderate	0.495	0.733
Lake Wohlford	C	Steep	0.496	0.735
Lake Wohlford	D	Low	0.548	0.784
Lake Wohlford	D	Moderate	0.554	0.788
Lake Wohlford	D	Steep	0.556	0.788
Oceanside	A	Low	0.256	0.679
Oceanside	A	Moderate	0.277	0.694
Oceanside	A	Steep	0.285	0.700

Rain Gauge	Soil	Slope	Q_2 (cfs/acre)	Q_{10} (cfs/ac)
Oceanside	B	Low	0.377	0.875
Oceanside	B	Moderate	0.391	0.879
Oceanside	B	Steep	0.395	0.881
Oceanside	C	Low	0.488	0.981
Oceanside	C	Moderate	0.497	0.985
Oceanside	C	Steep	0.499	0.986
Oceanside	D	Low	0.571	0.998
Oceanside	D	Moderate	0.575	0.999
Oceanside	D	Steep	0.576	0.999
Lindbergh	A	Low	0.057	0.384
Lindbergh	A	Moderate	0.073	0.399
Lindbergh	A	Steep	0.082	0.403
Lindbergh	B	Low	0.199	0.496
Lindbergh	B	Moderate	0.220	0.509
Lindbergh	B	Steep	0.230	0.513
Lindbergh	C	Low	0.335	0.601
Lindbergh	C	Moderate	0.349	0.610
Lindbergh	C	Steep	0.354	0.613
Lindbergh	D	Low	0.429	0.751
Lindbergh	D	Moderate	0.437	0.753
Lindbergh	D	Steep	0.439	0.753

G.2.2 Sizing Factors for "Infiltration" BMP

Table G.2-3 presents sizing factors for calculating the required surface area (A) 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 B, C, and D. This BMP is generally not applicable in hydrologic soil groups C and D, but applicants have the option if there are no geotechnical or water balance issues and the underlying design infiltration rate for the BMP is greater than 0.5 inches per hour. The infiltration BMP is surface ponding feature that allows infiltration into the native or amended soils of the BMP surface.

- **Ponding layer**: a nominal 36-inch ponding layer shall be included below the overflow elevation.
- **Design infiltration rate**: the design infiltration rate shall be greater than 0.5 inches per hour.
- **Overflow structure:** San Diego Regional Standard Drawing Type I Catch Basin (D-29). For the purposes of hydromodification flow control other type of overflow structures are allowed.



Infiltration BMP Example Illustration

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 Q_2, hydrologic soil group, post-project 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) for the infiltration BMP. The civil engineer shall provide the necessary surface area of the BMP on the plans.

Additional steps to use this BMP as a combined pollutant control and flow control BMP:

The BMP sized using the sizing factors in Table G.2-3 meets both pollutant control and flow control requirements.

Table G.2-3: Sizing Factors for Hydromodification Flow Control Infiltration BMPs Designed Using Sizing Factor Method

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A
$0.1Q_2$	A	Flat	Lindbergh	0.055
$0.1Q_2$	A	Moderate	Lindbergh	0.055
$0.1Q_2$	A	Steep	Lindbergh	0.055
$0.1Q_2$	B	Flat	Lindbergh	0.045
$0.1Q_2$	B	Moderate	Lindbergh	0.045
$0.1Q_2$	B	Steep	Lindbergh	0.045
$0.1Q_2$	C	Flat	Lindbergh	0.035
$0.1Q_2$	C	Moderate	Lindbergh	0.035
$0.1Q_2$	C	Steep	Lindbergh	0.035
$0.1Q_2$	D	Flat	Lindbergh	0.030
$0.1Q_2$	D	Moderate	Lindbergh	0.030
$0.1Q_2$	D	Steep	Lindbergh	0.030
$0.1Q_2$	A	Flat	Oceanside	0.060
$0.1Q_2$	A	Moderate	Oceanside	0.060
$0.1Q_2$	A	Steep	Oceanside	0.060
$0.1Q_2$	B	Flat	Oceanside	0.050
$0.1Q_2$	B	Moderate	Oceanside	0.050
$0.1Q_2$	B	Steep	Oceanside	0.050
$0.1Q_2$	C	Flat	Oceanside	0.050
$0.1Q_2$	C	Moderate	Oceanside	0.050
$0.1Q_2$	C	Steep	Oceanside	0.045
$0.1Q_2$	D	Flat	Oceanside	0.035
$0.1Q_2$	D	Moderate	Oceanside	0.035
$0.1Q_2$	D	Steep	Oceanside	0.035
$0.1Q_2$	A	Flat	L Wohlford	0.085
$0.1Q_2$	A	Moderate	L Wohlford	0.085
$0.1Q_2$	A	Steep	L Wohlford	0.085
$0.1Q_2$	B	Flat	L Wohlford	0.070
$0.1Q_2$	B	Moderate	L Wohlford	0.070
$0.1Q_2$	B	Steep	L Wohlford	0.070
$0.1Q_2$	C	Flat	L Wohlford	0.055
$0.1Q_2$	C	Moderate	L Wohlford	0.055

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A
$0.1Q_2$	C	Steep	L Wohlford	0.055
$0.1Q_2$	D	Flat	L Wohlford	0.040
$0.1Q_2$	D	Moderate	L Wohlford	0.040
$0.1Q_2$	D	Steep	L Wohlford	0.040

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

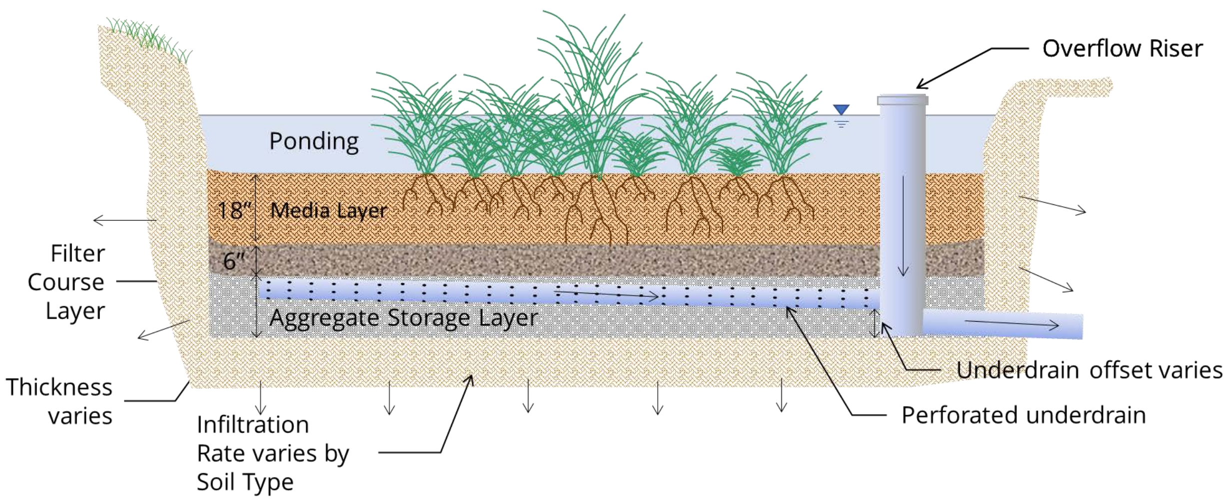
A = Surface area (at surface of the BMP before any ponding occurs) sizing factor for flow control

G.2.3 Sizing Factors for Biofiltration with Partial Retention

Table G.2-4 presents sizing factors for calculating the required surface area (A) for a biofiltration with partial retention BMP. The BMPs consist of four layers:

- **Ponding layer**: 12-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- **Growing medium**: 18-inches of soil [bioretention soil media]
- **Filter Course**: 6-inches
- **Storage layer**: 18-inches of gravel at 40 percent porosity for A and B soils and 12-inches of gravel at 40 percent porosity for C and D soils. The underdrain offset for A and B soils shall be 18-inches, for C soils it shall be 6-inches and for D soils it shall be 3-inches.
- **Overflow structure:** San Diego Regional Standard Drawing Type I Catch Basin (D-29). For the purposes of hydromodification flow control other type of overflow structures are allowed.

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 (Refer to Appendix G.2.4).



Biofiltration with Partial Retention BMP Example Illustration

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, post-project 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). Select a low flow orifice for the underdrain that will discharge the lower flow threshold flow at the overflow riser elevation. The civil engineer shall provide the necessary 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:

The BMP sized using the sizing factors in Table G.2-4 meets both pollutant control and flow control requirements.

Table G.2-4: Sizing Factors for Hydromodification Flow Control Biofiltration with Partial Retention BMPs Designed Using Sizing Factor Method

Lower Flow Threshold	Soil Group	Slope	Aggregate below low orifice invert (inches)	Rain Gauge	A
$0.1Q_2$	A	Flat	18	Lindbergh	0.080
$0.1Q_2$	A	Moderate	18	Lindbergh	0.080
$0.1Q_2$	A	Steep	18	Lindbergh	0.080
$0.1Q_2$	B	Flat	18	Lindbergh	0.065
$0.1Q_2$	B	Moderate	18	Lindbergh	0.065
$0.1Q_2$	B	Steep	18	Lindbergh	0.060
$0.1Q_2$	C	Flat	6	Lindbergh	0.050
$0.1Q_2$	C	Moderate	6	Lindbergh	0.050
$0.1Q_2$	C	Steep	6	Lindbergh	0.050
$0.1Q_2$	D	Flat	3	Lindbergh	0.050
$0.1Q_2$	D	Moderate	3	Lindbergh	0.050
$0.1Q_2$	D	Steep	3	Lindbergh	0.050
$0.1Q_2$	A	Flat	18	Oceanside	0.080
$0.1Q_2$	A	Moderate	18	Oceanside	0.075
$0.1Q_2$	A	Steep	18	Oceanside	0.075
$0.1Q_2$	B	Flat	18	Oceanside	0.070
$0.1Q_2$	B	Moderate	18	Oceanside	0.070
$0.1Q_2$	B	Steep	18	Oceanside	0.070
$0.1Q_2$	C	Flat	6	Oceanside	0.070
$0.1Q_2$	C	Moderate	6	Oceanside	0.070
$0.1Q_2$	C	Steep	6	Oceanside	0.070
$0.1Q_2$	D	Flat	3	Oceanside	0.070
$0.1Q_2$	D	Moderate	3	Oceanside	0.070
$0.1Q_2$	D	Steep	3	Oceanside	0.070
$0.1Q_2$	A	Flat	18	L Wohlford	0.110
$0.1Q_2$	A	Moderate	18	L Wohlford	0.110

Lower Flow Threshold	Soil Group	Slope	Aggregate below low orifice invert (inches)	Rain Gauge	A
$0.1Q_2$	A	Steep	18	L Wohlford	0.105
$0.1Q_2$	B	Flat	18	L Wohlford	0.090
$0.1Q_2$	B	Moderate	18	L Wohlford	0.085
$0.1Q_2$	B	Steep	18	L Wohlford	0.085
$0.1Q_2$	C	Flat	6	L Wohlford	0.065
$0.1Q_2$	C	Moderate	6	L Wohlford	0.065
$0.1Q_2$	C	Steep	6	L Wohlford	0.065
$0.1Q_2$	D	Flat	3	L Wohlford	0.060
$0.1Q_2$	D	Moderate	3	L Wohlford	0.060
$0.1Q_2$	D	Steep	3	L Wohlford	0.060

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

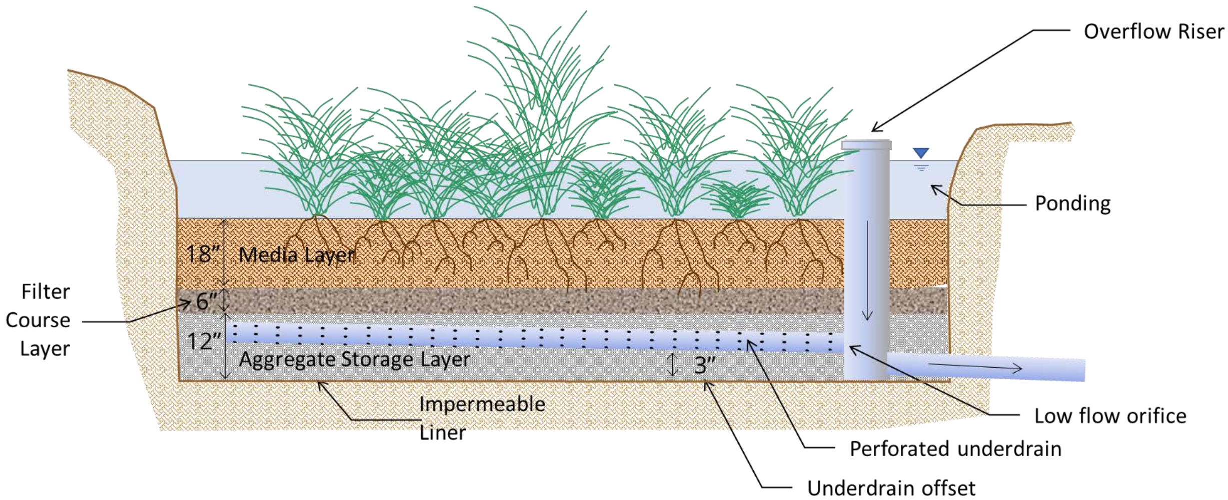
A = Surface area (at surface of the BMP before any ponding occurs) sizing factor for flow control

G.2.4 Sizing Factors for Biofiltration

Table G.2-5 presents sizing factors for calculating the required surface area (A) for a biofiltration BMP (formerly known as flow-through planter and/or biofiltration BMP with impermeable liner). The BMPs consist of four layers:

- **Ponding layer**: 12-inches active storage, [minimum] 2-inches of freeboard above overflow relief
- **Growing medium**: 18-inches of soil [bioretention soil media]
- **Filter Course**: 6-inches
- **Storage layer**: 12-inches of gravel at 40 percent porosity. The underdrain offset shall be 3-inches.
- **Overflow structure:** San Diego Regional Standard Drawing Type I Catch Basin (D-29). For the purposes of hydromodification flow control other type of overflow structures are allowed.

This BMP includes an impermeable liner to prevent infiltration into underlying soils.



Biofiltration BMP Example Illustration

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, post-project 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). Select a low flow orifice for the underdrain that will discharge the lower flow threshold flow at the overflow riser elevation. The civil engineer shall provide the necessary 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:

The BMP sized using the sizing factors in Table G.2-5 meets both pollutant control and flow control requirements except for surface drawdown requirements. Applicant must perform surface drawdown calculations and if needed develop a vector management plan (Refer to Section 6.3.7) or revise the BMP design to meet the drawdown requirements. If changes are made to the BMP design applicants must perform site specific continuous simulation modeling (Refer to Appendix G).

Table G.2-5: Sizing Factors for Hydromodification Flow Control Biofiltration BMPs Designed Using Sizing Factor Method

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A
$0.1Q_2$	A	Flat	Lindbergh	0.320
$0.1Q_2$	A	Moderate	Lindbergh	0.300
$0.1Q_2$	A	Steep	Lindbergh	0.285
$0.1Q_2$	B	Flat	Lindbergh	0.105
$0.1Q_2$	B	Moderate	Lindbergh	0.100
$0.1Q_2$	B	Steep	Lindbergh	0.095
$0.1Q_2$	C	Flat	Lindbergh	0.055
$0.1Q_2$	C	Moderate	Lindbergh	0.050
$0.1Q_2$	C	Steep	Lindbergh	0.050
$0.1Q_2$	D	Flat	Lindbergh	0.050
$0.1Q_2$	D	Moderate	Lindbergh	0.050
$0.1Q_2$	D	Steep	Lindbergh	0.050
$0.1Q_2$	A	Flat	Oceanside	0.150
$0.1Q_2$	A	Moderate	Oceanside	0.140
$0.1Q_2$	A	Steep	Oceanside	0.135
$0.1Q_2$	B	Flat	Oceanside	0.085
$0.1Q_2$	B	Moderate	Oceanside	0.085
$0.1Q_2$	B	Steep	Oceanside	0.085
$0.1Q_2$	C	Flat	Oceanside	0.075
$0.1Q_2$	C	Moderate	Oceanside	0.075
$0.1Q_2$	C	Steep	Oceanside	0.075
$0.1Q_2$	D	Flat	Oceanside	0.070
$0.1Q_2$	D	Moderate	Oceanside	0.070
$0.1Q_2$	D	Steep	Oceanside	0.070
$0.1Q_2$	A	Flat	L Wohlford	0.285
$0.1Q_2$	A	Moderate	L Wohlford	0.275

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A
$0.1Q_2$	A	Steep	L Wohlford	0.270
$0.1Q_2$	B	Flat	L Wohlford	0.150
$0.1Q_2$	B	Moderate	L Wohlford	0.145
$0.1Q_2$	B	Steep	L Wohlford	0.145
$0.1Q_2$	C	Flat	L Wohlford	0.070
$0.1Q_2$	C	Moderate	L Wohlford	0.070
$0.1Q_2$	C	Steep	L Wohlford	0.070
$0.1Q_2$	D	Flat	L Wohlford	0.060
$0.1Q_2$	D	Moderate	L Wohlford	0.060
$0.1Q_2$	D	Steep	L Wohlford	0.060

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Surface area (at surface of the BMP before any ponding occurs) sizing factor for flow control

G.2.5 Sizing Factors for "Cistern" BMP

Table G.2-6 presents sizing factors for calculating the required volume (V) 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. 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.2-6 based on the project's lower flow threshold fraction of Q_2, hydrologic soil group, post-project 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, cubic feet). Select a low flow orifice that will discharge the lower flow threshold flow at the overflow elevation (i.e. when there is 3.5 feet of head over the lower outlet orifice or adjusted head as appropriate if the cistern overflow elevation is not 3.5 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 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.2-6: Sizing Factors for Hydromodification Flow Control Cistern BMPs Designed Using Sizing Factor Method

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	V
$0.1Q_2$	A	Flat	Lindbergh	0.54
$0.1Q_2$	A	Moderate	Lindbergh	0.51
$0.1Q_2$	A	Steep	Lindbergh	0.49
$0.1Q_2$	B	Flat	Lindbergh	0.19
$0.1Q_2$	B	Moderate	Lindbergh	0.18
$0.1Q_2$	B	Steep	Lindbergh	0.18
$0.1Q_2$	C	Flat	Lindbergh	0.11
$0.1Q_2$	C	Moderate	Lindbergh	0.11
$0.1Q_2$	C	Steep	Lindbergh	0.11
$0.1Q_2$	D	Flat	Lindbergh	0.09
$0.1Q_2$	D	Moderate	Lindbergh	0.09
$0.1Q_2$	D	Steep	Lindbergh	0.09
$0.1Q_2$	A	Flat	Oceanside	0.26
$0.1Q_2$	A	Moderate	Oceanside	0.25
$0.1Q_2$	A	Steep	Oceanside	0.25
$0.1Q_2$	B	Flat	Oceanside	0.16
$0.1Q_2$	B	Moderate	Oceanside	0.16
$0.1Q_2$	B	Steep	Oceanside	0.16
$0.1Q_2$	C	Flat	Oceanside	0.14
$0.1Q_2$	C	Moderate	Oceanside	0.14
$0.1Q_2$	C	Steep	Oceanside	0.14
$0.1Q_2$	D	Flat	Oceanside	0.12
$0.1Q_2$	D	Moderate	Oceanside	0.12
$0.1Q_2$	D	Steep	Oceanside	0.12
$0.1Q_2$	A	Flat	L Wohlford	0.53
$0.1Q_2$	A	Moderate	L Wohlford	0.49
$0.1Q_2$	A	Steep	L Wohlford	0.49
$0.1Q_2$	B	Flat	L Wohlford	0.28
$0.1Q_2$	B	Moderate	L Wohlford	0.28
$0.1Q_2$	B	Steep	L Wohlford	0.28

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	V
$0.1Q_2$	C	Flat	L Wohlford	0.14
$0.1Q_2$	C	Moderate	L Wohlford	0.14
$0.1Q_2$	C	Steep	L Wohlford	0.14
$0.1Q_2$	D	Flat	L Wohlford	0.12
$0.1Q_2$	D	Moderate	L Wohlford	0.12
$0.1Q_2$	D	Steep	L Wohlford	0.12

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
V = Cistern volume sizing factor

Appendix H

Guidance for Investigating Potential Critical Coarse Sediment Yield Areas

The following guidance provides methodologies for protecting CCSYAs:

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H.1 Step 1: Identify CCSYAs

A CCSYA is an active or potential source of bed sediment to downstream channel reaches. When a Priority Development Project (PDP) is constructed, it has the potential to negatively impact characteristics of sediment supply and delivery. In order to prevent these impacts, PDP applicants must examine the tributaries identified in their storm water management plans and identify sources of critical coarse sediment within the following areas:

- Onsite CCSYAs: CCSYAs identified within the project's property boundary as indicated in the SWQMP. Refer to **Section 1.3** for defining a project.
- Upstream CCSYAs: CCSYAs identified within the drainage area draining through the project's property boundary as indicated in the SWQMP. Refer to **Section 1.3** for defining a project.

Applicants must first identify **potential** critical coarse sediment yield areas (PCCSYAs) per any one of the methods presented in **Section H.1.1**. Once these PCCSYAs are identified, applicants may either accept the PCCSYA mapping as final, or may elect to further refine the results of the mapping through consideration of the refinement methods outlined in **Appendix H.1.2**. At the end of Step 1, applicants will have identified CCSYAs that must be avoided and bypassed by the project.

H.1.1 Identification Methods

Applicants must identify onsite and/or upstream sources of critical coarse sediment through examination of the Regional Watershed Management Area Analysis PCCSYA maps provided in **Appendix H.6**.

H.1.2 Refinement Options

After identifying PCCSYAs using the method above, the applicant may either accept the PCCSYA mapping as final, or may elect to further refine the results of the mapping through consideration of one or more of the refinement methods outlined below.

H.1.2.1 Depositional Analysis

Areas identified as PCCSYAs may be removed from consideration if it is demonstrated that these sources are deposited into existing systems prior to reaching the first downstream unlined water of the state. Systems resulting in deposition may include existing natural sinks, existing structural BMPs, existing hardened MS4 systems, or other existing similar features that produce a peak velocity from the discrete 2-year, 24-hour runoff event of less than three feet per second in the system being analyzed. Applicants electing to perform depositional analysis to refine PCCSYA mapping must refer to the detailed guidance provided in **Appendix H.7.1**.

H.1.2.2 Threshold Channel Analysis

Areas identified as PCCSYAs may be removed from consideration if they discharge to a "threshold channel" that does not exhibit characteristics associated with significant bed load movement during design flows. Applicants electing to perform threshold channel analysis to refine PCCSYA mapping must refer to the detailed guidance provided in **Appendix H.7.2**.

H.1.2.3 Coarse Sediment Source Area Verification

Areas identified as PCCSYAs may be removed from consideration if an applicant demonstrates that these areas actually consist of fine grained sediment. Applicants electing to perform coarse sediment source area verification to refine PCCSYA mapping must refer to the detailed guidance provided in **Appendix H.7.3**.

H.1.2.4 Verification of Geomorphic Landscape Units (GLUs)

Areas identified as PCCSYAs may be refined through verification of GLUs. If this method is used, applicants must refer to detailed guidance provided in **Appendix H.6.1**.

H.2 Step 2: Avoidance of Onsite CCSYAs

A key element of preserving the stability of receiving waters is to avoid changes in bed sediment supply by avoiding development on CCSYAs. Avoidance is best achieved through proper site design. The following are some potential strategies that should be considered while determining the site layout to avoid CCSYAs:

- The civil engineer shall designate onsite CCSYAs that are to be avoided (undisturbed) for the purpose of preserving coarse soil supply. When feasible, use and/or access restriction should be established for these areas.
- Minimize new impervious footprint. Refer to **Chapter 4** for guidance on minimizing impervious footprint.

If onsite CCSYAs are not avoided per the metrics defined below, the applicant must demonstrate no net impact to the receiving water using guidance in **Appendix H.4**.

H.2.1 Avoidance Metrics

If the applicant has identified onsite CCSYAs using the Regional Watershed Management Area Analysis PCCSYA maps provided in **Appendix H.6**, encroachments of up to 5% into the onsite CCSYAs may be permitted.

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H.3 Step 3: Bypass Onsite and Upstream CCSYAs

Another key element of preserving the stability of receiving waters is to maintain current bed sediment supply characteristics through effective bypass of onsite and upstream sediment sources. Upstream bed sediment sources may include overland flow from CCSYAs and/or concentrated channel flows. Applicants must ensure both onsite and upstream sources of bed sediment are effectively bypassed through their project. If onsite and/or upstream CCSYAs are not effectively bypassed per the criteria below, applicant must demonstrate no net impact to the receiving water per the guidance presented in **Appendix H.4**.

H.3.1 Bypass CCSYAs from Hillslopes

Both onsite and upstream hillslopes mapped as CCSYAs must be effectively bypassed through and/or around the proposed project site.

- Proposed hardened drainage systems (e.g. storm drains, drainage ditches) that convey the bed sediment from the hillslopes to the downstream waters of the state should maintain a peak velocity from the discrete 2-year, 24-hour runoff event greater than three feet per second.
  - When drainage ditches are proposed for bypass, this velocity may be achieved by designing to the minimum dimensions listed in the San Diego Regional Standard drawing D-75.
  - When an 18" concrete storm drain is proposed for bypass, this velocity may typically be achieved by maintaining a storm drain slope of ≥0.5%. In instances where 2-year, 24-hour peak flow rates associated with the storm drain are less than 1.1 cfs, applicants may refer to the table below for minimum slopes needed to maintain three feet per second. Applicants may interpolate the values from the table below, or may elect to perform more detailed cleansing velocity calculations presented in **Appendix H.7.1**.

2-Year, 24-Hour Peak Flow (cfs)	Minimum Slope for 18" Concrete Storm Drain
<0.25	n/a, this PCCSYA is considered de-minimis
0.25	2.0%
0.50	1.0%
1.10	0.5%

- Storm water runoff that contains the bed sediment from CCSYAs must not be routed through detention basins or other facilities with restricted outlets that will trap sediment. Bypass systems shall be designed as necessary so that the bed material is conveyed to the downstream receiving water. Structural BMPs (including most flow-thru BMPs) are likely to trap sediment.
- For scenarios where a BMP must be constructed to treat offsite drainage area and there are CCSYAs outside of the project footprint, it may be feasible to achieve mitigation by

construction of an outlet structure that can convey the bed load to the downstream receiving water and clear water through a bypass structure to a BMP.

- Proposed crossings (culverts, driveways, etc.) should not impede the transport of upstream critical coarse sediment. Crossings should be designed to avoid headwater conditions that would result in the trapping/settling of sediment.

H.3.2 Bypass CCSYAs from Channels

Projects that effectively avoid and bypass CCSYAs mapped in Step 1 (**i.e., Appendix H.1**) of this guidance are not required to take specific action to ensure bypass of channel flows. This guidance does not set forth channel bypass criteria for this scenario because it recognizes that existing regulator mechanisms (such as 401 certifications, site design requirements, etc.) are generally sufficient to preserve the sediment transport functions of onsite channels.

However, projects that do not effectively avoid and bypass the CCSYAs mapped in Step 1 (**i.e., Appendix H.1**), will be required to specifically account for bypass of channel flows as part of the demonstration of no net impact outlined in **Appendix H.4**.

H.3.3 De Minimis Upstream CCSYA

Applicants have an option to exclude de minimis upstream CCSYAs. De minimis upstream CCSYAs consist of coarse hillslope areas that are not significant contributors of bed sediment yield due to their small size, and are considered by the owner and the City Engineer as not practicable to bypass to the downstream waters of the state. In limited scenarios where all of the criteria below are satisfied, de minimis upstream CCSYAs may be omitted from consideration.

- De minimis upstream CCSYA is not disturbed through the proposed project activities.
- De minimis upstream CCSYA is not part of an upstream drainage contributing more than 0.31 total acres to the project site.
- Multiple de minimis upstream CCSYAs cannot be adjacent to each other and hydraulically connected.
- The SWQMP must document the reason why each de minimis upstream CCSYA could not be bypassed to the downstream waters of the state.

The 0.31-acre (13,500 square feet) de minimis threshold was established using 0.25 cfs as the cut off peak flow for the 2-year, 24-hour event, rational method equation and the following assumptions:

- C = 0.225 (average runoff coefficient (C) for soil type A and B);
- Average 6-hour, 2-year storm depth = 1.5 inches;
- Time of concentration = 6 minutes; and
- 2-year peak intensity = 3.51 in/hr. (based on procedures from the County Hydrology Manual).

The strategies for sediment bypass do not mitigate for the reduction of CCSYA that have been replaced by development onsite but can only mitigate scenarios where development hinders movement of bed sediment through the project footprint. When preservation of existing channels and/or implementation of sediment bypass measures is not feasible and/or not implemented, the applicant must demonstrate no net impact to the receiving water via the guidance presented in **Appendix H.4**.

H.4 Step 4: Demonstrate No Net Impact

When impacts to CCSYAs cannot be avoided or effectively bypassed, the applicant must demonstrate that their project generates no net impact to the receiving water per the performance metrics identified herein.

- **Appendix H.4.1** provides background on the state of the current science for predicting hydromodification impacts due to reductions in sediment supply;
- **Appendix H.4.2** defines the management standard that will be the basis for evaluating whether "no net impact to the receiving water" is achieved;
- **Appendix H.4.3** identifies the type of mitigation measures (i.e., additional flow control, and applicant proposed mitigation measures) that can be used to meet the management standard;
- **Appendix H.8** provides the methodology for calculation of Erosion Potential (Ep) and Sediment Supply Potential (Sp); and
- **Appendix H.9** provides fact sheets for implementation of the mitigation measures.

H.4.1 Background

Channel form, by definition, is composed of bed and bank material as well as channel geometry (in plan, cross-section, and profile); however, the dominant forces typically controlling channel form are discharge and sediment supply (notably bed material) since a stream's most basic function is to convey water and sediment (Knighton, 1998). The interaction between form and function is qualitatively described through Lane's relationship in Equation H.4-1:

Equation H.4-1: Lane's Relationship

$$Q_s \times d \propto Q_w \times S$$

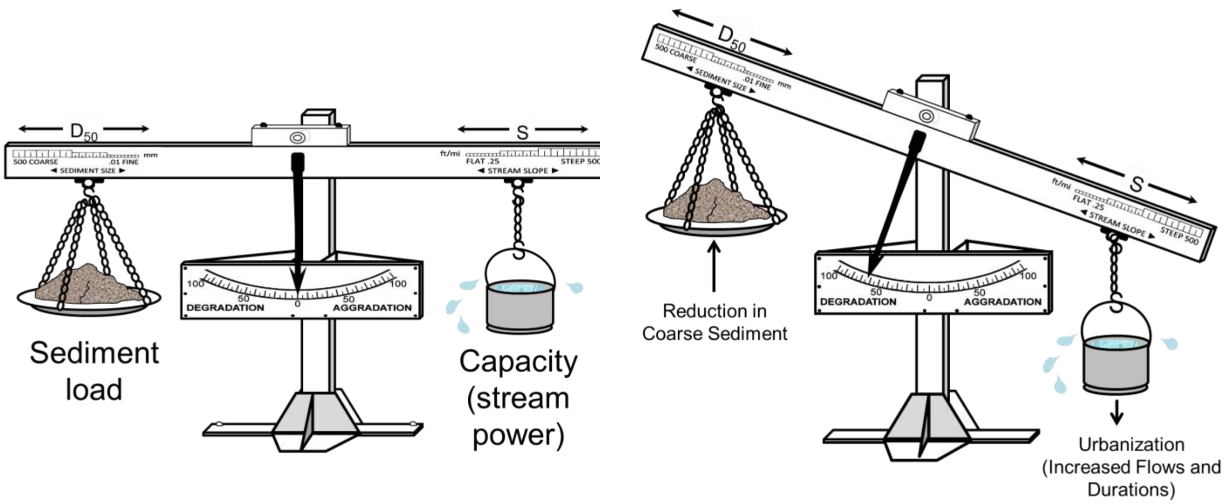
Where
Q_s = Sediment discharge
d = Particle diameter or size of sediment
Q_w = Streamflow
S = Stream slope

Lane's relationship qualitatively states that the sediment load (size and volume of sediment), which is the first half of the relationship, is proportional to the stream power (volume of runoff and slope) which is represented by the second half of the relationship. The sediment discharge (Q_s) in the relationship is the coarser part of sediment load, referred to as the "bed sediment", since this is the part of the load which largely molds the bed formation (Lane, 1955). Lane's relationship (Equation H.4.1) cannot be used for quantitative calculations since the proportionality is not necessarily linear.

For a stream at equilibrium, Lane's relationship states that if one of the variables changes and the other variables do not change proportionately, then the stream channel is no longer in equilibrium.

Sediment load and stream power can change considerably during and following new development, leading to changes in the equilibrium state of the receiving channel.

- Typically, sediment load increases during the construction period, due to the additional exposure of bare soil during the grading and construction process, and before landscaping vegetation has stabilized the soil. This is regulated through the construction-phase BMP requirements established by the Construction General Permit and/or the MS4 Permit.
- Following the construction period, sediment load typically decreases to below pre-development levels, as less sediment is available from areas that have been paved or stabilized by landscape vegetation. When this decrease is not regulated, the bed sediment supplied to the stream (first half of the relationship) is reduced and the sediment transport capacity (stream power) is increased due to increased flows and durations resulting from the addition of impervious areas (second half of the relationship). This may result in degradation of the stream system as illustrated in Figure H.4-1.



Stream in equilibrium

Post-construction condition with no flow control and/or sediment supply regulations

Schematics credit: SCCWRP

Figure H.4-1: Illustration of Lane's Relationship

Lane's relationship is useful for making qualitative predictions concerning channel impacts due to changes in runoff and/or sediment loads from the watershed. Although this qualitative assessment is useful for understanding how the watershed responds to development, quantitative predictions are valuable for determining the magnitude of response and they can inform the identification of locations where the greatest management attention should be invested.

Lane's relationship can be supplemented by the use of quantitative predictions which allow the evaluation of the stream under changing conditions. Quantitative predictions will include bed sediment supply calculations for the first half of the Lane relationship, and bed sediment transport capacity calculations for the second half of the Lane relationship. Imbalances between the bed sediment supply rate and transport capacity determines the rate of sediment deposition or erosion in the channel and the associated channel change (Wilcock et al., 2009).

The common practice is to use the Erosion Potential (Ep) metric to evaluate the changes in sediment transport capacity and the Sediment Supply Potential (Sp) metric to evaluate the changes in bed sediment supply for susceptible receiving channels of concern. In regards to Ep metric,

- SCCWRP Technical Report 667 (SCCWRP, 2012) states:

  "The underlying premise of the erosion potential approach advances the concept of flow duration control by addressing in-stream processes related to sediment transport. An erosion potential calculation combines flow parameters with stream geometry to assess long term (decadal) changes in the sediment transport capacity. The cumulative distribution of shear stress, specific stream power and sediment transport capacity across the entire range of relevant flows can be calculated and expressed using an erosion potential metric, Ep."

- SCCWRP Technical Report 753 (SCCWRP, 2013) states the following based on review of field measurements from 61 sites in Southern California:

  "Results indicate that channel enlargement is highly dependent on the ratio of post- to pre-urban sediment-transport capacity over cumulative duration simulations of 25 years (load ratio, a.k.a. erosion potential), which explained nearly 60% of the variance."

For the purposes of implementing mitigation measures within the MS4-permitted region of the County of San Diego: this manual defines Ep as the ratio of post-project/pre-development (natural) long-term transport capacity or work; and Sp as the ratio of post-project/pre-project (existing) long-term bed sediment supply. Guidance for calculating Ep and Sp are provided in **Appendix H.8**.

H.4.2 Management Standard

This guidance defines a sediment supply management standard through which no net impact to receiving water can be quantitatively indicated. This management standard is demonstrated through the Net Impact Index (NII), a dimensionless index that must be used by the applicant to evaluate if there is, or is not, a net impact to the receiving water. NII is defined in this manual as the ratio of Ep to Sp. Mitigation measures shall be designed to meet the NII management standard shown in Equation H.4-2 to achieve no net impact to the receiving water. The NII management standard is based on Lane's relationship (Ep is directly proportional to Sp) and an allowance of 10% (based on **Appendix H.4.2.1**). This represents the most appropriate current understanding of how to quantitatively account for sediment supply changes without replacing bed sediment sources (Palhegyi and Rathfelder, 2007 and Parra, 2015).

Equation H.4-2: Net Impact Index

$$NII = \frac{Ep}{Sp} \leq 1.1$$

Where

NII = Net Impact Index

E_p = Erosion Potential

S_p = Sediment Supply Potential

If NII ≤ 1.1, then the project produces no net impact to the receiving water in terms of coarse sediment yield, and no further analysis is required. If NII > 1.1, then the project generates an impact on the receiving water and the project is required to implement mitigation measures defined in **Appendix H.4.3** such that the NII is reduced to a compliant value (NII ≤ 1.1).

H.4.2.1 Allowance to the NII Management Standard

This manual establishes the NII defined in **Appendix H.4.2** as the management standard for coarse sediment supply. The 10% allowance to the management standard is supported by the following research studies or projects:

- The authors of the USACE report for channel design (USACE, 2001) state that, "achieving an optimum Capacity-Supply Ratio, within 10 percent of unity, should ensure dynamic stability while allowing the river itself to recover some of the fluvial detail that cannot be engineered."
- The authors of SCCWRP Technical Report 605 (SCCWRP, 2010), "anticipate that changes of less than 10% in either driver [discharge or sediment flux] are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium."
- Sediment transport and supply measurements and calculations are inherently inexact. Discrepancies of up to 10% should not be a source of concern (PCR et al., 2002).

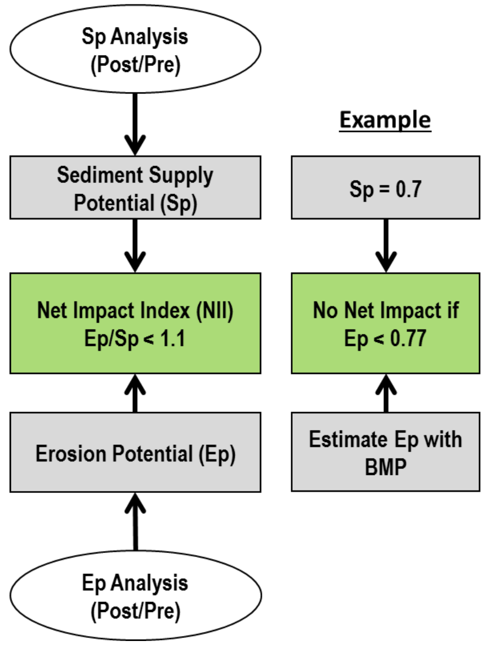
H.4.3 Types of Mitigation Measures

The following section discusses mitigation measures that may be used by the applicant to meet the NII management standard defined in **Appendix H.4.2**. These include:

- Additional Flow Control;
- Stream Rehabilitation; and
- Applicant Proposed Mitigation Measures

Appendix H.9 provides additional guidance for implementation of these mitigation measures.

H.4.3.1 Additional Flow Control



One option for managing bed sediment supply reductions is to provide additional detention and retention of site runoff to compensate for the reduction of bed sediment supply. This measure requires increasing flow attenuation by adding storage volume in structural BMPs. This management option accounts for changes in hydrology, channel geometry, and bed/bank material, but not sediment supply. For example, if there is a 30% reduction in bed-load due to proposed urbanization, then the sediment supply potential (Sp) equals 0.7. Assuming the appropriate range is +10%, hydromodification controls can be sized and situated such that the post-project effective in-stream work is lowered to less than 77% of the baseline pre-development condition.

Structural BMPs designed for hydromodification control utilize the following two basic principles:

- Detain runoff and release it in a controlled way that either mimics pre-development in-stream sediment transport capacity, mimics flow durations, or reduces flow durations to account for a reduction in bed sediment supply.
- Manage excess runoff volumes through one or more of the following pathways: (1) infiltration; (2) evapotranspiration; (3) storage and use; (4) discharge at a rate below the critical low flowrate; or (5) discharge downstream to a receiving water that is not susceptible to hydromodification impacts.

If desired, structural BMPs can be designed to support flood control and LID objectives in addition to hydromodification control. To the maximum extent possible, structural BMPs should be designed to receive flows from developed areas only. This facilitates design optimization as well as avoiding intercepting coarse sediments from open spaces that should ideally be passed through to the stream channel.

A fact sheet for additional flow control is provided in **Appendix H.9.1**.

H.4.3.2 Stream Rehabilitation

Hydromodification control can be achieved by stream rehabilitation projects including: drop structures, grade control structures, bed and bank reinforcement, increased channel sinuosity or meandering, increased channel width, and flow diversion. The objective of these in-stream controls, or stream restoration measures, is to reduce or maintain the overall Erosion Potential (Ep) of the receiving channel by modifying its hydraulic properties and/or bed/bank material resistance without fully replacing sediment supply or controlling increases in runoff. Stream rehabilitation is only an option where the receiving channel of concern is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel.

Stream rehabilitation projects are subject to the permitting requirements of the resource agencies. Stream rehabilitation projects may require the following permits:

- California Department of Fish and Wildlife – 1602 Streambed Alteration Agreement.
- US Fish and Wildlife Service – Authorization under the Endangered Species Act.
- US Army Corps of Engineers – Clean Water Act Section 404 Permit.
- Regional Water Quality Control Board – Clean Water Act Section 401 Water Quality Certification.
- Local Grading Permit

A fact sheet for stream rehabilitation is provided in **Appendix H.9.2**.

H.4.3.3 Applicant Proposed Mitigation Measures

The applicant may propose a mitigation measure not identified in this manual if it will achieve no net impact to the receiving water. Additional analysis may be requested by the City Engineer prior to approval of the mitigation measure to substantiate the finding of no net impact to the receiving water.

H.5 References

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H.5.1 Terms of Reference

The guidance described in **Appendix H** of this manual was developed by Geosyntec Consultants (Geosyntec) on behalf of the County of San Diego and the City of San Diego. **Appendix H** was specifically developed to provide PDP applicants guidance to meet the MS4 Permit Provision E.3.c.(2)(b) within the MS4-permitted region within the San Diego County. This guidance is not intended to be used for purposes, other than to meet this MS4 Permit requirement.

The guidance was developed with input from a Technical Advisory Committee (TAC) members through a series of meetings conducted in January 2016. The TAC input resulted in a streamlined guidance enhanced to provide applicants with simplified methods to determine impacts to coarse sediment delivery based on complex scientific principles. TAC participants included:

Bill Woolsey | Brian Haines | Charles Mohrlock | Chris Wolff | Dave Hammar | David Garcia | Emir Williams | Eric Mosolgo | Eric Stein | Erica Ryan | Howard Chang | Jon VanRhyn | Jonard Talamayan| Judd Goodman| Ken Susilo| Laura Henry| Luis Parra| Max Dugan | Rich Lucera | Sheri McPherson | Sumer Hasenin | Trevor Alsop | Venkat Gummadi | Wayne Chiu |

H.6 PCCSYAs: Regional WMAA Maps

PCCSYAs identified by the Regional WMAA were delineated using regional datasets for elevation, land cover, and geology. The methodology used to identify PCCSYAs from these datasets is based on Geomorphic Landscape Unit (GLU) methodology presented in the SCCWRP Technical Report 605. GLUs characterize the magnitude of sediment production from areas through three factors judged to exert the greatest influence on the variability on sediment-production rates: geology types, hillslope gradient, and land cover. The Regional WMAA document and the GIS layers for the map 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=248&Itemid=219

The regional-level mapping is based on the following sources:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd 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

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. If an applicant feels the Regional WMAA analysis inaccurately mapped their project area, they may elect to perform a site-specific GLU analysis based on data collected from project-level investigations to refine the mapping as outlined below.

The following PCCSYAs may be removed from the mapping without performing the full GLU analysis described in Appendix H.6.1 a) areas under 10% slope, b) paved areas.

H.6.1 Site-Specific GLU Analysis

In order to perform a site-specific GLU analysis the applicant must first delineate the project boundary and any areas draining through the project boundary. The applicant must then determine appropriate slopes, geology, and land cover categories for this area as identified below.

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.6-1 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.6-2 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 boundary to create GLUs. The GLUs listed in Table H.6-3 are considered to be PCCSYAs. 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).

GLUs are created by intersecting the geologic categories, land cover categories, and slope categories. This is a similar procedure to intersecting land uses with soil types to determine runoff coefficients or runoff curve numbers for hydrologic studies, but there are three categories to consider for the GLU analysis (slope, geology, and land cover), and the GLUs are not to be composited into a single GLU. When GLUs have been created, determine whether any of the GLUs listed in Table H.6-3 are found within the project boundary. The GLUs listed in Table H.6-3 are considered to be PCCSYAs.

If none of the GLUs listed in Table H.6-3 are present within the project boundary and area draining through the project boundary, no measures for protection of critical coarse sediment yield areas are necessary. If one or more GLUs listed in Table H.6-3 are present within the project boundary, they shall be considered critical coarse sediment yield areas. Complete Worksheet H.6-1 to document verification of GLUs.

Table H.6-1: 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

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
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
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
Kmgp	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
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

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
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
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

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
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
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
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
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

Table H.6-2: 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	Agricultural/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/Develpoed		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
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	Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
		Unvegetated Habitat	
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
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		Other

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
	Pool (southern mesas)		
86	13100 Open Water	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
87	13110 Marine		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	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe		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 donnax 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
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

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
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 Chapparal		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
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 VegetionVegetation		Unknown
174	11200 Disturbed Wetland		Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Table H.6-3: 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%

Worksheet H.6-1: Verification of GLUs

<table>
<tr><th colspan="2">Verification of GLUs</th><th>Worksheet H.6-1</th></tr>
<tr><td colspan="3">Detailed project-level review of GLUs may be performed to verify the presence or absence of potential critical coarse sediment yield areas within the project site and/or upstream areas. Use this form to document the evaluation of slope, geology, and land cover combined to determine the site-specific GLUs. Complete all sections of this form.</td></tr>
<tr><td colspan="3">Project Name:</td></tr>
<tr><td colspan="3">Project Tracking Number / Permit Application Number:</td></tr>
<tr><td>1</td><td>What are the pre-project slopes?</td><td>☐ 0% to 10% (1)
☐ 10% to 20% (2)
☐ 20% to 40% (3)
☐ >40% (4)</td></tr>
<tr><td>2</td><td>What is the underlying geology? Refer to Appendix H.6 to classify geologic categories into a geology grouping.

Note: site-specific geology may be determined in the field by a qualified geologist.</td><td>☐ Coarse bedrock (CB)
☐ Coarse sedimentary impermeable (CSI)
☐ Coarse sedimentary permeable (CSP)
☐ Fine bedrock (FB)
☐ Fine sedimentary impermeable (FSI)
☐ Fine sedimentary permeable (FSP)
☐ Other (O)</td></tr>
<tr><td>3</td><td>What is the pre-project land cover? Refer to Appendix H.6 for land cover category definitions.

Note: Land cover shall be determined from aerial photography and/or field visit.</td><td>☐ Agriculture/grass
☐ Forest
☐ Developed
☐ Scrub/shrub
☐ Other
☐ Unknown</td></tr>
<tr><td>4</td><td>List the GLU(s) within the project site and/or upstream areas.

Note the GLU nomenclature format is as follows: 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).</td><td></td></tr>
</table>

Worksheet H.6-1; Page 2 of 2			
5	Photo(s) Insert photos representative of the slopes, land cover, and geology.		
6	Are any of the GLUs found within the project boundary and/or upstream areas (listed in row 4) also listed in Table H.6-1?	☐ Yes	Go to 7
		☐ No	Go to 8
7	End – Provide management measures for preservation of coarse sediment supply as described in this guidance document, or the project applicant may elect to determine whether downstream systems would be sensitive to reduction of coarse sediment yield from the project site and/or perform site-specific method for mapping critical coarse sediment yield areas.		
8	End – Site-specific GLUs do not warrant preservation of coarse sediment supply, no measures for protection of critical coarse sediment yield areas onsite are necessary. Optional: use the note section below to provide justification for these findings.		
9	Notes		

H.6.2 Assumptions for Regional WMAA PCCSYA Maps

This appendix summarizes the assumptions used while developing Regional WMAA PCCSYA maps that are not listed in **Appendix H.6.1.1**:

- Critical coarse sediment would be generated from GLUs that are
  - composed of geologic units likely to generate coarse sediment (i.e. produces greater than 50% sand (0.074 mm; no. 200 sieve) by weight when weathered); **and**
  - have a potential for high relative sediment production (GLUs that produce soil loss greater than 8.4 tons/acre/year are assigned a high relative rating, this corresponds to 42% of the total coarse soil loss from the MS4-permitted region within the County of San Diego)
- Relative sediment production was assigned using RUSLE analysis of GLUs. It was assumed that this relative rating represents sediment production from sheet erosion, rill erosion, gullies and lower order channels, since these features are mostly on the hillslopes that are represented by the GLUs.
  - While performing the RUSLE analysis to assign the relative ranking, C factor from the regional maps from USEPA was adjusted to 0 for developed land covers to account for management actions implemented on developed sites (e.g. impervious surfaces).
- WMAA mapping does not account for sediment production from in-stream sediment supply (since these are mostly protected through other regulations) and sediment production from mass failures like landslides which are difficult to estimate on a regional scale without performing extensive field investigations.
- Regional WMAA map assumes that all receiving waters require coarse sediment and the map also does not account for potential existing impediments that may hinder delivery of coarse sediment to receiving waters.

For additional details refer to the Regional WMAA document on the Project Clean Water website at the following address:

http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=248&Itemid=219

H.6.3 Encroachment Allowance for Regional PCCSYA WMAA Map

When an applicant uses the regional PCCSYA map from WMAA to define onsite CCSYAs an encroachment allowance of up to 5% is allowed.

The following provides the supporting rational for 5% encroachment:

Step 1. Sp has to be greater than 0.5, based on current understanding of risks to receiving waters arising from changes in sediment production (SCCWRP Technical Report 605, 2010).

Step 2. Estimated Sp (Equation H.8.11) = $0.7*SY_{RUSLE}+0.3*SY_{NHD}$ = 0.7*0.42 + 0.3*1 = 0.59

A. Based on RUSLE analysis conducted during Regional WMAA the GLUs mapped as PCCSYAs contribute 42% of the bed sediment yield (i.e. SY_{RUSLE} = 0.42)

B. Disturbance to NHDPlus channels are protected through 401 water quality certifications issued by the RWQCB, so it is assumed that SY_{NHD} =1

Step 3. Dividing the Sp estimate from Step 2 by the required Sp in Step 1 provides the factor of safety that is currently implicit in the regional WMAA PCCSYA map = 0.59/0.5 = 1.18 or 18% factor of safety

Step 4. The remaining factor of safety after accounting for the proposed encroachment of 5% = 18% - 5% = 13%

H.7 Downstream System Sensitivity to Coarse Sediment

If an applicant has identified onsite and/or upstream PCCSYAs and elects to perform additional optional analyses to refine the PCCSYA designation, the guidance presented below should be followed. Protection of critical coarse sediment yield areas is a necessary element of hydromodification management because coarse sediment supply is as much an issue for causing erosive conditions to receiving streams as are accelerated flows. However, not all downstream systems warrant preservation of coarse sediment supply nor all source areas need to be protected. The following guidance shall be used to refine PCCSYA designations:

- Depositional Analysis (**Appendix H.7.1**)
- Threshold Channel Analysis (**Appendix H.7.2**)
- Coarse Sediment Source Area Verification (**Appendix H.7.3**)

H.7.1 Depositional Analysis

Areas identified as PCCSYAs may be removed from consideration if it is demonstrated that these sources are deposited into existing systems prior to reaching the first downstream unlined water of the state. Systems resulting in deposition may include existing natural sinks, existing structural BMPs, existing hardened MS4 systems, or other existing similar features. Applicants electing to perform depositional analysis to refine PCCSYA mapping must meet the following criteria to qualify for exemption from CCSYA designation:

- The existing hardened MS4 system that is being analyzed should be upstream of the first downstream unlined waters of the state; **and**
- The peak velocity from the discrete 2-year, 24-hour runoff event for the existing hardened MS4 system that is being analyzed is less than three feet per second.

The three feet per second criteria is consistent with the recommended minimum velocity for storm and sanitary sewers in ASCE Manual of Engineering Practice No. 37 (ASCE, 1970).

In limited scenarios, applicant may have the option to establish site specific minimum self-cleansing velocity using Equation H.7-1 or other appropriate equations instead of using the default three feet per second criteria. This site specific analysis must be documented in the SWQMP and the City Engineer has the discretion to request additional analysis prior to approving a site specific minimum self-cleansing velocity. If an applicant chooses to establish a site specific minimum self-cleansing velocity for refinement, then the applicant must design any new bypass hardened conveyance systems proposed by the project to meet the site specific criteria.

Equation H.7-1: Minimum Self Cleansing Velocity

$$V = \frac{1.486}{n} R^{1/6} \left[B(s_g - 1) D_g \right]^{1/2}$$

Where:

V = minimum self-cleansing velocity (ft/sec)
R = hydraulic radius (ft)
n = Manning's roughness coefficient (unitless)
B = constant equal to 0.04 for clean granular particles (unitless)
s_g = specific gravity of sediment particle (unitless): **Use 2.65**
D_g = sediment particle diameter (inches): **Use 0.20 in**

H.7.2 Threshold Channel Analysis

A threshold channel is a stream channel in which channel boundary material has no significant movement during the design flow. If there is no movement of bed load in the stream channel, then it is not anticipated that reductions in sediment supply will be detrimental to stream stability because the channel bed consists of the parent material and not coarse sediment supplied from upstream. In such a situation, changes in sediment supply are not considered a geomorphic condition of concern. SCCWRP Technical Report 562 (2008) states the following in regards to sand vs. gravel bed behavior/threshold vs. live-bed contrasts:

> "Sand and gravel systems are quite varied in their transport of sediment and their sensitivity to sediment supply. On the former, sand-bed channels typically have live beds, which transport sediment continuously even at relatively low flows. Conversely, gravel/cobble-bed channels generally transport the bulk of their bed sediment load more episodically, requiring higher flow events for bed mobility (i.e., threshold behavior)."
>
> "Sand-bed streams without vertical control are much more sensitive to perturbations in flow and sediment regimes than coarse-grain (gravel/cobble) threshold channels. This has clear implications in their respective management regarding hydromodification (i.e., sand systems being relatively more susceptible than coarser systems). This also has direct implications for the issue of sediment trapping by storm water practices in watersheds draining to sand-bed streams, as well as general loss of sediment supply following the conversion from undeveloped sparsely-vegetated to developed well-vegetated via irrigation."

The following provides guidance for evaluating whether a stream channel is a threshold channel or not. This determination is important because while accounting for changes in bed sediment supply is appropriate for quantifying geomorphic impacts in non-threshold stream channels, it is not considered appropriate for threshold channels. The domain of analysis for this evaluation shall be the same as that used to evaluate susceptibility, per SCCWRP Technical Report 606, Field Manual for Assessing Channel Susceptibility (2010). This domain is defined by the following upstream and downstream boundaries:

- From the point of compliance proceed downstream until reaching one of the following:
  - At least one reach downstream of the first grade-control point (preferably second downstream grade control location);
  - Tidal backwater/lentic (still water) waterbody;
  - Equal order tributary (Strahler 1952);
  - A 2-fold increase in drainage area.

  OR demonstrate sufficient flow attenuation through existing hydrologic modeling.
- From the point of compliance proceed upstream for 20 channel top widths OR to the first grade control in good condition, whichever comes first.

Applicant must complete Worksheet H.7-1 to document selection of the domain of analysis. If the entire domain of analysis is classified as a threshold channel, then the PDP can be exempt from the MS4 Permit requirement for sediment supply. The following definitions from the Natural Resources Conservation Service's (NRCS) National Engineering Handbook Part 654 - Stream Restoration Design (2007) are helpful in understanding what a threshold channel is.

- **Alluvial Channel**: Streams and channels that have bed and banks formed of material transported by the stream. There is an exchange of material between the inflowing sediment load and the bed and banks of an alluvial channel (NRCS, 2007).
- **Threshold Channel**: A channel in which channel boundary material has no significant movement during the design flow (NRCS, 2007).

The key factor for determining whether a channel is a threshold channel is the composition of its bed material. Larger bed sediment consisting primarily of cobbles and boulders are typically immobile, unless the channel is a large river with sufficient discharge to regularly transport such grain sizes as bed load. As a rule-of-thumb, channels with bed material that can withstand a 10-year peak discharge without incipient motion are considered threshold channels and not live-bed alluvial channels. Threshold channel beds typically consist of cobbles, boulders, bedrock, or very dense vegetation (e.g., a thicket). Threshold channels also includes channels that have existing grade control structures that protect the stream channels from hydromodification impacts.

For a project to be exempt from coarse sediment supply requirements, the applicant must submit the following for approval by the City Engineer:

- Photographic documentation and grain size analysis used to determine the d_{50} of the bed material; **and**
- Calculations that show that the receiving water of concern meets the specific stream power criteria defined below **or** a finding from a geomorphologist that the stream channel has existing grade control structures that protect the stream channel from hydromodification impacts.

Specific Stream Power

Specific (i.e., unit) stream power is the rate at which the energy of flowing water is expended on the bed and banks of a channel (refer to Equation H.7-2). SCCWRP studies have found that locating channels on a plot of Specific Stream Power at Q_{10} (as calculated by the Hawley et al. method optimized for Southern California watersheds – Figure H.7-1) versus median channel grain size is a good predictor of channel stability. The Q10 equation from SCCWRP TR 606 is presented as Equation H.7-3.

Equation H.7-2: Calculation of Specific Stream Power

$$Specific\ Stream\ Power = \frac{Total\ Stream\ Power}{Channel\ Width} = \frac{\gamma QS}{w}$$

Where:

γ: Specific Weight of Water (9810 N/m^3)
Q: Flow Rate (dominant discharge in many cases, m^3/sec)
S: Slope of Channel
w: Channel Width (meters)

Equation H.7-3: Calculation of Q_{10} using the Hawley et al. Method

$$Q_{10cfs} = 18.2 * A^{0.87} * P^{0.77}$$

Where:

Q_{10cfs}: 10 year Flow Rate in cubic feet per second
A: Drainage Area in sq. miles
P: Mean Annual Precipitation in inches

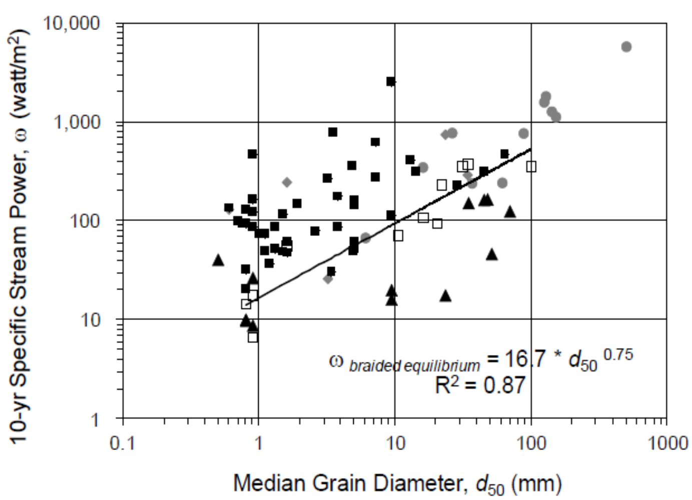

Figure H.7-1 : Threshold of stream instability based on specific stream power and channel sediment diameter

Since the SCCWRP TR 606 Q_{10} (Equation H.7-3) does not explicitly consider watershed imperviousness, adjustment factors (AF) shown in Figure H.7-2 were developed using the following Equation H.7-4 for Q_{10} from SCCWRP TR 654 to account for imperviousness while estimating Q_{10}.

Equation H.7-4: Calculation of Q_{10} using equation from SCCWRP TR 654

$$Q_{10} = e^{3.61} * A^{0.865} * DD^{0.804} * P_{224}^{0.778} * IMP^{0.096}$$

Where:

Q_{10}: 10 year Flow Rate
A: Drainage Area in sq. miles
DD: Drainage Density
P_{224}: 2-Year 24-Hour Precipitation in inches
IMP: Watershed Imperviousness

Adjustment factors were developed as part of this methodology by changing the watershed imperviousness in Equation H.7-4 and keeping the remaining terms constant. Adjustment factor for imperviousness of 3.6% was set to 1; since it is the mean imperviousness of the dataset used to develop the stability curve in Figure H.7-1. Updated Q_{10} equation with adjustment factor is presented as Equation H.7-5 below:

Equation H.7-5: Calculation of Q10 with Adjustment Factor for Watershed Imperviousness

$$Q_{10cfs} = AF * 18.2 * A^{0.87} * P^{0.77}$$

Where:

Q_{10cfs}: 10 year Flow Rate in cubic feet per second
AF: Adjustment Factor
A: Drainage Area in sq. miles
P: Mean Annual Precipitation in inches

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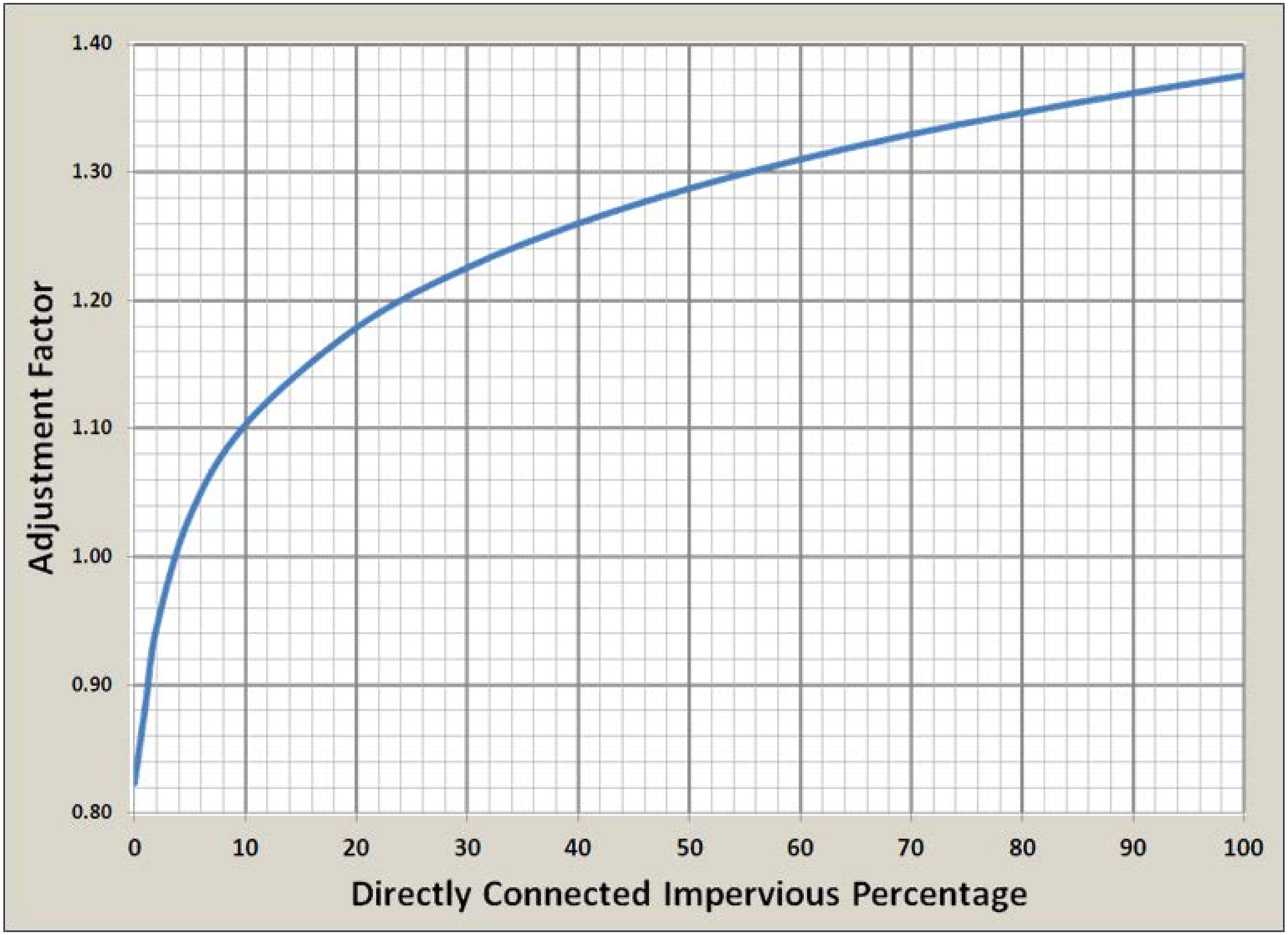

Figure H.7-2 : **Adjustment factor to account for imperviousness while estimating Q_{10}**

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Steps for evaluating the specific stream power criteria are presented below:

- **Step 1**: Calculate the specific stream power for the receiving water. Use Equation H.7-2, H.7-5 and Figure H.7-2. Directly connected imperviousness shall be estimated using guidance provided in the Water Quality Equivalency guidance document.
- **Step 2**: Determine the d_{50} of representative cross section within the domain of analysis.
- **Step 3**: Use results from Step 1 and Step 2; and Figure H.7-1 to determine if the receiving water meets the specific stream power criteria. Receiving water shall be considered meeting the specific stream power criteria when the point plotted based on results from Step 1 and Step 2 is below the solid line in Figure H.7-1.

H.7.3 Coarse Sediment Source Area Verification

When it has been determined that PCCSYAs are present, and it has been determined that downstream systems require protection, additional analysis may be performed that may refine the extents of actual CCSYAs to be protected onsite. The following analysis shall be performed to determine if the mapped PCCSYAs are a significant source of bed sediment supply to the receiving water, based on the coarse sediment proportion of the soil onsite

- Obtain a grain size distribution per ASTM D422 for the project's PCCSYA that is being evaluated.
- Identify whether the source material is a coarse grained or fine grained soil. Coarse grained is defined as over 50% by weight coarse than no. 200 sieve (i.e., d50 > 0.074 mm).
- By performing this analysis, the applicant can exclude PCCSYAs that are determined to be fine grained (i.e., d50 < 0.074 mm). Fine grained soils are not considered significant sources of bed sediment supply.
- Applicant shall include the following information in the SWQMP when this refinement option is performed:
  - Map with locations on where the grain size distribution analysis was performed;
  - Photographic documentation; and
  - Grain size distribution.
- Additional grain size distribution analysis may be requested at specific locations by the City Engineer prior to approval of this refinement.

Areas that are not expected to be a significant source of bed sediment supply (i.e. fine grained soils) to the receiving stream do not require protection and are not considered CCSYAs.

If it is determined that the PCCSYAs are producing sediment that is critical to receiving streams, or if the optional additional analysis presented above has not been performed, the project must provide management measures for protection of critical coarse sediment yield (refer to **Appendix H.2, H.3 and H.4**).

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Worksheet H.7-1: Domain of Analysis

Domain of Analysis		Worksheet H.7-1
Use this form to document the domain of analysis		
Project Name:		
Project Tracking Number / Permit Application Number:		
Part 1: Identify Domain of Analysis		
Project Location (at proposed storm water discharge point)		
1	Address:	
2	Latitude (decimal degrees):	
3	Longitude (decimal degrees):	
4	Watershed:	
Basis for determining downstream limit:		
Channel length from discharge point to downstream limit:		
Basis for determining upstream limit:		
Channel length from discharge point to upstream limit:		

Worksheet H.7-1; Page 2 of 2
Photo(s) Map or aerial photo of site. Include channel alignment and tributaries, project discharge point, upstream and downstream limits of analysis, ID number and boundaries of geomorphic channel units, and any other features used to determine limits (e.g. exempt water body, grade control).

H.8 Calculation Methodology for Ep and Sp

One method for quantifying hydromodification impacts to stream channels, which takes into account changes in the four factors in Lane's relationship (i.e., hydrology, channel geometry, bed and bank material, and sediment supply), is to compare long-term changes in sediment transport capacity, or in-stream work, to bed sediment supply. For the purposes of demonstrating no net impact within the MS4-permitted region of the County of San Diego, Erosion Potential (Ep) is defined as the ratio of post-project/pre-development (natural) long-term transport capacity or work. To calculate Ep, the hydrology, channel geometry, and bed/bank material factors mentioned above need to be characterized for both land use scenarios. Sediment Supply Potential (Sp) is defined as the ratio of post-project/pre-project (existing) long-term bed sediment supply. While evaluating changes in discharge and sediment supply is done primarily as a desktop analysis, geomorphic field assessment is often necessary to characterize channel geometry and bed/bank material, and to ground truth assumptions for the desktop analyses. This appendix provides methodologies for the following:

- Calculation of Ep, and
- Calculation of Sp.

H.8.1 Calculation of Ep

Erosion Potential (Ep) is defined as the ratio of post-project/pre-development (natural) long-term transport capacity or work. To calculate Ep, the hydrology, channel geometry, and bed/bank material factors mentioned above need to be characterized for both land use scenarios. Traditionally, Ep is calculated based on a watershed-scale analysis (using future built out conditions) of the area tributary to a given receiving channel of concern at the point of compliance. However, watershed-scale continuous hydrologic modeling might not be feasible for small projects, with this understanding specific simplification steps for project-scale modeling are provided in this appendix. The applicant shall perform Ep calculations using one of the following methods, as applicable:

- <u>Simplified Ep Method</u>: Applicable when the default low flow threshold of $0.1Q_2$ is used and no changes to the receiving water are proposed. Refer to **Appendix H.8.1.1**.
- <u>Standard Ep Method</u>: Applicable for all scenarios. Refer to **Appendix H.8.1.2**.

H.8.1.1 Simplified Ep Method

The simplified method is based on the relationships developed by Parra (2016) between the flow duration curve in the pre-development and post-project conditions and the standard simplified work equation. These relationships were developed using standard hydraulic equations and approximations that are applicable for channels of any lateral slope and the following geometrical cross sections: (a) wide rectangular sections; (b) relatively wide parabolic sections, and (c) triangular sections. The simplified Ep method is only applicable when the default low flow threshold of $0.1Q_2$ has been selected by the applicant for flow duration control and no changes to the receiving water geometry are proposed. Applicants shall follow Steps 1 through 3 to calculate Ep using the simplified methodology:

1. Perform continuous hydrologic simulation for the pre-development and post-project condition following guidelines in **Appendix G**. Generate flow bins and flow duration tables for the range of flows from $0.1Q_2$ to Q_{10}.

2. Calculate the total work in the pre-development and the post-project condition using Equation H.8-1

Equation H.8-1: Total Work (Simplified)

$$W_t = \sum_{j=1}^{n} \Delta t_j . \left(Q^{3m/2} - (0.1Q_2)^{3m/2}\right)^{1.5} \quad Q^m$$

Where:

W_t = Total Work [dimensionless]

Δt_j = Duration per flow bin

Q = Flow Rates estimated in STEP 1 [cfs] for a typical bin "j". Usually, in Flow Duration Curve (FDC) analyses, the number of bins is 100, so j = 1 to n (with n= 100). However, the number of bins can be as small as 20 (n = 20).

Q_2 = Pre-development 2-year peak flow [cfs]

m = Exponent based on the function of the receiving channels geometry.

- For narrow creek where the top width is 7 times or less the corresponding depth, m = 1/4.
- For intermediate creeks, where the top width is more than 7 times but less than 25 times the depth, m = 4/13.
- For wide creeks, where the top width is more than 25 times the depth, m = 2/5.

3. Ep is calculated by dividing the total work of the post-project condition by that of the pre-development (natural) condition (Equation H.8-2). Ep is expressed as:

Equation H.8-2: Ep (Simplified)

$$E_p = W_{t,post}/W_{t,pre}$$

Where:

E_p = Erosion Potential [unitless]

$W_{t,post}$ = Total Work associated with the post-project condition [unitless]

$W_{t,pre}$ = Total Work associated with the pre-development condition [unitless]

H.8.1.2 Standard Ep Method

While using the standard method, Ep calculation must be performed using the receiving water information from the point of compliance. Suggested steps for performing an Ep analysis are shown in the Figure H.8-1 below. This section describes each analysis step shown in Figure H.8-1, including the inputs and outputs of each step.

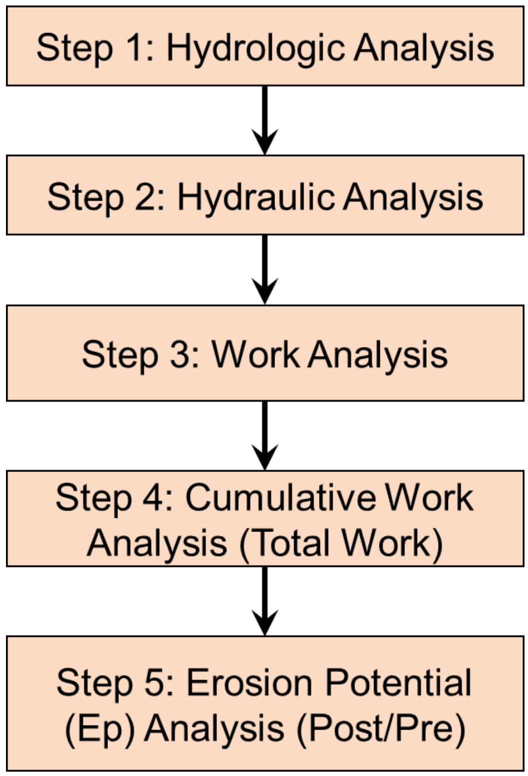

Figure H.8-1 : Erosion Potential Flow Chart

STEP 1: CONTINOUS HYDROLOGIC ANALYSIS

Hydrologic models are applied to simulate the hydrologic response of the watershed under pre-development and post-project conditions for a continuous period of record. Modeling software appropriate for this type of simulation includes USEPA's Storm Water Management Model (SWMM), Hydrological Simulation Program – Fortran (HSPF) developed by the USGS and USEPA, USACE's Hydrologic Modeling System (HEC-HMS), and the San Diego Hydrology Model (SDHM) developed by Clear Creek Solutions, Inc. SDHM uses an HSPF computational engine, long-term precipitation data, and is a visually-oriented interactive tool for automated modeling and facility sizing.

Input parameters for these continuous simulations are hourly precipitation data for a long-term (>30 years) record, sub-catchment delineation, impervious cover, soil type, vegetative cover, terrain steepness, lag time or flow path length, and monthly evapotranspiration rate. The primary output is a simulated discharge record associated with the receiving channel of concern. Flow routing through drainage conveyances is necessary for continuous hydrologic analysis at the watershed scale. **Appendix G** provides guidance for developing continuous simulation models.

Traditionally, a hydrograph (Figure H.8-2) is the primary means for graphically comparing discharge records; however, a hydrograph is not ideal because long-term flow records span several decades.

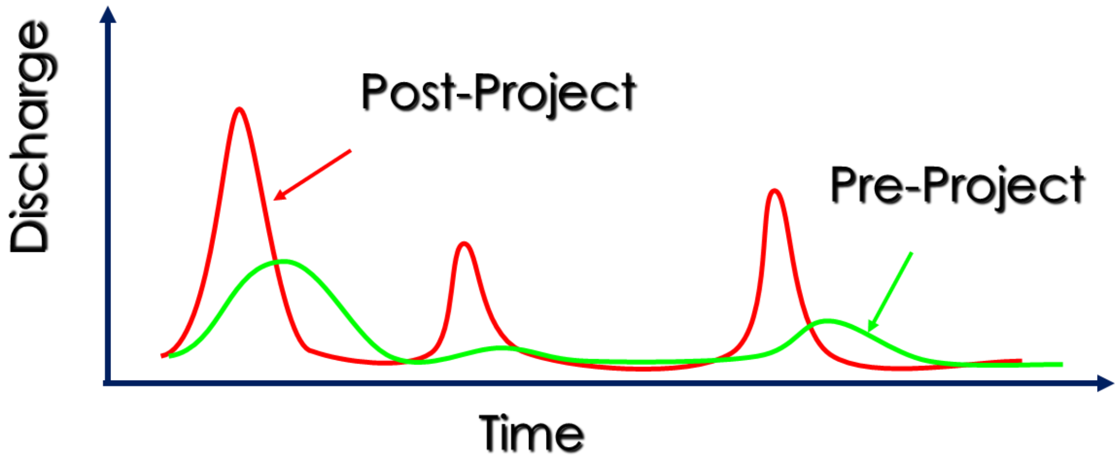

Figure H.8-2 : Example Hydrograph Comparison

Instead, a more effective means for comparing long-term continuous discharge records is to create a flow histogram, which differentiates the simulated flowrates into distinct "flow bins" so that the duration of flow for each bin can be tabulated. One method for establishing the distribution of flow bins is to increment the flow bins according to increments of flow stage using a hydraulic analysis, such as the normal depth equation. In this way, the hydraulic analysis step (Step 2) can be considered an input to the continuous hydrologic analysis step. While there is no established rule of thumb for how many flow bins are necessary, it is suggested that no less than 20 be used for an Ep analysis. An example of a flow histogram is provided on Figure H.8-3.

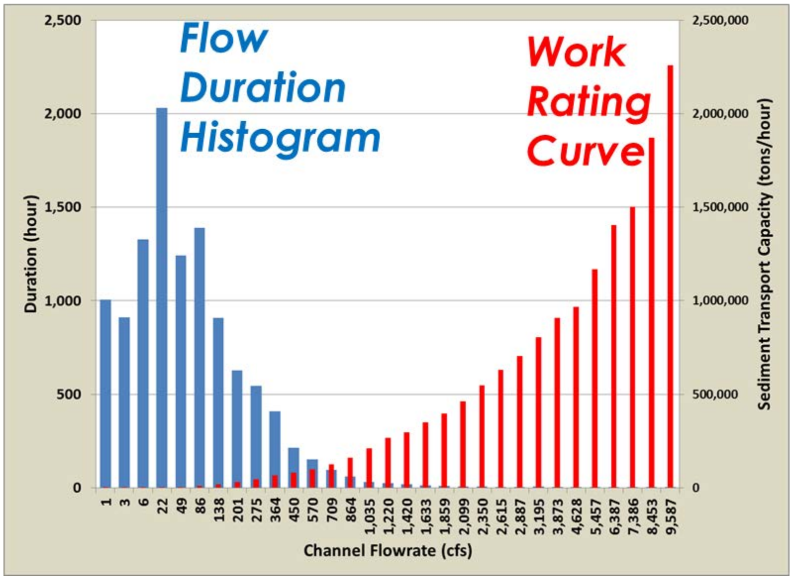

Figure H.8-3 : Example Flow Duration Histogram

Flow duration curves are another commonly used method for graphically interpreting long-term flow records. A flow duration curve is simply a plot of flowrate (y-axis) versus the cumulative duration, or percentage of time, that a flowrate is equaled or exceeded in the simulation record (x-axis). Figure H.8-4 provides an example flow duration curve comparison.

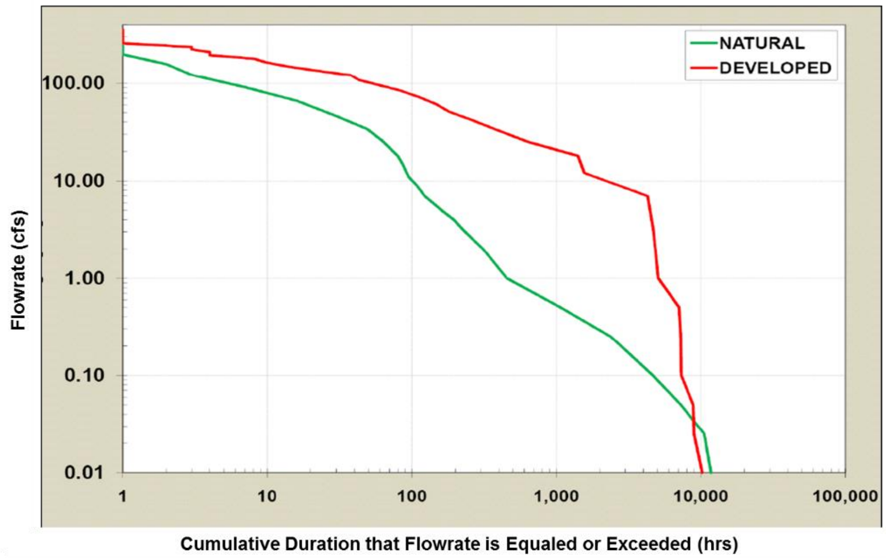

Figure H.8-4 : Example Flow Duration Curve

Scaling Factor for Project-Scale Modeling

Project-scale flow rates derived from continuous hydrologic simulation can be scaled using the ratio of the pre-development 2-year peak discharge for the watershed and project catchment (i.e., Q_2 watershed / Q_2 project catchment) so that hydraulic and effective work calculations can be performed at the point of compliance with a larger tributary watershed. This scaling translates the runoff from the project catchment to its contribution to erosivity in the down gradient receiving channel, without the need for a complex watershed-scale continuous hydrologic model.

Applicant can estimate the scaling factor using Equation H.8-3. The scaling factor equation was developed using the 2-year peak flow rate empirical equation from Hawley and Bledsoe (2011) and removing the terms (average annual precipitation and imperviousness (pre-development condition as required by the MS4 Permit) that are constant.

Equation H.8-3: Scaling Factor

$$Scaling\ Factor = \left(\frac{A_{watershed}}{A_{project}}\right)^{0.667}$$

Where:

$A_{watershed}$ = total watershed drainage area at the point of compliance (mi^2)

$A_{project}$= total project drainage area (mi^2)

STEP 2: HYDRAULIC ANALYSIS

Hydraulic parameters, such as stage, effective shear stress, and flow velocity, are computed for each designated flow bin using channel geometry and roughness data. Hydraulic calculations can be as simple as using the normal flow equation and obtaining results for the central channel or as complicated as using hydraulic models which account for backwater effects, such as HEC-RAS.

Using the formula for unit tractive force (Chow 1959), effective shear stress is expressed using Equation H.8-4

Equation H.8-4: Effective Shear Stress

$$\tau = \gamma RS$$

Where:

- τ = Effective Shear Stress [lb/ft^2]
- γ = Unit Weight of Water [62.4 lb/ft^3]
- R= Hydraulic Radius [ft]
- S = Energy Gradient Assumed Equal to Longitudinal Slope [ft/ft].

Normal depth can be estimated using Manning's equation (Equation H.8.5). Several sources provide lists of roughness coefficients for use in hydraulic analysis (Chow, 1959).

Equation H.8-5: Manning's Equation

$$Q = \frac{1.49AR^{0.67}S^{0.5}}{n} \; or \; V = \frac{1.49R^{0.67}S^{0.5}}{n}$$

Where:

- Q = Peak Flowrate [cfs]
- V = Average Flow Velocity [ft/s]
- A = Cross-Section Flow Area [ft^2]
- R = Hydraulic Radius [ft] = A/P
- P = Wetted Perimeter [ft]
- S = Energy Gradient Assumed Equal to Longitudinal Slope [ft/ft]
- n = Manning Roughness [unit less]

Channel geometry inputs should be characterized by surveying cross-sections and longitudinal profiles of the active channel at strategic locations. Methods of collecting topographic survey data can range from traditional survey techniques (auto level, cloth tape, and survey rod), to conducting a detailed ground-based LiDAR survey.

STEP 3: WORK ANALYSIS

Hydraulic results for each flow bin along with the critical bed/bank material strength parameters are input into a work or sediment transport function in order to produce a work or transport rating curve. An example of such a rating curve is provided on Figure H.8-3. The work equations can range from simplistic indices, material-specific sediment transport equations, or more complex functions based on site-calibrated sediment transport rating curves.

- **Simplistic indices:** An acceptable equation for effective work, as stated in the Los Angeles Regional MS4 Permit (LARWQCB, 2012) is expressed using Equation H.8-6:

Equation H.8-6: Effective Work

$$W = (\tau - \tau_c)^{1.5} V$$

Where:

W = Work [dimensionless];

τ = Effective Shear Stress [lb/ft^2];

τ_c = Critical Shear Stress [lb/ft^2];

V = Mid-Channel Flow Velocity [ft/s]

- **Material-specific sediment transport equations**: Material specific sediment transport equations are allowed to estimate the sediment transport capacity in the post-project and pre-development condition.
- **Site-calibrated sediment transport curves**: Applicants may have an option to use site-calibrated sediment transport curves. In the future these may be available based on monitoring efforts being performed to support the County of San Diego's Hydromodification Management Plan.

The critical shear stress to be used in equation H.8.6 must be estimated using one of the following:

- Shear stress corresponding to the critical flow rate or low flow threshold (Qc). Qc is the flowrate that results in incipient motion of bed or bank material, whichever is least resistant. Qc is expressed as a fraction of the pre-development 2-year peak flow. The allowable low flow threshold Qc can be estimated as 10%, 30%, or 50% of the pre-development 2-year peak flow ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) depending on the receiving stream susceptibility to erosion, per SCCWRP Technical Report 606, Field Manual for Assessing Channel Susceptibility (SCCWRP, 2010). If a channel susceptibility assessment is not performed, then the conservative default is a Qc equal to $0.1Q_2$.
- Bed and bank material can also be characterized through a geomorphic field assessment. For each stream location analyzed, a measure of critical shear stress can be obtained for the weakest bed or bank material prevalent in the channel. For non-cohesive material, a Wolman pebble count or sieve analysis can be used to obtain a grain size distribution, which can be converted to a critical shear stress using empirical relationships or published reference tables. For cohesive material, an in-situ jet test or reference tables are used. For banks reinforced with vegetation, reference tables are generally used. Appropriate references for critical shear stress values are provided in ASCE No.77 (1992) and Fischenich (2001). To account for the effects of vegetation density and channel irregularities, the applied shear stress can be partitioned into channel form and bed/bank roughness components. SCCWRP Technical Report 667 also has guidance for estimating critical shear stress.

STEP 4: CUMULATIVE WORK ANALYSIS

Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a creek location. It incorporates the distribution of both discharge magnitude and duration for the flow rates simulated. The cumulative work analysis must be performed up to the maximum geomorphically significant flow of Q_{10}. To calculate cumulative work, first multiply the work (from STEP 3) and duration associated with each flow bin (from STEP 1). Then, the total work is obtained by summing the cumulative for all flow bins (Q_c to Q_{10} Equation H.8-7). This analysis can be expressed as:

Equation H.8-7: Cumulative Work

$$W_t = \sum_{i=1}^{n} W_i \, \Delta t_i$$

Where:

- W_t = Total Work [dimensionless]
- W_i = Work per flow bin [dimensionless]
- Δt = Duration per flow bin [hours]
- n = number of flow bins

The distribution of cumulative work, also referred to as a work curve (or work histogram), is helpful in understanding which flow rates are performing the most work on the channel of interest. An example work curve is provided in Figure H.8-5.

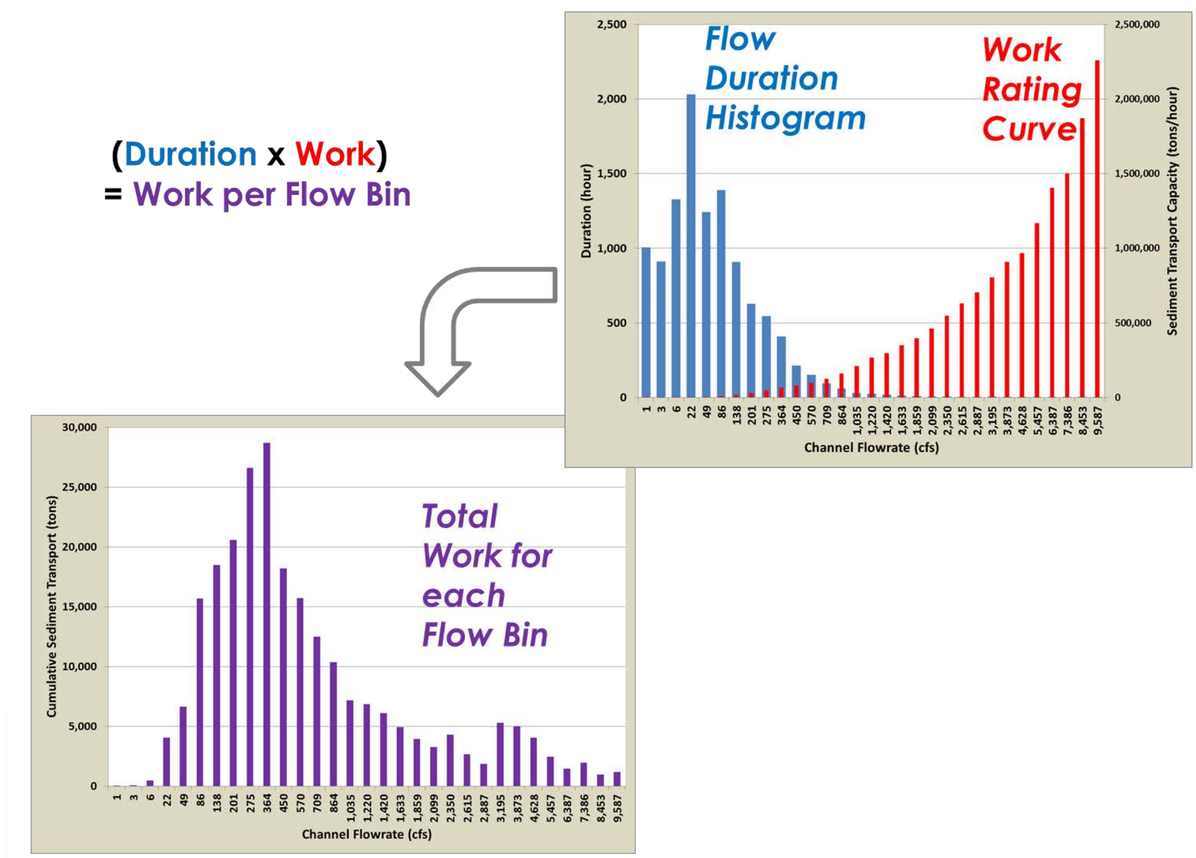

Figure H.8-5 : Example Work Curve

STEP 5: EROSION POTENTIAL ANALYSIS

Ep is calculated by simply dividing the total work of the post-project condition by that of the pre-development (natural) condition (Equation H.8-8). Ep is expressed as:

Equation H.8-8: Erosion Potential

$$E_p = W_{t,post} / W_{t,pre}$$

Where:

E_p = Erosion Potential [unitless]

$W_{t,post}$ = Total Work associated with the post-project condition [unitless]

$W_{t,pre}$ = Total Work associated with the pre-development condition [unitless]

As applicable, the applicant must use Worksheet H.8.1-1 and H.8.1-2 to document the Ep calculations for each point of compliance.

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Worksheet H.8-1: Erosion Potential (Ep) Analysis

Erosion Potential (Ep) Analysis		Worksheet H.8-1	
Background Information			
1	Low Flow Threshold: results of SCCWRP channel susceptibility analysis (Select $0.1*Q_2$ if analysis has not been performed).	☐ 0.1*Q2 ☐ 0.3*Q2 ☐ 0.5*Q2	
2	Selected Ep Method	☐ Simplified Ep Method ☐ Standard Ep Method	
2	Hydrologic Analysis: Select hydrologic analysis method.	☐ Project-Scale ☐ Project-Scale and Watershed-Scale Continuous Simulation	
4	Number of Points of Compliance (Copy and complete worksheet for each Point of Compliance)		unitless
Step 1: Hydrologic Analysis (not applicable for Simplified Ep Method)			
5	Project-Scale Q_2 (from continuous simulation)		cfs
6	Project Area draining to the point of compliance		sq. miles
7	Watershed Area draining to the point of compliance		sq. miles
8	Scaling Factor for Flows $(\text{Line 7/Line 6})^{0.667}$		unitless
9	Low flow threshold (factor from Line 1 x Line 6)		cfs
10	Watershed-Scale Q_{10} at Point of Compliance (from continuous simulation or Project Q_{10} * Line 8)		cfs
	Hydrologic analysis results (Attach results of continuous simulation including: full pre-development runoff time series at POC, full post-development runoff time series at POC, and flow duration histogram and/or cumulative flow duration curve for each POC).		☐ Yes ☐ No
Step 2: Hydraulic Analysis (not applicable for Simplified Ep Method)			
11	Provide details about the cross-section (width, depth, slope, roughness, etc.)		

Erosion Potential (Ep) Analysis			Worksheet H.8-1	
Step 3: Work Analysis (not applicable for Simplified Ep Method)				
12	Select work index, equation, or transport curve method for use in work analysis.	☐ Equation H.8.6 ☐ Sediment Transport Equation ☐ Sediment Transport Curve ☐ Other: ____________		
13	Describe/Justify selection in Line 12 above:			
14	Calculate work done for each flow bin under the pre-development and post-project condition using Worksheet H.8.1-2. Or similar documentation for sediment transport modeling or transport curve analysis.	☐ Yes ☐ No		
Step 4: Cumulative Work Analysis				
14	Cumulative pre-development work (Equation H.8.1 for Simplified Ep Method) (from Worksheet H.8.1-2 for Standard Ep Method)			
15	Cumulative post-project work (Equation H.8.1 for Simplified Ep Method) (from Worksheet H.8.1-2 for Standard Ep Method)			
Step 5: Erosion Potential Analysis				
16	Erosion Potential (Line 15 / Line 14)		unitless	

Worksheet H.8-2: Work Calculations (Supplement to Worksheet 8-1)

Work Calculations (Supplement to Worksheet H.8-1)									Worksheet H.8-2	
1	Channel Slope								(ft/ft)	
2	Channel Roughness (n)								(unitless)	
3	Low Flow Threshold								cfs	
4	Critical Shear Stress								(lb/ft^2)	
A	B	C	D	E	F	G	H	I	J	K
Bin	Flow (cfs)			Duration (hours)		Hydraulic Radius (ft)	Average Velocity (ft/s)	Shear Stress (lb/ft^2)	Work (unitless)	
	Lower Limit	Upper Limit	Average	Pre-development	Post-Project				Pre-development	Post-Project
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
n										
Sum (Bins 1 to n) =										

Worksheet H.8-2 Key

A Number of flow bins, add additional rows as needed

B Lower limit for the corresponding flow bin

C Upper limit for the corresponding flow bin

D Average flow for the corresponding flow bin; [(**B** + **C**)/2]

E Duration in hours for the corresponding flow bin in pre development condition

F Duration in hours for the corresponding flow bin in post project condition

G Hydraulic radius (in feet) associated with the average flow for the corresponding flow bin (from Manning's equation and/or hydraulic analysis)

H Average flow velocity (in fps) associated with the average flow for the corresponding flow bin (from Manning's equation and/or hydraulic analysis)

I Shear stress (lb/ft^2) associated with the average flow for the corresponding flow bin = γ * Hydraulic Radius*Slope = 62.4 * **G** * Line 1

J Pre-development work for associated flow bin

J = 0; If (**I** – Line 4) ≤ 0

J = **E** * (**I** – Line 4)$^{1.5}$ * **H**; If (**I** – Line 4) > 0

K Post-project work for associated flow bin

K = 0; If (**I** – Line 4) ≤ 0

K = **F** * (**I** – Line 4)$^{1.5}$ * **H**; If (**I** – Line 4) > 0

Note: If the receiving water dimensions are different in pre-development and post-project condition then Worksheet H.8.1-2 is not valid for work calculations.

H.8.2 Calculation of Sp

While there are many categories of erosion processes (e.g., landslides, debris flows, gullies, tree throw, animal burrows, sheetwash erosion, wind erosion, dry ravel, bank erosion), in this evaluation processes will be simplified to sediment production from hillslopes and channels. Under ideal circumstances, the total bed sediment supply rate (tons/year) would be calculated for both the post-project buildout condition and pre-project condition using a watershed-scale Geomorphic Landscape Unit (GLU) and Geomorphic Channel Unit (GCU) approach which:

1. identifies different sources of sediment supply based on categories of terrain slope, geology, land cover, and stream order;
2. estimates the base erosion rate of those sources (GLUs and GCUs);
3. approximates the sediment delivery ratio (SDR) to the receiving channel;
4. evaluates the coarse bed-load fraction of the sources; and
5. integrates these considerations into a bed-load yield rate for both the existing condition and proposed buildout condition.

However, calculation of sediment yield rates for each GLU (tons/mi^2-yr) and GCU (tons/mi-yr) using the available science is inherently inexact and requires extensive field calibration. Additionally, performing the geospatial calculations necessary for such a comprehensive GLU and GCU analysis may not be straightforward for some project applicants. Since the objective is to determine the fraction of reduction in bed sediment supply in the post-project condition compared to the pre-project condition, but not to determine the bed sediment yield in physical units (tons/year/acre, for example) the following simplifications are allowed. These simplifications take into consideration the regional sediment yield map shown in Figure H.8.6.

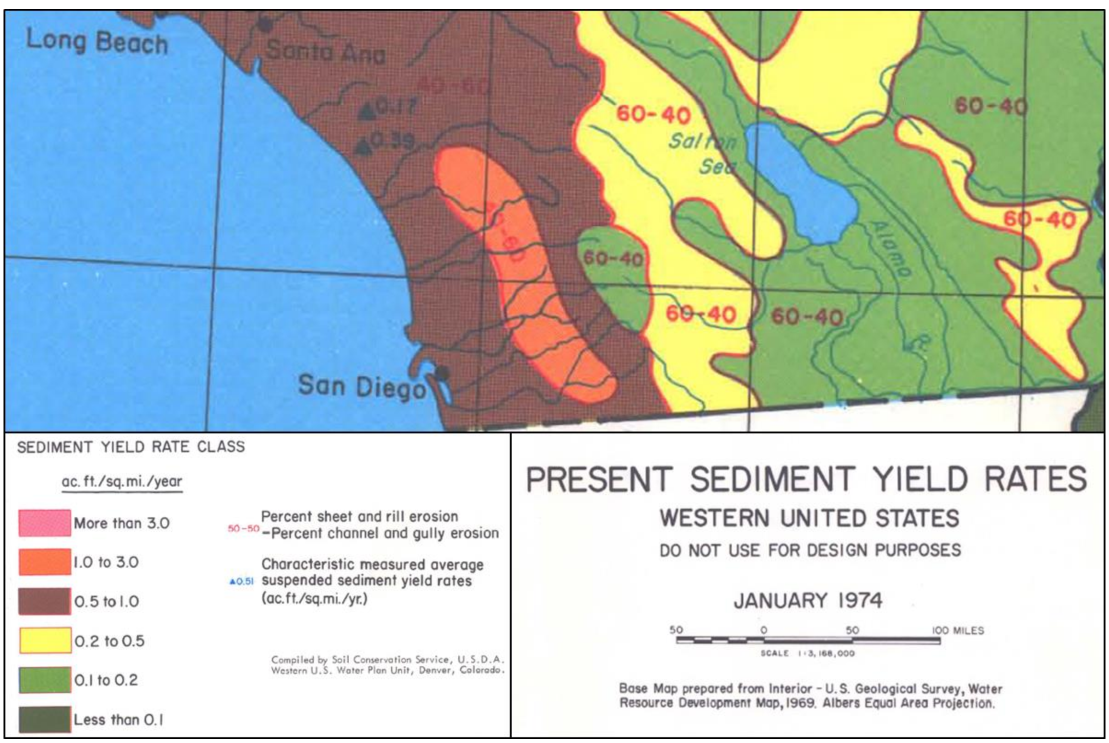

Figure H.8-6 : Regional Sediment Yield Map

According to a regional sediment yield map of the Western US (USDA, 1974), hillslope processes (sheet and rill erosion) account for approximately 40% of the sediment yield in the San Diego County region, while channel processes (in-stream and gully erosion) account for approximately 60% of the sediment yield. Figure H.8-7 shows the different erosion processes. Provision E.3.a.(3)(a) of the MS4 Permit requires, "maintenance or restoration of natural storage reservoirs and drainage corridors (including topographic depressions, areas of permeable soils, natural swales, and ephemeral and intermittent streams)", effectively making maintenance or restoration of channels and gullies within a project site a site design requirement.

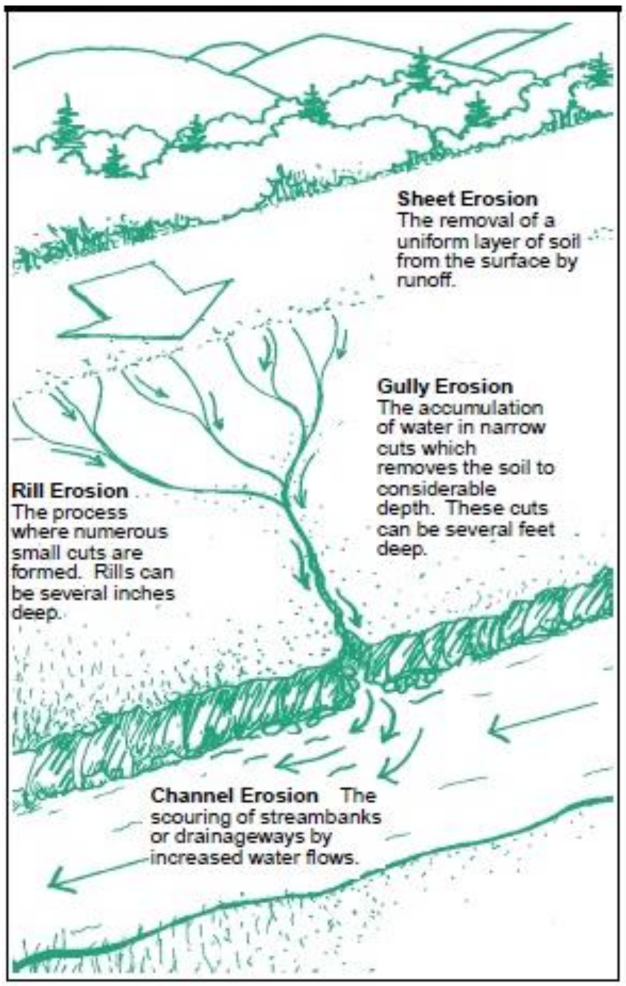

Figure H.8-7 : Different Erosion Processes that Contribute Sediment

Source: http://www.fairfaxcounty.gov/nvswcd/youyourland/soil.htm

Sediment yield from hillslope processes can be estimated using the Revised Universal Soil Loss Equation (RUSLE) and a sediment delivery ratio. For channel processes, the best available regional datasets are the USGS National Hydrography Dataset (NHD) and the NHDPlus dataset from USEPA and USGS (http://www.horizon-systems.com/nhdplus/). Both these datasets may not include the lowest order channels or gullies in the stream network, which can contribute a considerable amount of sediment produced from channel processes. Since the lower order channels and gullies originate and are mostly on the hillslopes, it is assumed for the Sp analysis that the sediment yield from lower order channels and gullies is proportional to the sediment yield from hill slopes. Based on feedback received during the TAC meetings (**Appendix H.5.1**) the following distribution is proposed for the calculation of Sp:

- 70% of bed sediment yield ratio from RUSLE analysis (assumed to account for sediment yield from hillslope processes (sheet and rill erosion) and channels and gullies not part of the NHDPlus dataset); and
- 30% of bed sediment yield ratio from channels in the NHDPlus dataset.

<u>Note:</u>

- If an applicant elects to map the waters of the state, the Sp distribution shall be revised to
  - 40% of bed sediment yield ratio from RUSLE analysis;
  - 30% of bed sediment yield ratio from waters of the state that are not part of NHDPlus dataset; and
  - 30% of bed sediment yield ratio from channels in the NHDPlus dataset.

SCALE OF ANALYSIS

The project applicant shall perform the Sp analysis at point (or points) where runoff leaves the project site.[24] The steps for performing an Sp analysis are shown in Figure H.8-8 and described below.

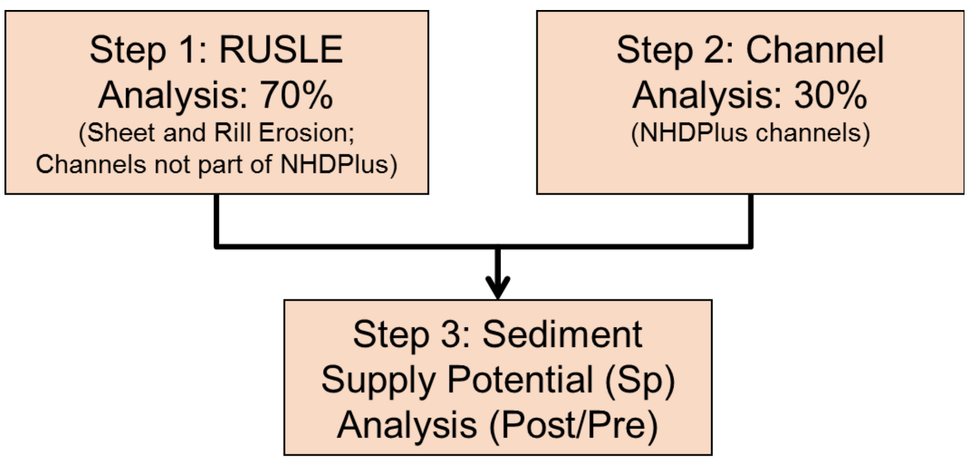

Figure H.8-8: Sediment Supply Potential Flow Chart

STEP 1: RUSLE ANALYSIS

RUSLE analysis is assumed to account for sediment yield from hillslope processes (sheet and rill erosion) and channels and gullies not part of the NHDPlus dataset. The change in bed sediment yield in the post-project condition compared to the pre-project condition using the RUSLE analysis must be

[24] The City Engineer has the discretion to allow for a watershed-scale Sp analysis to be performed at the point of compliance if the future built-out conditions of the watershed are used in the analysis.

estimated using Equation H.8-9. This equation is a modified form of the standard RUSLE equation. Only hillslopes that are anticipated to generate coarse sediment must be used in this analysis. Since Sp is a dimensionless index the terms that are relatively constant in the pre and post project condition, such as rainfall factor, have been removed.

Equation H.8-9: Sediment Yield (Hillslope)

$$SY_{HillSlope} = \frac{Post - Project \sum\{A \times K \times LS \times C\}}{Pre - Project \sum\{A \times K \times LS \times C\}}$$

Where:

A = Hillslope Area (acres)

K = Soil erodibility factor, this value can be obtained from regional K factor map from SWRCB or web soil survey or site-specific grain size analysis

LS = Slope length and steepness factor, this value can be obtained from the regional LS factor map from SWRCB or site-specific determination using look up tables based on slope and horizontal slope length from USDA Agriculture Handbook Number 703 (Renard et al., 1997) or other relevant sources

C= Cover management factor, use regional C factor map from USEPA or site-specific information; this is the reciprocal of the amount of surface cover on soil, whether it be vegetation, temporary mulch or other material. It is roughly the percentage of exposed soil, i.e., 95 percent cover yields a “C” value of 0.05. Use C=0 for areas where management actions are implemented (e.g. impervious areas) or where the project proposes any significant grading activities.

The applicant may be allowed to receive credit for bed sediment yield from engineered slopes on the project perimeter directly discharging to conveyance systems if **all** of the following criteria are met:

- The engineered slopes consist of coarse bed material. This is confirmed by performing grain size distribution per ASTM D422 for the engineered slope and verifying that the d_{50} is greater than no. 200 sieve (0.074 mm).
- Cover factor in the post project condition shall not be greater than the cover factor used in the pre project condition for the same area.
- A maximum practice factor of 0.25 is applied to proposed fill slopes. A maximum practice factor of 0.50 is applied to proposed cut slopes.
- A statement from the geotechnical engineer is included in the SWQMP certifying that the engineered slope will be stable even after accounting for bed sediment generation and the anticipated soil loss during the planned lifetime of the engineered slope is acceptable.

Additional analysis and/or documentation may be requested by the City Engineer prior to approval of the credit for bed sediment yield from engineered slopes.

STEP 2: CHANNEL ANALYSIS

If an NHDPlus mapped channel exists within the project property boundary, applicants must consider the sediment production from this existing channel system. The change is bed sediment yield in the post-project condition compared to the pre-project condition from channels in the NHDPlus dataset must be estimated using Equation H.8-10 (SY_{NHD}). This equation is based on screening-level GIS calculations of stream length that will be contributing sediment in the post-project condition in the watershed tributary to the point of compliance.

Equation H.8-10: Sediment Yield (NHD)

$$SY_{NHD} = \frac{L_{post}}{L_{pre}}$$

Where:

L_{post} = Length of NHDplus streams in the watershed contributing to bed sediment supply in the post-project condition [miles]

L_{pre} = Length of NHDplus streams in the watershed contributing to bed sediment supply in the pre-project existing condition [miles]

STEP 3: SEDIMENT SUPPLY POTENTIAL ANALYSIS

Sediment Supply Potential (Sp) is defined as the ratio of post-project/pre-project (existing) long-term bed sediment supply. Sp must be calculated using Equation H.8-11 presented below:

Equation H.8-11: Sediment Supply Potential

$$S_p = 0.7 \times SY_{RUSLE} + 0.3$$

Where:

S_p = Sediment Supply Potential [unitless]

$SY_{Hillslopes}$ = Change in bed sediment yield from hillslopes [unitless]

SY_{NHD} = Change in bed sediment yield from channels in NHDPlus dataset [unitless]

When estimating Sp the following additional conditions apply:

- Projects that do not have onsite NHDPlus channels shall omit consideration of SY_{NHD} and weighting factors depicted in Equation H.8-11. This simply results in Sp = SY_{RUSLE}.
- It must be assumed that the sediment yield from an area that drains to a structural BMP is zero. Consideration of sediment yield from an area draining to the structural BMP may be allowed if sediment bypass measures are implemented upstream of the structural BMP. However, additional analysis may be requested by the City Engineer to substantiate the sediment yield estimates proposed by the applicant from implementing sediment bypass measures.

- For scenarios where an upstream coarse sediment yield area drains through the project footprint and the project footprint cuts off conveyance of bed sediment generated upstream of the project footprint to the point of compliance, (e.g., via debris basins) the contribution from the upstream area shall be assumed to be zero.

As applicable, the applicant must use Worksheet H.8-3 to document the Sp calculations for each point of compliance.

Worksheet H.8-3: Sediment Supply Potential (Sp) Analysis

Sediment Supply Potential (Sp) Analysis										Worksheet H.8-3	
1	Scale of Analysis						☐ Project Scale ☐ Watershed Scale (built-out condition)				
Step 1: RUSLE Analysis											
2	GLU	Pre-Project					Post-Project				
		A	K	LS	C	A*K*LS*C	A	K	LS	C	A*K*LS*C
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	Add additional rows as needed										
3	Sum Pre-Project						Sum Post-Project				
4	SY_{RUSLE}: (Sum Post-Project/ Sum Pre-Project) (From Line 3)										unitless
Step 2: Channel Analysis: NHDPlus Channels											
5	L_{pre} (from GIS analysis of pre-project existing condition)										miles
6	L_{post} (from GIS analysis of post-project condition)										miles
7	SY_{NHD}: (Line 6 / Line 5)										unitless
Step 3: Sediment Supply Potential Analysis											
8	RUSLE Analysis Bed Sediment Yield Ratio Calculated (Line 4)										unitless
9	Channel Bed Sediment Yield Ratio from NHDPlus dataset (Line 7)										unitless
10	Sediment Supply Potential Calculated using Equation H.8.11. (0.7 x Line 8 + 0.3 x Line 9)										unitless

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H.9 Mitigation Measures Fact Sheets

The following fact sheets were developed to assist the project applicants with designing mitigation measures:

- Additional flow control
- Stream Rehabilitation

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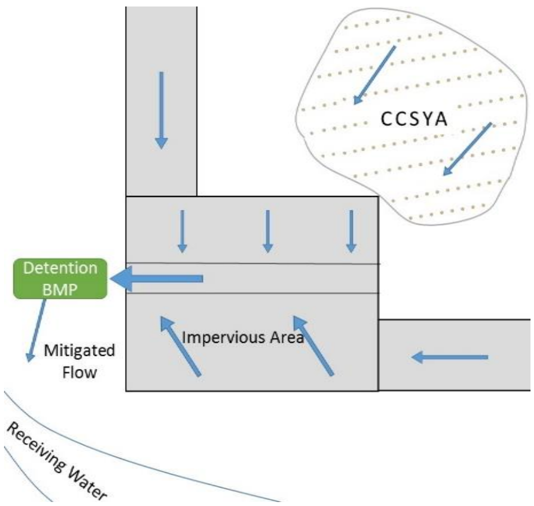
H.9.1 Additional Flow Control



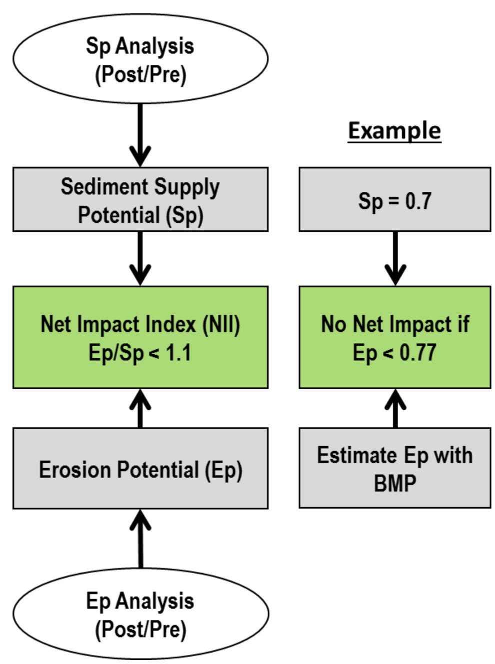
Description

Additional flow control refers to the modification of post-development flow rates and durations beyond the levels required by standard HMP criteria (i.e. control of flow rates and durations from Q_c to Q_{10}). Additional flow control can mitigate the effect of decreased sediment delivery by equivalently limiting sediment transport capacity. BMPs providing additional flow control are detention/retention type BMPs and will typically be larger than those that meet HMP criteria only. The performance standard for additional flow control can be demonstrated through the NII management standard.

Management Standard and Sizing Approach

The management standard additional flow control BMPs need to meet to demonstrate that there is no net impact to the receiving waters is presented in the equation below:

$$NII = \frac{Ep}{Sp} \leq 1.1$$



Where:

Ep: is the ratio of post-project/pre-development sediment transport capacity

Sp: ratio of post-project/pre-project (existing) long-term bed sediment supply

Note: Redevelopment projects typically do not have critical coarse sediment yield areas onsite because management actions have been implemented onsite (e.g. impervious areas, stabilization, etc.). Refer to Appendix H.8 for methodologies to calculate Ep and Sp.

Project applicants must demonstrate that the NII management standard will be met under the post-project scenario through the following steps:

1. Calculate the Sp at the point of compliance using guidance in **Appendix H.8.2**.
2. Determine the Target Ep: EpTarget ≤ 1.1 * Sp

3. Calculate the pre-development sediment transport capacity or work (Ep denominator). Refer to **Section 6.3.3** for definition of pre-development and refer to **Appendix H.8.1** for guidance on calculating the sediment transport capacity or work.
4. Iteratively size additional flow control BMPs and calculate the post-project sediment transport capacity (Ep numerator) until the target Ep is reached.
5. Summarize the calculations performed to size the BMPs in the SWQMP.

In addition to the general approach outlined above, additional flow control BMPs must meet the design criteria presented in the Model BMP Design Manual (refer to **Appendix E** Fact Sheets). Deviations from these criteria may be approved at the discretion of the City Engineer if it is determined appropriate.

Design Adaption for Project Goals

NII management standard is met by additional flow control. Larger BMPs may be able to provide adequate additional flow control to meet the required performance standard. In this scenario no additional sediment BMPs are required.

For example, project that has an Sp = 0 (i.e. 100% of the bed sediment in the drainage area to the point of compliance is impacted by the project) can be mitigated by designing a BMP such that there is no discharge within the geomorphically significant flow range (i.e. Q_c to Q_{10}).

NII management standard is not fully met by additional flow control. Additional flow control alone may not be able to entirely meet the NII management standard due to site, or other, constraints. In scenarios where the target Ep cannot be met by additional flow control, additional BMPs that increase the supply of bed sediment or reduce the susceptibility of the receiving channel will be required.

Note: Additional flow control BMPs can be independent BMPs that provide flow control only or they can be integrated with storm water pollutant control BMPs.

Conceptual Design and Sizing Approach

The following steps detail an approach that can be used to appropriately size BMPs that provide additional flow control:

Step 1: **Calculate the Sediment Supply Potential (Sp) based on pre- and post-project condition at the point of compliance.**

- Refer to **Appendix H.8.2** for methodology to calculate Sp. Applicant must document this analysis using Worksheet H.8.2-1.

Step 2: Determine the Target Ep based on the results of Step 1.

- $Ep_{Target} \leq 1.1 * Sp$

Step 3: **Perform continuous simulation modeling for pre-development condition.**

- Perform continuous simulation (refer to **Appendix G**) for the pre-development condition.

- Determine the flow durations for the pre-project scenario as described in **Appendix G.1.6.2**.

Step 4: Perform pre-development work analysis.

- Calculate the cumulative work performed by the range of geomorphically significant flows for the pre-development scenario, (refer to Step 3 and Step 4 in **Appendix H.8.1** for calculation of work).

Step 5: Implement flow control BMPs and perform continuous simulation modeling for post-project scenario.

- Appropriately size pollutant control and hydromodification management BMPs according to the procedures presented in this manual.
- Perform continuous simulation (refer to **Appendix G**) for the post-project condition.
- Determine the flow durations for the post-project scenario as described in **Appendix G.1.6.2**.
- Typically, BMPs sized to satisfy the flow duration control will provide for some level of Sp reduction and will ensure that the minimum design standards and sizing requirements are met.

Step 6: Perform post-project work analysis.

- Follow the steps presented in Step 4 to determine the post-project total work.

Step 7: Calculate Ep and determine if Target Ep has been met.

- Divide the post-project total work by the pre-development total work and determine if the target Ep has been met.
- If the target Ep is met by the standard BMPs, document results and compliance with hydrologic and sediment supply performance standards.
- If the target Ep is not met, proceed to Step 8.

Step 8: Provide additional flow control storage and calculate Ep.

- Following the procedures presented in the previous steps, iteratively calculate Ep for increasingly large BMPs until the target Ep is met.
- Document results and compliance with hydrologic and NII management standard.

As applicable, the applicant must use Worksheet H.8.1-1, Worksheet H.8.2-1 and Worksheet H.9.1-1 to document sizing of the additional flow control mitigation measure.

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Worksheet H.9-1: Additional Flow Control Mitigation Measure

Additional Flow Control Mitigation Measure		Worksheet H.9-1	
1	Sediment Supply Potential (Line 16 of Worksheet H.8-3)		unitless
2	Attached completed Worksheet H.8-3 and associated documentation	☐ Yes ☐ No	
3	Target Ep ≤ 1.1 * Line 1		unitless
4	Erosion Potential (Line 16 of Worksheet H.8-1)		unitless
5	Attached completed Worksheet H.8-1 and associated documentation	☐ Yes ☐ No	
6	Is Line 4 ≤ Line 3? If Yes, NII management standard is met. If No, increase the size of the BMP and recalculate Line 4.	☐ Yes ☐ No	

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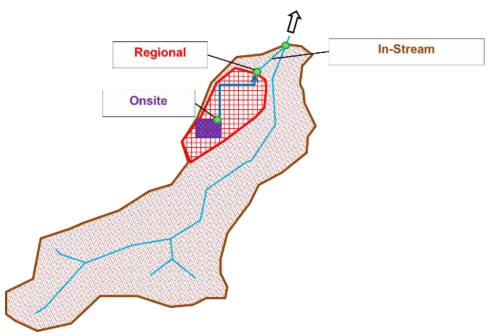
H.9.2 Stream Rehabilitation



Description

Hydromodification control can be achieved by stream rehabilitation projects including: drop structures, grade control structures, bed and bank reinforcement, increased channel sinuosity or meandering, increased channel width, and flow diversion. The objective of these in-stream controls, or stream restoration measures, is to reduce or maintain the overall Ep of the receiving channel. Stream rehabilitation option is only available when the receiving channel of concern is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel.

Management Standard and Sizing Approach

The management standard stream rehabilitation projects need to meet to demonstrate that there is no net impact to the receiving waters is presented in the equation below:

$$NII = \frac{Ep}{Sp} \leq 1.1$$

Where:

Ep: is the ratio of post-project/pre-development sediment transport capacity

Sp: ratio of post-project/pre-project (existing) long-term bed sediment supply

Note: Stream rehabilitation project reduce Ep by modifying the stream's hydraulic properties and/or bed/bank material resistance without fully replacing sediment supply or controlling increases in runoff. Refer to **Appendix H.8** for methodologies to calculate Ep and Sp.

Design Adaption for Project Goals

The following describes different types of stream rehabilitation projects that could be implemented to meet the NII management standard by reducing or maintaining the overall Ep:

Drop Structures: Drop structures are designed to reduce the average channel slope, thereby reducing the shear stresses generated by stream flows. These controls can be incorporated as natural looking rock structures with a step-pool design which allows drop energy to be dissipated into the pools while providing a reduced longitudinal slope between structures.

Grade Control Structures: Grade control structures are designed to maintain the existing channel slope while allowing for minor amounts of local scour. These control measures are often buried and entail a narrow trench across the width of the stream backfilled with concrete or similar material, as well as the creation of a "plunge pool" feature by placing boulders and vegetation on the downstream side of the sill. A grade control structure provides a reduced footprint and impact as compared to drop structures, which are designed to alter the channel slope.

Bed and Bank Reinforcement: Channel reinforcement serves to increase bed and bank resistance to instream erosion. A number of vegetated approaches are widely used. Such approaches include large woody debris, live crib walls, vegetated mechanically stabilized earth, live siltation, live brushlayering, willow posts and poles, live staking, live fascine, rootwad revetment, live brush mattresses, and vegetated reinforcement mats. These technologies provide erosion control that stabilizes bed and bank surfaces and allows for re-establishment of native plants, which serves to further increase channel stability.

Channel Sinuosity: Increasing channel sinuosity (meandering) can serve to reduce the channel slope, thereby reducing the shear stresses generated by stream flows. However, forcing a channel to be too sinuous is likely to lead to subsequent channel avulsion (cutting a new stream path) to a straighter course. Channel sinuosity needs to be supported by a geomorphic basis of design that shows the proposed form and gradient are appropriate for the valley slope, sediment, and water regime. This support may take the form of reference reaches in similar watersheds that have supported the proposed morphology over a significant period of time, or comparison between the proposed form and typical literature values.

Channel Widening: Increasing the width-to-depth ratio of a stream's cross section is meant to spread flows out over a wider cross section with lower depths, thereby reducing shear stress for a given flow rate. This approach can be a useful management strategy in incised creeks to restore them to equilibrium conditions once vertical incision has ceased. As with sinuosity, it is important to develop a robust geomorphic basis of design that shows the increase in width-to-depth ratio to be sustainable.

Flow Diversion: Flow diversions can be designed to divert the excess flows caused by development to an hydromodification management exempt water body so that the shear stresses do no increase in the susceptible receiving water. When diversions are proposed to a water body exempt through watershed management area analysis, the applicant is required to provide a supporting analysis that the excess flows diverted to the exempt water body do not invalidate the exemption.

Design Considerations

Each stream rehabilitation project is to some degree unique because of differences in geomorphic process, morphology and previous watershed history. For this reason, this fact sheet does not provide a prescriptive 'cookery book' approach for rehabilitating streams, but instead provides guidelines and recommendations. Shields (1996) provides a helpful overview of the analytical steps involved in stream restoration and Shields et al. (1999) provides examples of approaches used to rehabilitate incised channels. Applicant will need to provide geomorphic and engineering information to support their proposed project approach. It is recommended that multiple lines of technical evidence be used by applicants to develop creek restoration plans based on the preponderance of evidence for design criteria such as channel width, depth, slope and planform. It is also important to understand that all creek rehabilitation projects must comply with relevant Federal, State and local regulations and permits. These will likely include obtaining permits from the RWQCB, USACE and California DF&W, and may involve additional permits or consultation with USDF&W and FEMA, as well as permits from the local jurisdiction. The proposed design shall also meet local drainage design guidelines for channel design.

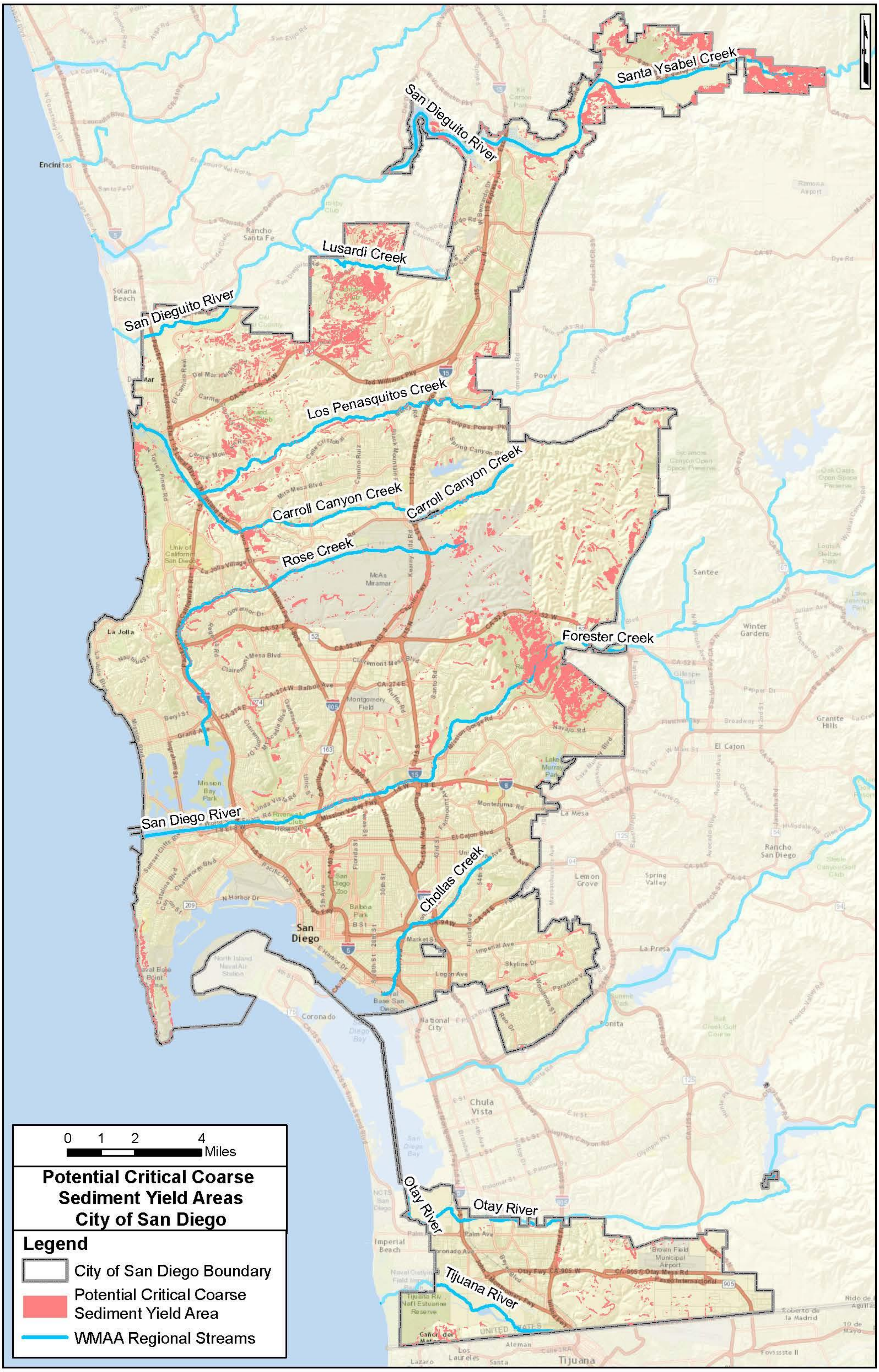


Figure H.9-1 : Potential Critical Coarse Sediment Yield Areas

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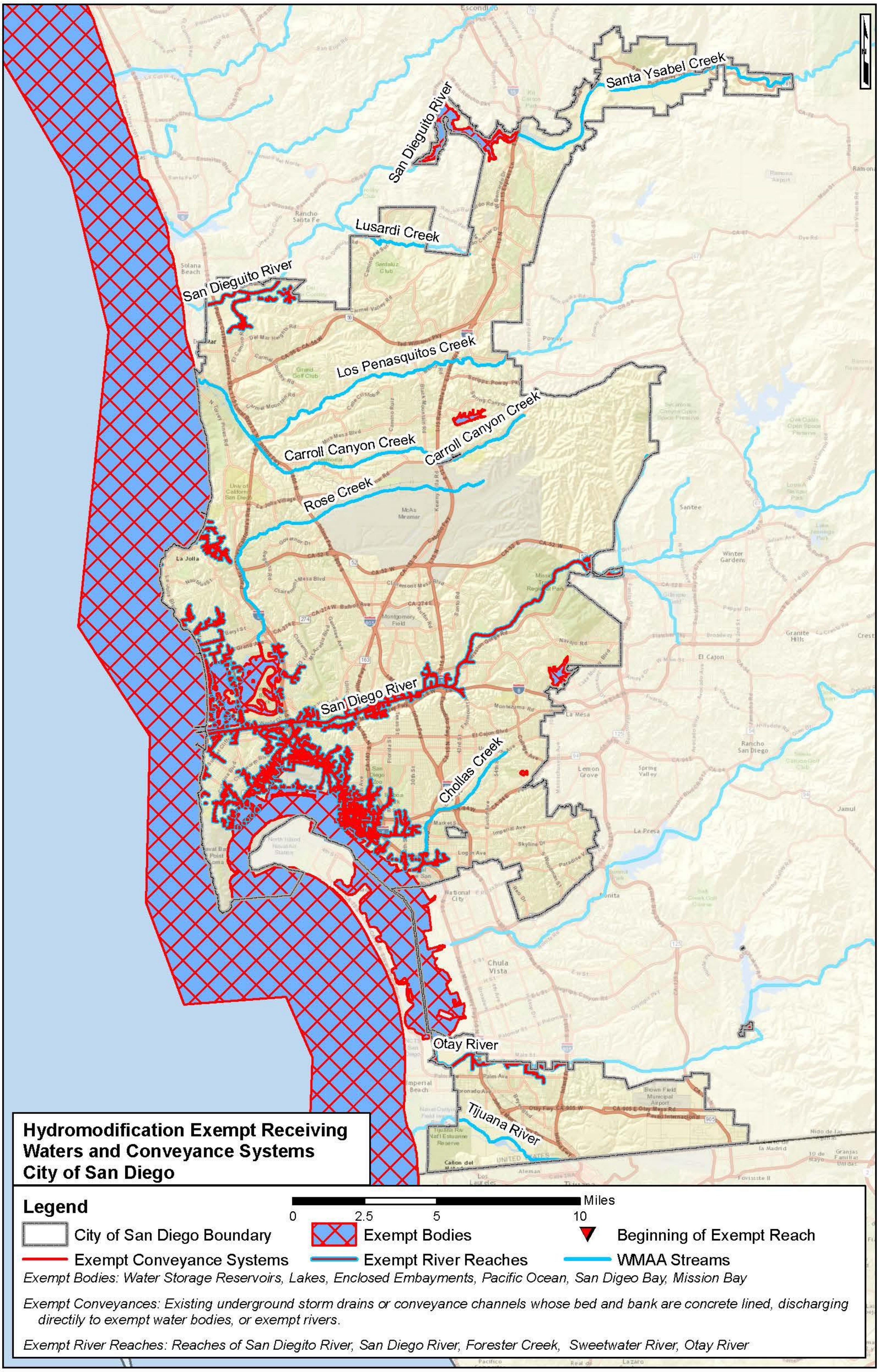

Figure H.9-2 : Hydromodification Exempt Areas

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Appendix
I

Forms and Checklists

The following Forms/ Checklists/ Worksheets were developed for use by the project applicant to document the storm water management design.

Form I-1: Applicability of Permanent, Post-Construction Storm Water BMP Requirements

Form I-3A: Site Information Checklist for Standard Projects

Form I-3B: Site Information Checklist for PDPs

Form I-4A: Source Control BMP Checklist for Standard Projects

Form I-4B: Source Control BMP Checklist for PDPs

Form I-5A: Site Design BMP Checklist for Standard Projects

Form I-5B: Site Design BMP Checklist for PDPs

Form I-6: Summary of PDP Structural BMPs

Form I-7: Worksheet B.3-1: Harvest and Use Feasibility Screening Checklist

Form I-8A: Worksheet C.4-1: Categorization of Infiltration Feasibility Condition Based on Geotechnical Conditions

Form I-8B: Worksheet C.4-2: Categorization of Infiltration Feasibility Condition Based on Groundwater Conditions

Form I-9: Worksheet D.5-1: Factor of Safety and Design Infiltration Rate Worksheet for Full Infiltration Designs

Form I-10: Onsite Compact Biofiltration BMP Checklist

Fillable forms and checklists for use with the SWQMP submittal are available at the following location.

https://www.sandiego.gov/stormwater/regulations

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Appendix J

PDP Exemption Guidance

There are two categories of projects that can be exempted from being classified as PDPs.

- PDP Exemption Category 1: New or retrofit paved sidewalks, bicycle lanes, or trails that meet certain criteria (Refer to **Appendix J.1**)
- PDP Exemption Category 2: Retrofitting or redevelopment of existing paved alleys, streets or roads that meet certain criteria (Refer to **Appendix J.2**)

Technical guidance related to both exemption categories are provided in this appendix.

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J.1 Guidance for Qualifying for PDP Exemption Category 1

PDP Exemption Category 1 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 storm water runoff to adjacent vegetated areas, or other non-erodible permeable areas (**Appendix J.1.1**); OR
2. Designed and constructed to be hydraulically disconnected from paved streets or roads (**Appendix J.1.2**); OR
3. Designed and constructed with permeable pavements or surfaces (**Appendix J.1.3**).

What does this exemption provide?

Where a project or portion of a project meets the criteria to be considered exempt, 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.

What are the limitations?

In order to qualify for these exemptions, the exempted projects or areas of a project must meet the applicable criteria in the sections below. PDP exemptions are approved at the discretion of the City Engineer.

J.1.1 Guidance for Directing Storm Water into Vegetated or Non-Erodible Permeable Areas to Meet PDP Exemption Category 1

Routing storm water 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:

- Satisfy the specifications outlined within the impervious dispersion (**SD-B in Appendix E**) factsheet, **OR**
- 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 J.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 must be designed with the standard cross slope and the adjacent vegetated/non-erodible permeable area depressed by 2 inches.

The definition of non-erodible permeable surfaces does **NOT** include areas of loose gravel fill, mulch, sand, or soils, which are easily dislodged during sheet flow conditions.

<u>Intent</u>: 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.

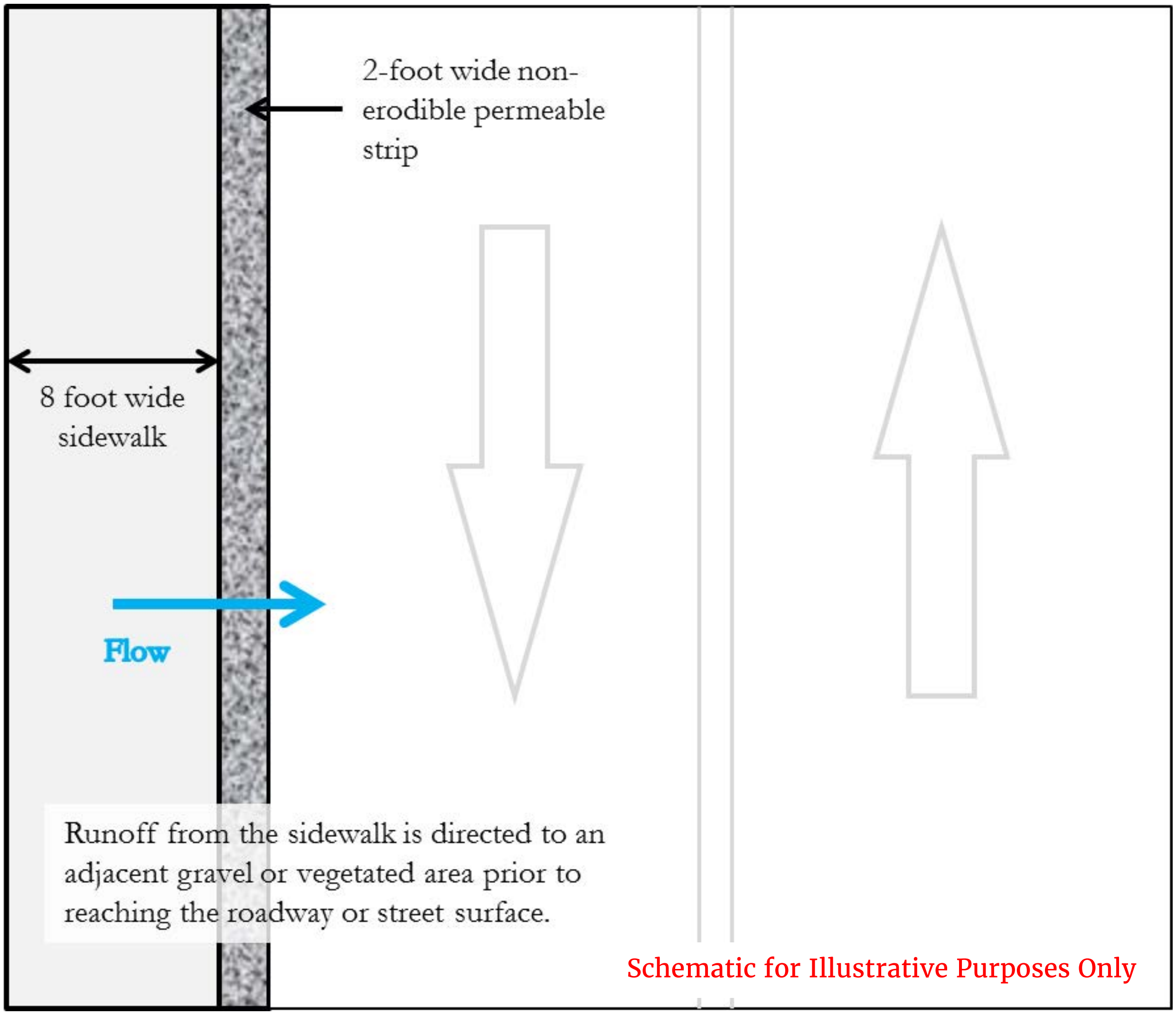


Figure J.1-1 : Schematic of an all gravel non-erodible permeable area configuration (not to scale)

J.1.2 Guidance for Hydraulic Disconnection to Meet PDP Exemption Category 1

Hydraulic disconnection involves separating the storm water collected from the sidewalk, bicycle lane, and/or trail surface from the runoff collected form an adjacent paved street or roadway. If the surface runoff from the sidewalk, bicycle lane, and/or trail surfaces does not comingle 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 J.1-2 and Figure J.1-3 provide examples of how this exemption could be achieved. Water is allowed to comingle once it is in the storm drain pipe.

<u>Intent</u>: 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 comingle 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 City Engineer may determine that it is not appropriate to grant this exemption.

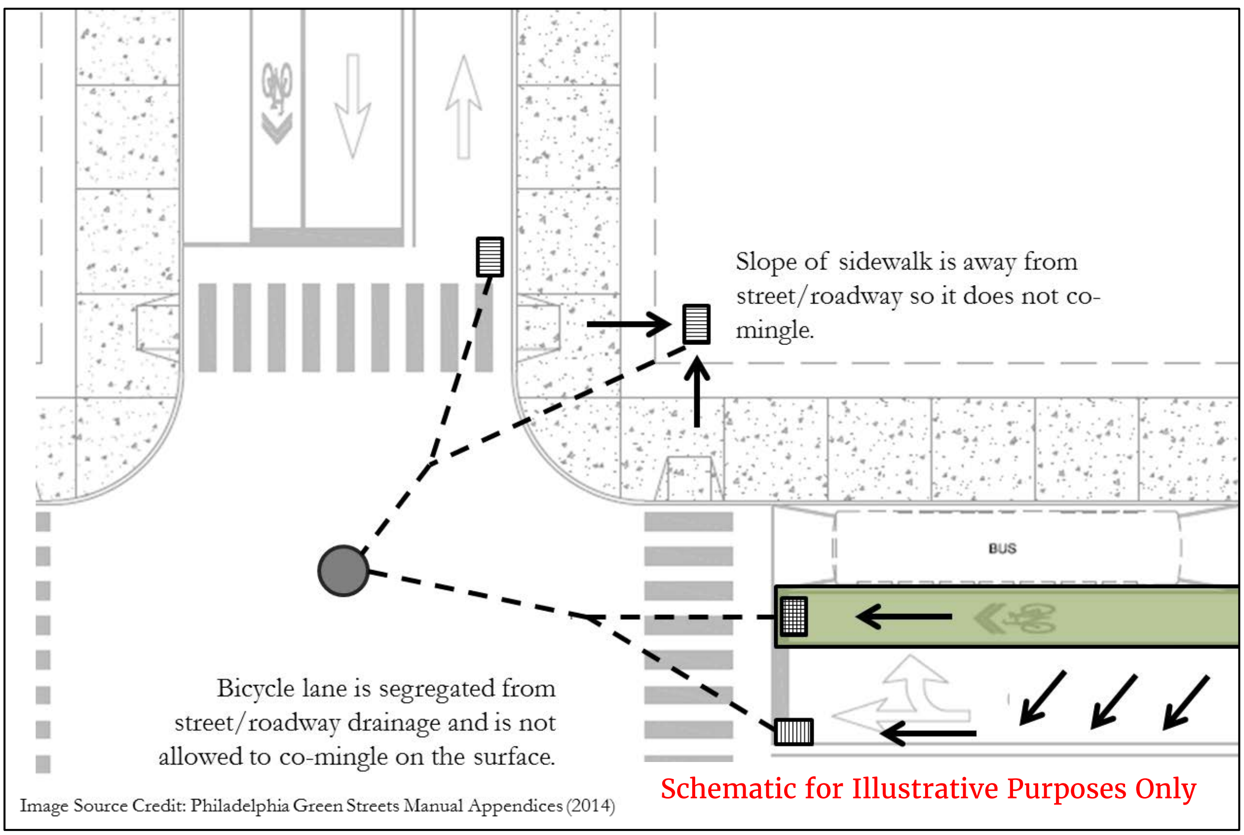


Figure J.1-2 : Schematic showing hydraulic disconnection of sidewalks and bicycle lanes in a typical intersection.

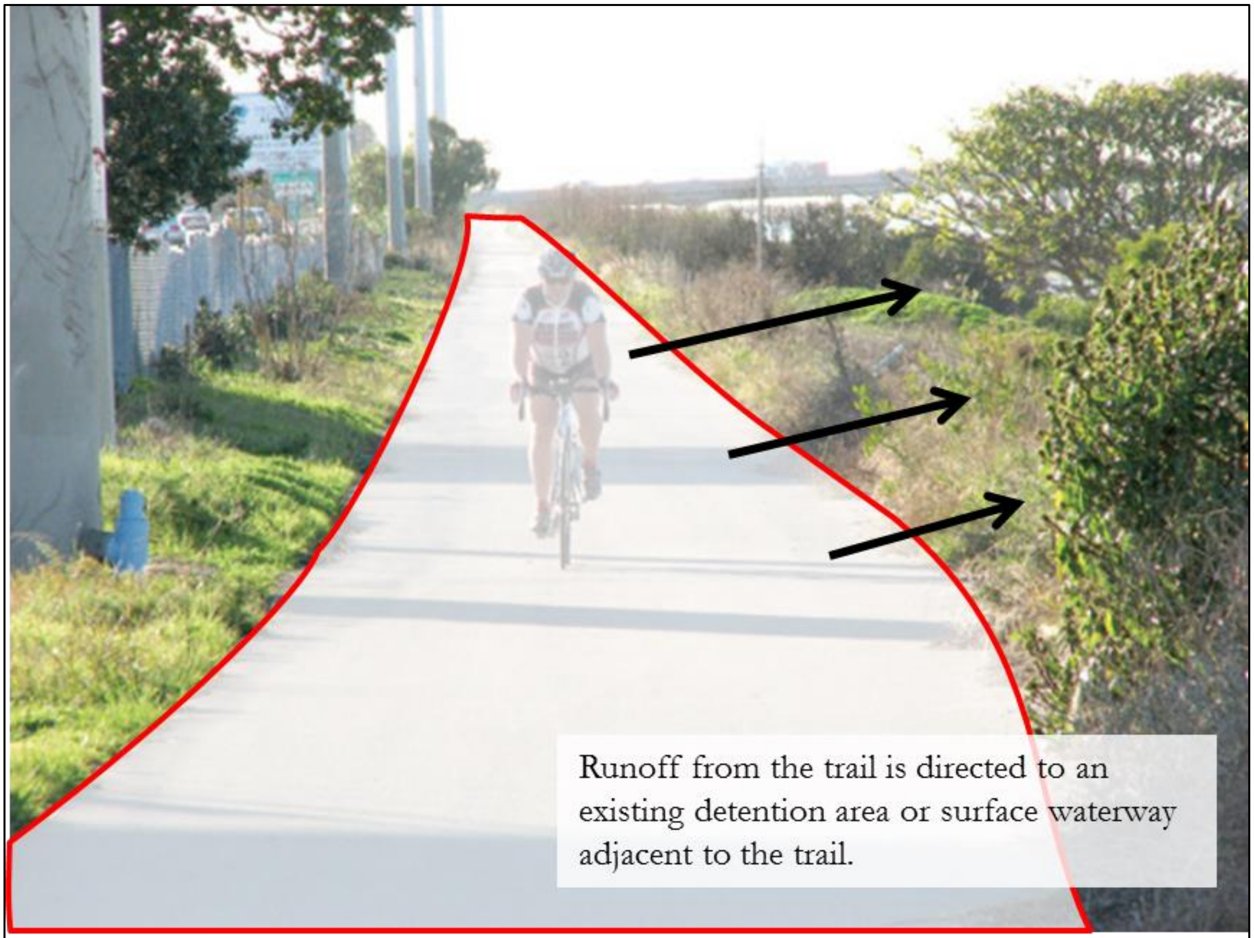


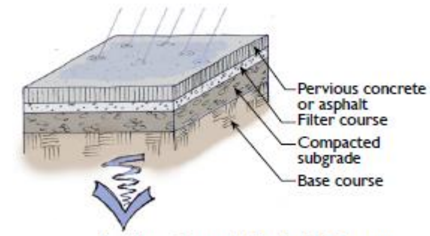
Image Source Credit: http://sdrc.ca.gov/photo_gallery.html

Figure J.1-3 : Schematic of a trail where the runoff does not comingle with street or road runoff

J.1.3 Permeable Pavements/Surfaces Guidance for PDP Exemption Category 1

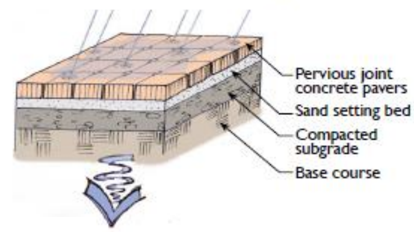
Permeable pavements or surfaces allow rainwater to pass through the surface and soak into the underlying ground. These help in reducing the amount of storm water runoff generated. These surfaces should not be used where infiltration of storm water runoff causes geotechnical or groundwater concerns (refer 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 storm water infiltration. <u>No exemption is granted if the permeable pavement is lined with an impermeable liner</u>. 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. It is also important to note that, 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.



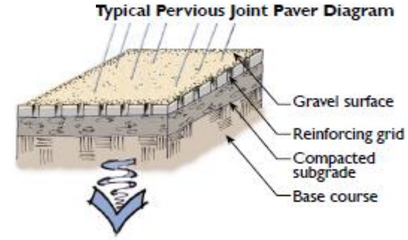
Pervious Concrete/Asphalt Diagram

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 storm water 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.

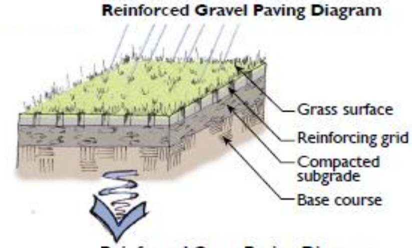


Typical Pervious Joint Paver Diagram

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 Gravel Paving Diagram



Reinforced Grass Paving Diagram

Source Credit: San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook (adapted)

Reinforced Grass Paving: In the right situations, grass paving, or other hybrids between paving and planting, can be used to provide structural support while also allowing for some plant growth and storm water infiltration. These systems may be appropriate in areas of low use and where soil, drainage, sunlight, and other conditions are conducive to plant growth.

J.2 Guidance for Qualifying for PDP Exemption Category 2

PDP Exemption Category 2 is defined in Section 1.4.3. This section provides technical guidance for developing a project that meets the criteria to be considered exempt. Refer to Section 1.4.3 for specific exemption criteria.

The guidelines in this section must be followed for determination of which green streets elements (or combinations of elements) are applicable to a project. This section consists of:

- Menu of Potential Green Streets Elements (**Appendix J.2.1**);
- Guidance for Selecting Applicable Green Street Elements/Combinations to Meet Green Street Exemption Criteria (**Appendix J.2.2** and Table J.2-1); and
- Checklist to document the selected and implemented green street elements (**Form J-1**)

J.2.1 Menu of Potential Green Street Elements

The functional goals of green streets are to provide source control of storm water, limit storm water transport and pollutant conveyance to the collection system, restore predevelopment hydrology to the extent possible, and provide environmentally enhanced roads. This goal can be achieved by incorporating the following elements from the Green Streets Municipal Handbook[25] into the design, as applicable:

- Vegetated Swales
- Sidewalk Planters
- Curb Extensions
- Permeable Surfaces
- Green Gutters
- Rain Gardens (Bioretention or Biofiltration with Partial Retention or Biofiltration)
- Trees and/or tree boxes
- Alternative green streets approaches that provide equivalent benefit and are acceptable to the City Engineer

Successful application of green street elements should encourage soil and vegetation contact and infiltration and retention of storm water.

[25] Municipal Handbook: Managing Wet Weather with Green Infrastructure – Green Streets, December 2008, United States Environmental Protection Agency, EPA-833-F-08-009.

J.2.2 Guidance for Selecting Applicable Green Street Elements to Meet Green Street Exemption Criteria

Applicability guidance for each green street element is presented in Table J.2-1. The following sections provide overall guidance for selecting applicable green streets elements and combinations of elements.

- ✓ **Street Category.** As summarized in Table J.2-1, street category can be used as an important indicator of what types of elements may be most applicable. However, a street classification alone does not provide adequate basis for determining feasibility. Site-specific factors must be evaluated, as described in the following paragraphs.
- ✓ **Infiltration Feasibility.** The infiltration condition of the project (full infiltration, partial infiltration, or no infiltration) determines which green street elements are applicable and which variations would apply (i.e., planters with underdrains vs. no underdrains). Therefore, the determination of applicability of green street features must include an infiltration feasibility analysis per the criteria and methods in **Appendix C**.
- ✓ **Slope and Drainage Patterns.** Slope is a key factor in determining which features can be used. Slope ranges are presented in Table J.2-1. Additionally, the drainage patterns of the site may be important. If green street elements can serve a conveyance purpose in addition to a pollutant control purpose, they can potentially help avoid traditional grey infrastructure and help avoid some project costs.
- ✓ **Available Space and Geometric Opportunities.** Available space and the shape of the space that is available are two key factors in determining the types of green streets elements that apply. Table J.2-1 provides guidance on the types of areas where each green street element may be applicable.
- ✓ **Traffic Safety and Emergency Vehicle Access.** Green street elements shall not be selected and sited where they would compromise traffic safety or emergency access.
- ✓ **Preservation of Existing Trees.** Green street elements shall not be selected and sited where they would require removal of existing trees (Refer to **Chapter 4** for additional guidance).
- ✓ **Maintenance Access.** Green street elements shall be sited such that they can be accessed for routine maintenance without unacceptable traffic disruptions.
- ✓ **Parking and Accessibility.** Green street elements shall be selected and sited to be compatible with parking and accessibility goals of a project; in general, green streets can be compatible with these considerations. However, where conflicts cannot be addressed, a different green street element should be selected.
- ✓ **Run-on from Adjacent Surfaces.** In some cases, site drainage patterns may be such that drainage from adjacent (unaffected) surfaces comingles with new or replaced impervious areas. This may create an opportunity to treat additional area to offset for not managing runoff from some project areas. The amount of run-on area and the expected sediment load from this area may influence the applicability of green street elements. For example, run-on from a large area with elevated sediment load may be problematic for permeable pavement, but a swale or green gutter could be an effective solution for conveying and treating this runoff.

- ✓ **Combining Multiple Features.** In determining which green street elements are applicable, consideration should be given to overlaps in opportunity area and how the potential green street elements would work in combination. Some green street elements may occupy the same space within the right-of-way and/or serve overlapping purposes. For example, a vegetated swale, green gutter, and sidewalk planter occupy effectively the same space within the right-of way and serve effectively the same purposes. While it may be physically possible to implement several different elements in a given space and for a given drainage area, this would tend to require that each be sized for only a portion of the available footprint. In this case, greater diversity of design features would tend to increase design complexity and construction cost while not necessarily providing commensurate increases in performance. As such, a green street element can be considered to be not applicable if another green street element would occupy the same space and/or serve a similar storm water control function for the same drainage area.
- ✓ **Equivalent Benefit.** Site specific conditions and increasing body of experience with green street design in the City of San Diego may lead to alternative designs or approaches. The initial menu of green street elements is not intended to restrict the use of other elements that have been demonstrated to provide equivalent or better benefit.

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Table J.2-1: Summary Table of Green Street Elements

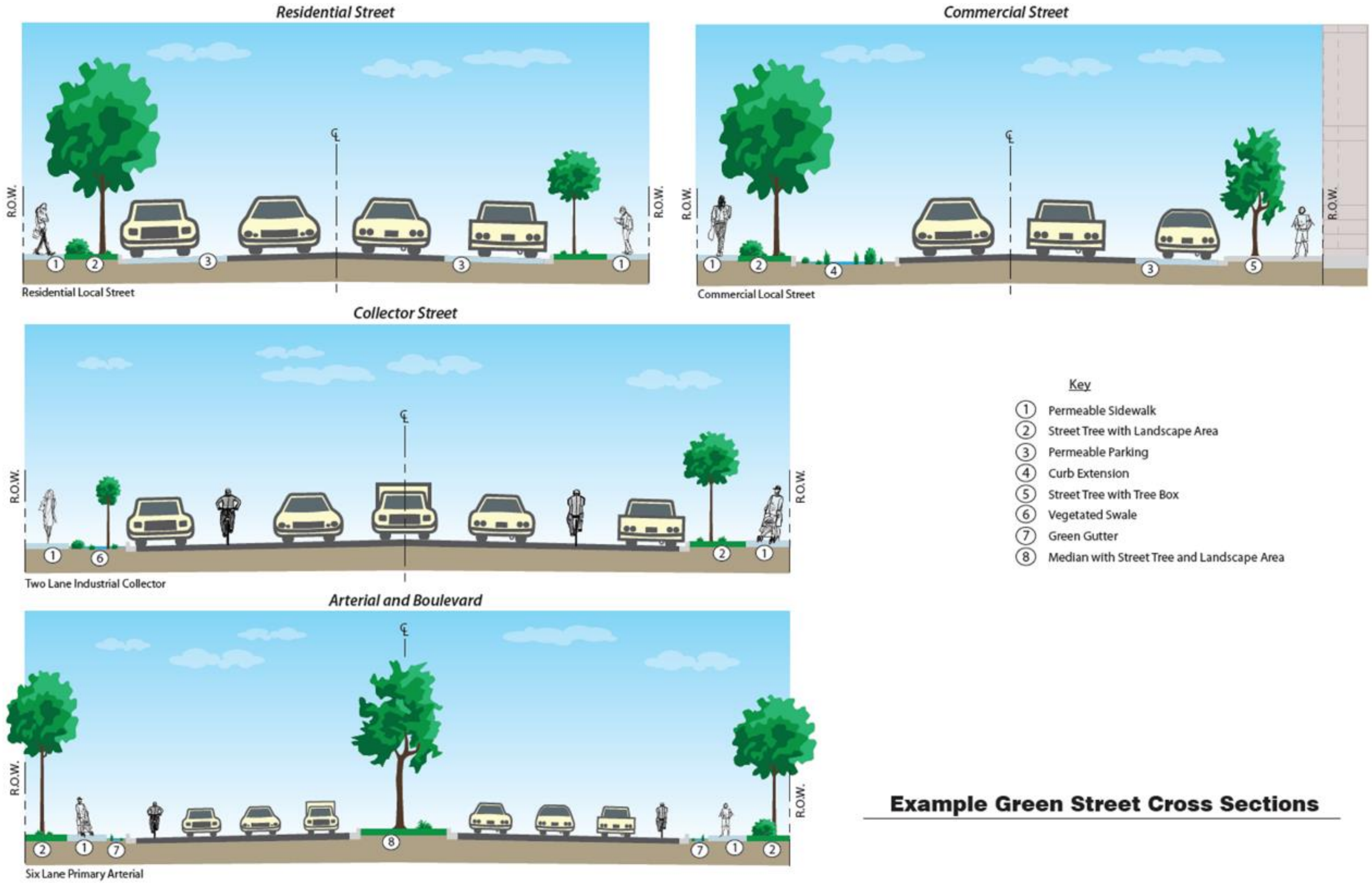
		Vegetated Swales	Sidewalk Planters	Curb Extensions	Permeable Surfaces	Green Gutters	Rain Gardens	Trees
General Applicability Factors for All Street and Roadway Types	Typical Opportunities	• Parkway strips or medians, or other long and mostly continuous space	• Parkway strips	• At intersections or intermediate locations for traffic calming	• Sidewalks, parking strips, shoulders, travel lanes of low traffic roadway	• Parkway strips or medians, or other long and mostly continuous space	• Relatively broad and flat areas that can receive flow; irregularly shaped areas in ROW	• Parkway strips or medians; extra ROW on back side of sidewalk; irregular parcels
	Siting Factors	• Preferably slope > 1% and < 3%; possible up to 6% with check dams/drop structures • Typically require wider widths than green gutters (approx. 8 ft) • Good for conveying run-on to site	• Can fit in short spaces; can be separated into segments • Most practical for slopes < 4%; possibly higher with design considerations • May conflict with egress from cars if located next to parking strips	• Most practical for slopes < 4%; possibly higher with design considerations • May pose conflict with bike lanes • Consider site distance issues at intersections	• Locate where reservoir can be flat unless internal contouring provided • Typically most applicable on slopes < 2 to 3 % • Does not qualify as a green street element if lined with an impermeable liner	• Preferably slope > 1% and < 3%; possible up to 6% with check • Fit in narrower spaces than swales (as little as 2 to 3 feet) • May conflict with egress from cars if located next to parking strips • Good for conveying run-on to site	• Preferably in relatively flat areas (< 2%) or potentially higher with retaining wall/berm to create level ponding area	• Very versatile placement • Not dependent on slope • Should be located outside of clear zone to avoid collision hazards for higher speed roadways
	Infiltration Feasibility Considerations	• Adaptable to all infiltration conditions, • Most appropriate where infiltration is partially feasible or not feasible	• Adaptable to all infiltration conditions • Require underdrain connection unless designed for full infiltration	• Adaptable to all infiltration conditions • Require underdrain connection unless designed for full infiltration	• Use where infiltration is fully or partially feasible • Provide positive overflow • Ability to allow run-on depends on infiltration feasibility	• Adaptable to all infiltration conditions, but most appropriate where infiltration is partially feasible or not feasible	• Adaptable to all infiltration conditions • Require underdrain connection unless designed for full infiltration	• If tree wells will accept storm water inflow, ensure drainage is adequate to avoid root damage from long term submergence
	Other Factors	• May require irrigation system • Can potentially allow reduced spacing of storm drain inlets • Can potentially discharge into gutter if no storm drain present	• May require irrigation system	• May require irrigation system • May accept larger tributary area than project; ensure inflow energy dissipation adequate for all inflows	• Select surface type based on anticipated traffic/loading • Not well suited in cases with significant run-on from areas with sediment load	• May require irrigation system • Can potentially allow reduced spacing of storm drain inlets • Can potentially discharge into gutter if no storm drain present	• May require irrigation system • May accept significantly larger tributary area than project; ensure inflow energy dissipation adequate for all inflows	• May require periodic irrigation during establishment

		Vegetated Swales	Sidewalk Planters	Curb Extensions	Permeable Surfaces	Green Gutters	Rain Gardens	Trees
Applicability Ratings by Street Type								
Residential Street	Applicability:	◉	◉	●	●	○	◉	●
	Key factors:	• Frequent driveway interruptions	• May conflict with car egress along parking areas	• Good compatibility with traffic calming objectives and parking	• Compatible with lower traffic/lighter loads • Evaluate potential sediment run-on loads	• Frequent driveway interruptions • Typically enough space for larger elements	• Dependent on site-specific opportunities	• No issues with clear zone
Commercial Street/Business District	Applicability:	○	◉	●	●	◉	◉	◉
	Key factors:	• Frequent driveway interruption • ROW width typically too limited	• May conflict with car egress along parking areas	• Good compatibility with traffic calming objectives and parking	• Compatible with parking uses • Evaluate potential sediment run-on loads	• Frequent driveway interruption • May conflict with car egress along parking areas	• Dependent on site-specific opportunities	• Can be limited space for roots/canopy in tighter commercial areas
Collector Street	Applicability:	◉	●	◉	◉	●	◉	◉
	Key factors:	• Typically have long continuous segments • Typically have more parkway width than arterials	• Less concern about parking conflicts • Compatible with bike uses	• May conflict with bike travel • Typically do not desire traffic calming/restriction	• If low traffic/light load areas exist • Evaluate potential sediment run-on loads	• Compatible with typical space constraints encountered in this type of road	• Dependent on site-specific opportunities	• Consider clear zone requirements
Arterial and Boulevard	Applicability:	◉	●	◉	◉	●	◉	◉
	Key factors:	• Typically have long continuous segments • May not have enough parkway width in more constrained streets	• Less concern about parking conflicts than other street types • Compatible with bike uses	• May conflict with bike travel • Typically do not desire traffic calming/ restriction in these road types	• If low traffic/light load areas exist • Evaluate potential sediment run-on loads	• Compatible with typical space constraints encountered in this type of road	• Dependent on site-specific opportunities	• Consider clear zone requirements

● High applicability for roads within this category, however may still be limited by site-specific factors

◉ Generally applicable for roads in this category; largely dependent on site-specific factors

○ Limited applicability for roads within this category; may still be applicable in some cases; should be considered



Example Green Street Cross Sections

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BMP Applicability and Selection for Green Street Exemption	Form J-1
Project Identification	
Project Name:	
Permit Application Number:	Date:
Project Characterization and Selection Synopsis	
The purpose of this form is to guide the selection of BMPs, given project specific constraints to meet the Green Streets exemption as defined in Appendix J.2 of the BMP Design Manual. In order to qualify for a PDP exemption, the project must incorporate all applicable Green Street BMP elements described in Appendix J.2, based on the applicability guidance provided in Appendix J.2. Complete the sections below providing detailed justification for each selection.	
Step 1: Does this project include retrofitting or redevelopment of an existing alley, street, or roadway criteria? Exemptions do not apply for projects that construct new alleys, streets, or roadways. See Appendix J for additional guidance on distinguishing between redevelopment of a street and new development. ☐ Yes ☐ No (if No is selected, the Green Street exemption is not applicable)	
Provide a brief overview of the project, key details, and site-specific opportunities and constraints:	
Step 2: Complete the BMP-specific applicability checklists on the following pages and attach them to this form. Complete forms for all BMPs, including those that were used and those that were not used.	
Step 3: Summarize the BMP(s) that were selected through the guidance process (Select all that apply):	

BMP Type	Applicable?	Used?	Summary of justification for Inclusion or Finding of Non-applicability
Vegetated Swales	☐	☐	
Sidewalk Planters	☐	☐	
Curb Extensions	☐	☐	
Permeable Surfaces	☐	☐	
Green Gutters	☐	☐	
Rain Gardens	☐	☐	
Trees	☐	☐	
Other___________	☐	☐	

Form J-1 Page 2 of 8: Vegetated Swale			
Brief 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.			
Site Type (Check all that apply):	Street Type	Rating[26]	Present in Project?
	Residential Streets	⦿	☐
	Commercial Street/ Business District	○	☐
	Collector Street	⦿	☐
	Arterial and Boulevard	⦿	☐
	Alleys	○	☐
	Parking Areas	⦿	☐
Key Opportunities for Vegetated Swales (Check all that apply):	Parkway strips		☐
	Medians		☐
	Long, mostly continuous space		☐
	Other (must justify below)		☐
Site-Specific Factors (Check all that apply):	Favorable Conditions for Vegetated Swales		
	Slope > 1% and <3%		☐
	Conveying run-on to a site		☐
	Infiltration is partially feasible or not feasible		☐
	Long continuous segments available		☐
	More parkway width		☐
	Unfavorable Conditions for Vegetated Swales		
	Available width is < 8 feet		☐
	Frequent driveway interruption		☐
	ROW width too limited		☐
Summary of Findings:			
Were Vegetated Swales determined to be applicable as part of the Green Streets BMP plan? ☐ Yes ☐ No		If yes, were they used? ☐ Yes ☐ No	
Provide discussion/justifications for selections and decisions above:			

[26] ● High applicability within this category, however may still be limited by site-specific factors

⦿ Generally applicable in this category; largely dependent on site-specific factors

○ Limited applicability within this category; may still be applicable in some cases; should be considered

Form J-1 Page 3 of 8: Sidewalk Planters			
Brief Description: A planter imbedded in the sidewalk designed to manage storm water runoff from the adjacent roadway and sidewalk.			
Site Type (Check all that apply):	Street Type	Rating[27]	Present in Project?
	Residential Streets	◉	☐
	Commercial Street/ Business District	◉	☐
	Collector Street	●	☐
	Arterial and Boulevard	●	☐
	Alleys	○	☐
	Parking Areas	◉	☐
Key Opportunities for Sidewalk Planters (Check all that apply):	Parkway strips		☐
	Medians		☐
	Between driveways		☐
	Other (must justify below)		☐
Site-Specific Factors (Check all that apply):	Favorable Conditions for Sidewalk Planters		
	Slope <4%		☐
	Wide sidewalks		☐
	More parkway width		☐
	Unfavorable Conditions for Sidewalk Planters		
	Conflicts with car egress		☐
	ROW width too limited		☐
Summary of Findings:			
Were Sidewalk Planters determined to be applicable as part of the Green Streets BMP plan? ☐ Yes ☐ No	If yes, were they used? ☐ Yes ☐ No		
Provide discussion/justifications for selections and decisions above:			

[27] ● High applicability within this category, however may still be limited by site-specific factors
◉ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

Form J-1 Page 4 of 8: Curb Extensions			
Brief Description: Curb extensions expand the edge of the sidewalk into the roadway or parking area and allow storm water runoff to collect and infiltrate through a detention area of porous media.			
Site Type (Check all that apply):	Street Type	Rating[28]	Present in Project?
	Residential Streets	●	☐
	Commercial Street/ Business District	●	☐
	Collector Street	⦿	☐
	Arterial and Boulevard	⦿	☐
	Alleys	○	☐
	Parking Areas	⦿	☐
Key Opportunities for Curb Extensions (Check all that apply):	Intersections		☐
	Parking area		☐
	Other (must justify below)		☐
Site-Specific Factors (Check all that apply):	Favorable Conditions for Curb Extensions		
	Slope <4%		☐
	Traffic calming needed		☐
	Unfavorable Conditions for Curb Extensions		
	Conflicts with bike lanes		☐
	Site distance issues at intersection		☐
Summary of Findings:			
Were Curb Extensions determined to be applicable as part of the Green Streets BMP plan? ☐ Yes ☐ No	If yes, were they used? ☐ Yes ☐ No		
Provide discussion/justifications for selections and decisions above:			

[28] ● High applicability within this category, however may still be limited by site-specific factors
⦿ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

Form J-1 Page 5 of 8: Permeable Surfaces			
Brief Description: Permeable surfaces are pavement that allows for percolation through void spaces into subsurface layers.			
Site Type (Check all that apply):	Street Type	Rating[29]	Present in Project?
	Residential Streets	●	☐
	Commercial Street/ Business District	●	☐
	Collector Street	⦿	☐
	Arterial and Boulevard	⦿	☐
	Alleys	●	☐
	Parking Areas	⦿	☐
Key Opportunities for Permeable Surfaces (Check all that apply):	Sidewalks		☐
	Parking strips		☐
	Shoulders		☐
	Low traffic roadways		☐
	Other (must justify below)		☐
Site-Specific Factors (Check all that apply):	Favorable Conditions for Permeable Surfaces		
	Slope < 2-3%		☐
	Conveying limited run-on to a site		☐
	Low traffic area		☐
	Unfavorable Conditions for Permeable Surfaces		
	High traffic area		☐
	Run-on has high sediment load		☐
Summary of Findings:			
Were Permeable Surfaces determined to be applicable as part of the Green Streets BMP plan? ☐ Yes ☐ No	If yes, were they used? ☐ Yes ☐ No		
Provide discussion/justifications for selections and decisions above:			

[29] ● High applicability within this category, however may still be limited by site-specific factors
⦿ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

<table>
<tr><th colspan="4">Form J-1 Page 6 of 8: Green Gutters</th></tr>
<tr><td colspan="4"><u>Brief Description</u>: Green Gutters are shallow and narrow strips of landscaping in a typical curb and gutter location with a lower elevation than the street gutter elevation to allow capture of storm water from the sidewalk and street.</td></tr>
<tr><td rowspan="7">Site Type (Check all that apply):</td><td>Street Type</td><td>Rating[30]</td><td>Present in Project?</td></tr>
<tr><td>Residential Streets</td><td>○</td><td>☐</td></tr>
<tr><td>Commercial Street/ Business District</td><td>⦿</td><td>☐</td></tr>
<tr><td>Collector Street</td><td>●</td><td>☐</td></tr>
<tr><td>Arterial and Boulevard</td><td>●</td><td>☐</td></tr>
<tr><td>Alleys</td><td>⦿</td><td>☐</td></tr>
<tr><td>Parking Areas</td><td>○</td><td>☐</td></tr>
<tr><td rowspan="4">Key Opportunities for Green Gutters (Check all that apply):</td><td colspan="2">Parkway strips</td><td>☐</td></tr>
<tr><td colspan="2">Medians</td><td>☐</td></tr>
<tr><td colspan="2">Long, mostly continuous space</td><td>☐</td></tr>
<tr><td colspan="2">Other (must justify below)</td><td>☐</td></tr>
<tr><td rowspan="9">Site-Specific Factors (Check all that apply):</td><td colspan="3">Favorable Conditions for Green Gutters</td></tr>
<tr><td colspan="2">Slope > 1% and <3%</td><td>☐</td></tr>
<tr><td colspan="2">Conveying run-on to a site</td><td>☐</td></tr>
<tr><td colspan="2">Infiltration is partially feasible or not feasible</td><td>☐</td></tr>
<tr><td colspan="2">Long continuous segments available</td><td>☐</td></tr>
<tr><td colspan="2">Narrower spaces (as little as 2 to 3 feet)</td><td>☐</td></tr>
<tr><td colspan="3">Unfavorable Conditions for Green Gutters</td></tr>
<tr><td colspan="2">Frequent driveway interruption</td><td>☐</td></tr>
<tr><td colspan="2">ROW width too limited</td><td>☐</td></tr>
<tr><td colspan="4">Summary of Findings:</td></tr>
<tr><td colspan="2">Were Green Gutters determined to be applicable as part of the Green Streets BMP plan?
☐ Yes ☐ No</td><td colspan="2">If yes, were they used?
☐ Yes ☐ No</td></tr>
<tr><td colspan="4">Provide discussion/justifications for selections and decisions above:</td></tr>
</table>

[30] ● High applicability within this category, however may still be limited by site-specific factors
⦿ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

<table>
<tr><th colspan="4">Form J-1 Page 7 of 8: Rain Gardens</th></tr>
<tr><td colspan="4"><u>Brief Description</u>: Rain Gardens are shallow detention basins with vegetation that temporarily store water to allow for infiltration of the stored volume. Rain Gardens could be a bioretention or a biofiltration with partial retention or a biofiltration BMP.</td></tr>
<tr><td rowspan="7">Site Type (Check all that apply):</td><td>Street Type</td><td>Rating[31]</td><td>Present in Project?</td></tr>
<tr><td>Residential Streets</td><td>◉</td><td>☐</td></tr>
<tr><td>Commercial Street/ Business District</td><td>◉</td><td>☐</td></tr>
<tr><td>Collector Street</td><td>◉</td><td>☐</td></tr>
<tr><td>Arterial and Boulevard</td><td>◉</td><td>☐</td></tr>
<tr><td>Alleys</td><td>○</td><td>☐</td></tr>
<tr><td>Parking Areas</td><td>●</td><td>☐</td></tr>
<tr><td rowspan="3">Key Opportunities for Rain Gardens (Check all that apply):</td><td colspan="2">Irregularly shaped areas in ROW</td><td>☐</td></tr>
<tr><td colspan="2">Broad and flat areas</td><td>☐</td></tr>
<tr><td colspan="2">Other (must justify below)</td><td>☐</td></tr>
<tr><td rowspan="7">Site-Specific Factors (Check all that apply):</td><td colspan="3">Favorable Conditions for Rain Gardens</td></tr>
<tr><td colspan="2">Slope <2%</td><td>☐</td></tr>
<tr><td colspan="2">Infiltration is partially feasible or not feasible</td><td>☐</td></tr>
<tr><td colspan="2">Large area available</td><td></td></tr>
<tr><td colspan="3">Unfavorable Conditions for Rain Gardens</td></tr>
<tr><td colspan="2">Slope > 2%</td><td>☐</td></tr>
<tr><td colspan="2">ROW too limited</td><td>☐</td></tr>
<tr><td colspan="4">Summary of Findings:</td></tr>
<tr><td colspan="2">Were Rain Gardens determined to be applicable as part of the Green Streets BMP plan?
☐ Yes ☐ No</td><td colspan="2">If yes, were they used?
☐ Yes ☐ No</td></tr>
<tr><td colspan="4">Provide discussion/justifications for selections and decisions above:</td></tr>
</table>

[31] ● High applicability within this category, however may still be limited by site-specific factors
◉ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

Form J-1 Page 8 of 8: Trees			
Brief Description: Trees planted in the sidewalk right-of-way provide rainfall interception and infiltration benefits and typically supplements other storm water management tools.			
Site Type (Check all that apply):	Street Type	Rating[32]	Present in Project?
	Residential Streets	●	☐
	Commercial Street/ Business District	⦿	☐
	Collector Street	⦿	☐
	Arterial and Boulevard	⦿	☐
	Alleys	⦿	☐
	Parking Areas	●	☐
Key Opportunities for Trees (Check all that apply):	Parkway strips		☐
	Medians		☐
	Irregularly shaped areas		☐
	Extra ROW on back side of sidewalk		☐
	Other (must justify below)		☐
Site-Specific Factors (Check all that apply):	Favorable Conditions for Trees		
	Located outside of clear zone		☐
	Infiltration is feasible		☐
	ROW not limiting		
	Unfavorable Conditions for Trees		
	Limited space for root growth		☐
	Clear zone issues		☐
Summary of Findings:			
Were Trees determined to be applicable as part of the Green Streets BMP plan? ☐ Yes ☐ No	If yes, were they used? ☐ Yes ☐ No		
Provide discussion/justifications for selections and decisions above:			

[32] ● High applicability within this category, however may still be limited by site-specific factors
⦿ Generally applicable in this category; largely dependent on site-specific factors
○ Limited applicability within this category; may still be applicable in some cases; should be considered

Appendix K

ESA and 303(d) Listed Waterbodies

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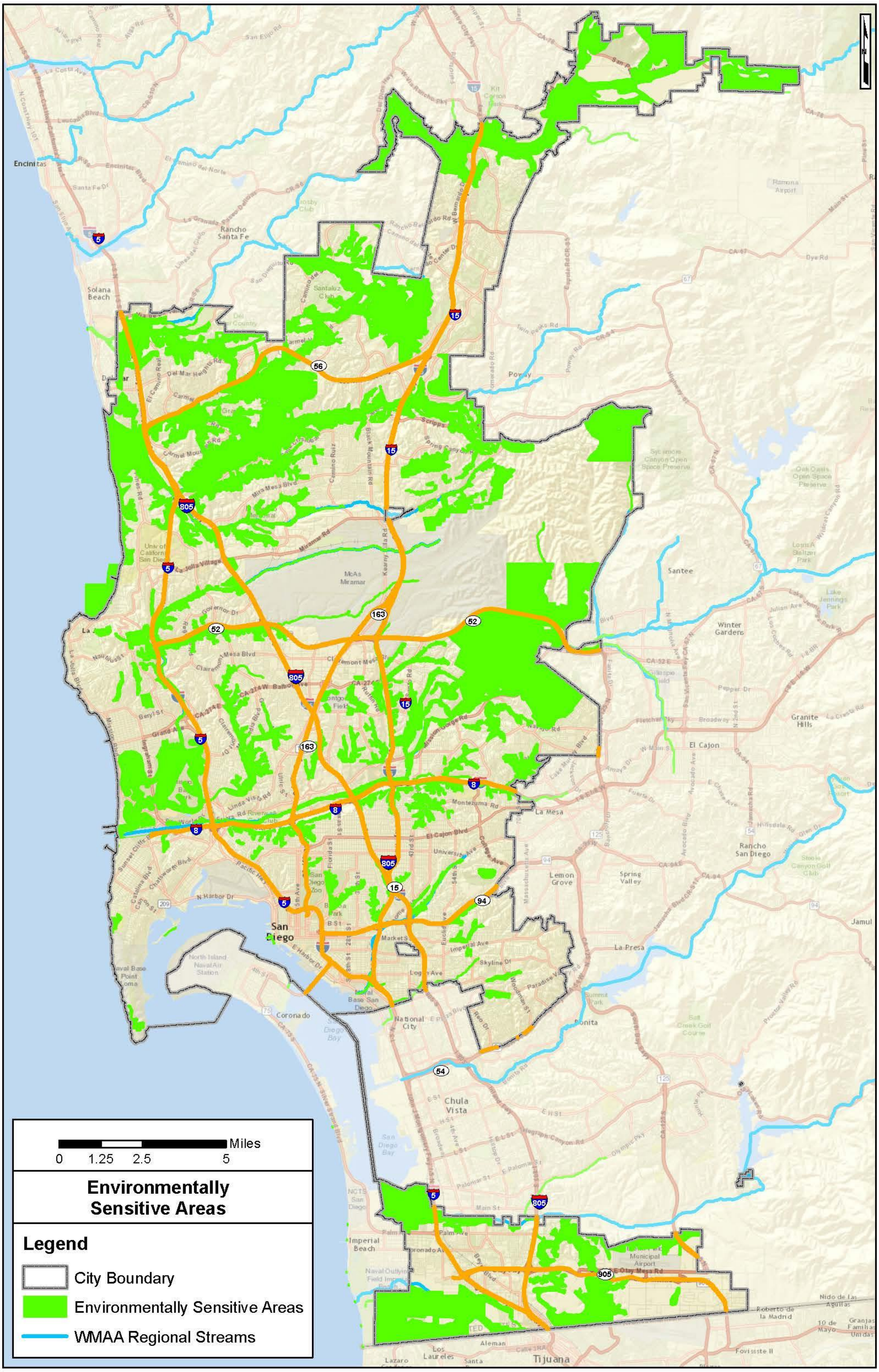

Figure K-1: Environmentally Sensitive Areas

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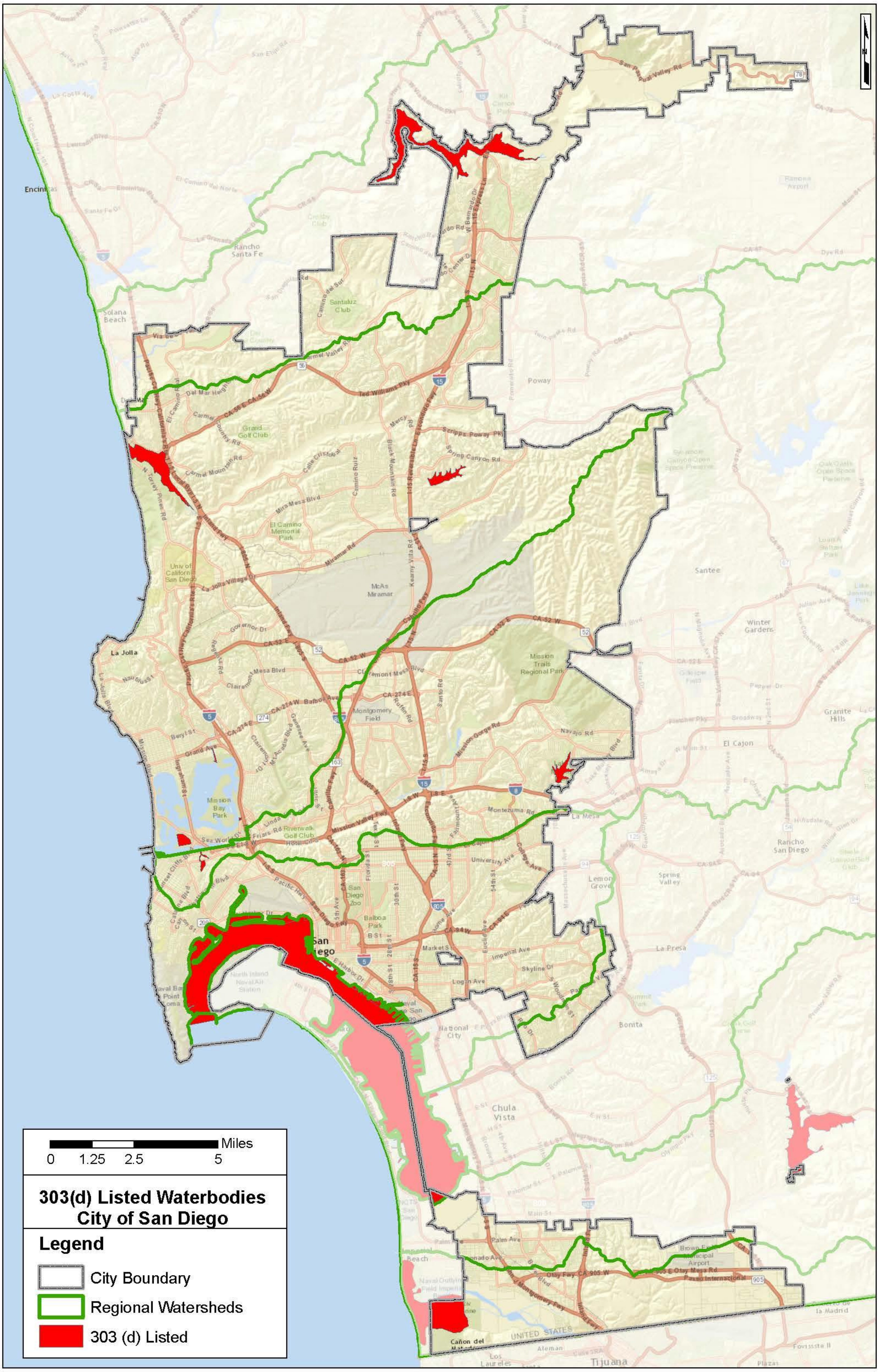

Figure K-2: 303(d) Listed Waterbodies

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Watershed Name	Waterbody Name	Waterbody Type	Estimated Size Affected	Unit	Pollutant	Pollutant Category for use in Appendix B.6 (Based on WQE Pollutants of Concern)
Los Penasquitos	Los Penasquitos Creek	River & Stream	12	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Selenium	Uncategorized
					Total Dissolved Solids	Uncategorized
					Total Nitrogen as N	Nutrients, Oxygen Demanding
					Toxicity	Uncategorized
Los Penasquitos	Los Penasquitos Lagoon	Estuary	469	Acres	Sedimentation/Siltation	Sediment
Los Penasquitos	Miramar Reservoir	Lake & Reservoir	138	Acres	Total Nitrogen as N	Nutrients, Oxygen Demanding
Los Penasquitos	Soledad Canyon	River & Stream	1.7	Miles	Sediment Toxicity	Sediment
					Selenium	Uncategorized
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at Avenida de la Playa at La Jolla Shores Beach	Coastal & Bay Shoreline	0.03	Miles	Total Coliform	Bacteria
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at Childrens Pool	Coastal & Bay Shoreline	0.03	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at La Jolla Cove	Coastal & Bay Shoreline	0.03	Miles	Total Coliform	Bacteria
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at Pacific Beach Point , Pacific Beach	Coastal & Bay Shoreline	0.03	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at Ravina	Coastal & Bay Shoreline	0.03	Miles	Total Coliform	Bacteria
Mission Bay/La Jolla	Pacific Ocean Shoreline, Scripps HA, at Vallecitos Court at La Jolla Shores Beach	Coastal & Bay Shoreline	0.03	Miles	Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay (area at mouth of Rose Creek only)	Bay & Harbor	9.2	Acres	Eutrophic	Nutrients, Oxygen Demanding
					Lead	Heavy Metals
Mission Bay/La Jolla	Mission Bay (area at mouth of Tecolote Creek only)	Bay & Harbor	3.1	Acres	Eutrophic	Nutrients, Oxygen Demanding
					Lead	Heavy Metals
Mission Bay/La Jolla	Mission Bay Shoreline, at Bahia Point	Coastal & Bay Shoreline	0.14	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Bonita Cove	Coastal & Bay Shoreline	0.09	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Campland	Coastal & Bay Shoreline	0.08	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at De Anza Cove	Coastal & Bay Shoreline	0.06	Miles	Enterococcus	Bacteria
				Miles	Fecal Coliform	Bacteria
				Miles	Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Fanual Park		0.12	Miles	Enterococcus	Bacteria

Watershed Name	Waterbody Name	Waterbody Type	Estimated Size Affected	Unit	Pollutant	Pollutant Category for use in Appendix B.6 (Based on WQE Pollutants of Concern)
		Coastal & Bay Shoreline			Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Leisure Lagoon	Coastal & Bay Shoreline	0.12	Miles	Enterococcus	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at North Crown Point	Coastal & Bay Shoreline	0.12	Miles	Enterococcus	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Tecolote Shores	Coastal & Bay Shoreline	0.04	Miles	Enterococcus	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay Shoreline, at Visitors Center	Coastal & Bay Shoreline	0.1	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Mission Bay at Quivira Basin	Bay & Harbor	65	Acres	Copper	Uncategorized
Mission Bay/La Jolla	Pacific Ocean Shoreline, San Diego HU, at the San Diego River outlet, at Dog Beach	Coastal & Bay Shoreline	0.03	Miles	Enterococcus	Bacteria
					Total Coliform	Bacteria
Mission Bay/La Jolla	Rose Creek	River & Stream	13	Miles	Selenium	Uncategorized
					Toxicity	Uncategorized
Mission Bay/La Jolla	Tecolote Creek	River & Stream	6.6	Miles	Cadmium	Heavy Metals
					Copper	Uncategorized
					Indicator Bacteria	Bacteria
					Lead	Heavy Metals
					Nitrogen	Nutrients, Oxygen Demanding
					Phosphorus	Nutrients, Oxygen Demanding
					Selenium	Uncategorized
					Toxicity	Uncategorized
					Turbidity	Sediment, Trash & Debris
					Zinc	Heavy Metals
San Diego Bay	Chollas Creek	River & Stream	3.5	Miles	Copper	Uncategorized
					Diazinon	Pesticides
					Indicator Bacteria	Bacteria
					Lead	Heavy Metals
					Phosphorus	Nutrients, Oxygen Demanding
					Total Nitrogen as N	Nutrients, Oxygen Demanding
					Trash	Trash & Debris
					Zinc	Heavy Metals
San Diego Bay	Otay Reservoir, Lower	Lake & Reservoir	1,050	Acres	Ammonia	Nutrients, Oxygen Demanding
					Color	Uncategorized
					Iron	Uncategorized
					Manganese	Uncategorized
					Nitrogen	Nutrients, Oxygen Demanding
					pH (high)	Uncategorized

Watershed Name	Waterbody Name	Waterbody Type	Estimated Size Affected	Unit	Pollutant	Pollutant Category for use in Appendix B.6 (Based on WQE Pollutants of Concern)
San Diego Bay	Pacific Ocean Shoreline, Point Loma HA, at Bermuda Ave	Coastal & Bay Shoreline	0.03	Miles	Total Coliform	Bacteria
San Diego Bay	Paleta Creek	River & Stream	4.1	Miles	Copper	Uncategorized
					Lead	Heavy Metals
San Diego Bay	Poggi Canyon Creek	River & Stream	7.8	Miles	Toxicity	Uncategorized
San Diego Bay	San Diego Bay	Bay & Harbor	10,783	Acres	PCBs (Polychlorinated biphenyls)	Uncategorized
San Diego Bay	San Diego Bay Shoreline, 32nd St San Diego Naval Station	Bay & Harbor	103	Acres	Benthic Community Effects	Sediment
					Sediment Toxicity	Sediment
San Diego Bay	San Diego Bay Shoreline, G Street Pier	Coastal & Bay Shoreline	0.4	Miles	Total Coliform	Bacteria
San Diego Bay	San Diego Bay Shoreline, Shelter Island Shoreline Park	Coastal & Bay Shoreline	0.4	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Total Coliform	Bacteria
San Diego Bay	Switzer Creek	River & Stream	1.3	Miles	Copper	Uncategorized
					Lead	Heavy Metals
					Zinc	Heavy Metals
San Diego Bay	San Diego Bay Shoreline, Downtown Anchorage	Bay & Harbor	7.4	Acres	Benthic Community Effects	Sediment
					Sediment Toxicity	Sediment
San Diego Bay	San Diego Bay Shoreline, Vicinity of B St and Broadway Piers	Bay & Harbor	10	Acres	Benthic Community Effects	Sediment
					Sediment Toxicity	Sediment
					Total Coliform	Bacteria
San Diego Bay	San Diego Bay Shoreline, at Americas Cup Harbor	Bay & Harbor	88	Acres	Copper	Uncategorized
San Diego Bay	San Diego Bay Shoreline, at Harbor Island (East Basin)	Bay & Harbor	73	Acres	Copper	Uncategorized
San Diego Bay	San Diego Bay Shoreline, at Harbor Island (West Basin)	Bay & Harbor	132	Acres	Copper	Uncategorized
San Diego Bay	San Diego Bay Shoreline, at Marriott Marina	Bay & Harbor	24	Acres	Copper	Uncategorized
San Diego Bay	San Diego Bay Shoreline, at Spanish Landing	Bay & Harbor	47	Acres	Total Coliform	Bacteria
San Diego Bay	San Diego Bay Shoreline, between Sampson and 28th Streets	Bay & Harbor	53	Acres	Copper	Uncategorized
					Mercury	Uncategorized
					PAHs (Polycyclic Aromatic Hydrocarbons)	Uncategorized
					PCBs (Polychlorinated biphenyls)	Uncategorized
					Zinc	Heavy Metals
San Diego Bay	San Diego Bay Shoreline, near Chollas Creek	Bay & Harbor	15	Acres	Benthic Community Effects	Sediment
					Sediment Toxicity	Sediment
San Diego Bay	San Diego Bay Shoreline, near Coronado Bridge	Bay & Harbor	37	Acres	Benthic Community Effects	Sediment
					Sediment Toxicity	Sediment
San Diego Bay	San Diego Bay Shoreline, near Switzer Creek	Bay & Harbor	5.5	Acres	Chlordane	Organic Compounds, Oxygen Demanding, Pesticides
					PAHs (Polycyclic Aromatic Hydrocarbons)	Uncategorized
San Diego Bay	San Diego Bay Shoreline, near sub base	Bay & Harbor	16	Acres	Benthic Community Effects	Sediment

Watershed Name	Waterbody Name	Waterbody Type	Estimated Size Affected	Unit	Pollutant	Pollutant Category for use in Appendix B.6 (Based on WQE Pollutants of Concern)
					Sediment Toxicity	Sediment
					Toxicity	Uncategorized
San Diego Bay	San Diego Bay, Shelter Island Yacht Basin	Bay & Harbor	154	Acres	Copper, Dissolved	Uncategorized
San Diego River	Alvarado Creek	River & Stream	5.1	Miles	Selenium	Uncategorized
San Diego River	Famosa Slough and Channel	Estuary	32	Acres	Eutrophic	Nutrients, Oxygen Demanding
San Diego River	Forester Creek	River & Stream	6.4	Miles	Fecal Coliform	Bacteria
					Selenium	Uncategorized
					Total Dissolved Solids	Uncategorized
					pH	Uncategorized
San Diego River	Murray Reservoir	Lake & Reservoir	119	Acres	Nitrogen	Nutrients, Oxygen Demanding
					pH	Uncategorized
San Diego River	San Diego River (Lower)	River & Stream	16	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Low Dissolved Oxygen	Oxygen Demanding
					Manganese	Uncategorized
					Nitrogen	Nutrients, Oxygen Demanding
					Phosphorus	Nutrients, Oxygen Demanding
					Total Dissolved Solids	Uncategorized
					Toxicity	Uncategorized
San Dieguito	Cloverdale Creek	River & Stream	1.2	Miles	Phosphorus	Nutrients, Oxygen Demanding
					Total Dissolved Solids	Uncategorized
San Dieguito	Felicita Creek	River & Stream	0.9	Miles	Aluminum	Uncategorized
					Total Dissolved Solids	Uncategorized
San Dieguito	Green Valley Creek	River & Stream	1.0	Miles	Chloride	Uncategorized
					Manganese	Uncategorized
					Pentachlorophenol (PCP)	Uncategorized
					Sulfates	Uncategorized
San Dieguito	Hodges, Lake	Lake & Reservoir	1,104	Acres	Color	Uncategorized
					Manganese	Uncategorized
					Mercury	Uncategorized
					Nitrogen	Nutrients, Oxygen Demanding
					Phosphorus	Nutrients, Oxygen Demanding
					Turbidity	Sediment, Trash & Debris
					pH	Uncategorized
San Dieguito	Kit Carson Creek	River & Stream	1.0	Miles	Pentachlorophenol (PCP)	Uncategorized
					Total Dissolved Solids	Uncategorized
San Dieguito	San Dieguito River	River & Stream	19	Miles	Enterococcus	Bacteria
					Fecal Coliform	Bacteria
					Nitrogen	Nutrients, Oxygen Demanding

Watershed Name	Waterbody Name	Waterbody Type	Estimated Size Affected	Unit	Pollutant	Pollutant Category for use in Appendix B.6 (Based on WQE Pollutants of Concern)
					Phosphorus	Nutrients, Oxygen Demanding
					Total Dissolved Solids	Uncategorized
					Toxicity	Uncategorized
Tijuana	Morena Reservoir	Lake & Reservoir	104	Acres	Ammonia as Nitrogen	Nutrients, Oxygen Demanding
					Color	Uncategorized
					Manganese	Uncategorized
					Phosphorus	Nutrients, Oxygen Demanding
					pH	Uncategorized
Tijuana	Tijuana River	River & Stream	6.0	Miles	Eutrophic	Nutrients, Oxygen Demanding
					Indicator Bacteria	Bacteria
					Low Dissolved Oxygen	Oxygen Demanding
					Pesticides	Pesticides
					Phosphorus	Nutrients, Oxygen Demanding
					Sedimentation/Siltation	Sediment
					Selenium	Uncategorized
					Solids	Sediment
					Surfactants (MBAS)	Other Organics, Oxygen Demanding
					Synthetic Organics	Other Organics, Oxygen Demanding
					Total Nitrogen as N	Nutrients, Oxygen Demanding
					Toxicity	Uncategorized
					Trace Elements	Heavy Metals
					Trash	Trash & Debris
Tijuana	Tijuana River Estuary	Estuary	1,319	Acres	Eutrophic	Nutrients, Oxygen Demanding
					Indicator Bacteria	Bacteria
					Lead	Heavy Metals
					Low Dissolved Oxygen	Oxygen Demanding
					Nickel	Heavy Metals
					Pesticides	Pesticides
					Thallium	Heavy Metals
					Trash	Trash & Debris
					Turbidity	Sediment, Trash & Debris

Pollutants that are grouped as “uncategorized” in the pollutant category column can be excluded from BMP Selection process in **Appendix B.6.**

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Appendix L

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 and/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 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, that has a media filtration rate greater than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor. Compact biofiltration BMPs are typically proprietary BMPs that may qualify as biofiltration.
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 typical 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 public or private 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.
DMAs	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 SDRWQCB; State Water Quality Protected Areas; water bodies designated with the RARE beneficial use by the State Water Board and SDRWQCB; 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 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, Q_2 and Q_{10} 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 Q_2 and Q_{10}.
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	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.
Hydromodification Management BMP	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.
Impervious Surface	Any material that prevents infiltration of water into the soil vertically (e.g. asphalt, concrete).
Infeasible	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.
Infiltration	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)].
Infiltration BMP	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).
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.
Non-Standard Biofiltration BMP	A biofiltration BMP that has a media filtration rate equal to or smaller than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor.
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	The project scope boundary indicated in the SWQMP, which includes the project footprint and undisturbed portions within the project's property (or properties if the project footprint crosses multiple parcels. For projects in the right-of-way, the project area is the entire right-of-way width over the length of the project activities.
Project Footprint	All areas proposed by an applicant to be altered or developed, including both impervious and pervious areas.
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 City Engineer 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 (SDRWQCB)	California RWQCBs are responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within their jurisdiction. There are nine California RWQCBs.
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. 85th 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 85th 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 biofiltration BMP	A biofiltration BMP that has a media filtration rate equal to or smaller than 5 in/hr. and a media surface area of 3% of contributing area times adjusted runoff factor or greater.
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; from the project footprint. 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 Copermittee, 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 Copermittee 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 SDRWQCB 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.

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