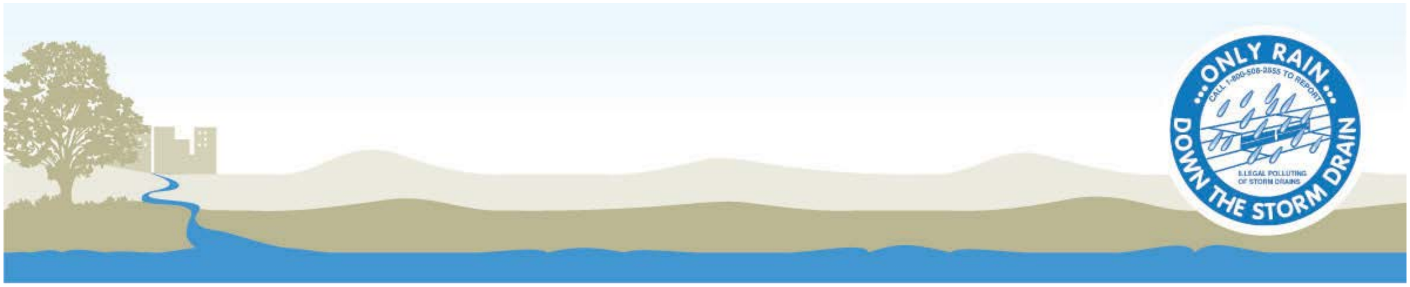
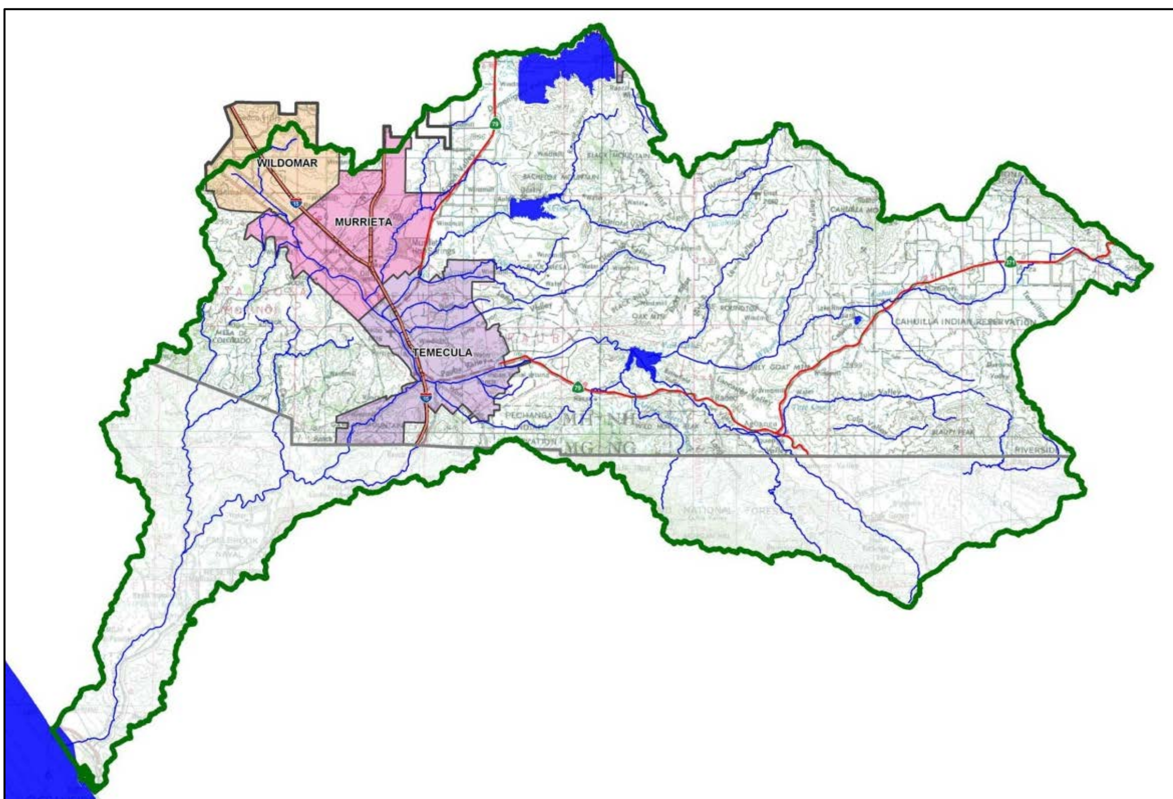


2014 WATER QUALITY MANAGEMENT PLAN

for the Santa Margarita Region of Riverside County



Water Quality Management Plan

for the Santa Margarita Region *of Riverside County*

In compliance with Order No. R9-2010-0016, this WQMP has been developed and will be implemented by the Copermittees in the Santa Margarita Region:

Copermittees:

County of Riverside
All Project applications:
www.countyofriverside.us/

For WQMP questions in unincorporated County areas:
www.rctlma.org
(951) 955-3185

Riverside County Flood Control and Water Conservation District
http://www.rcflood.org/

Murrieta
http://www.murrieta.org/

Temecula
http://www.cityoftemecula.org/

Wildomar
http://www.cityofwildomar.org/

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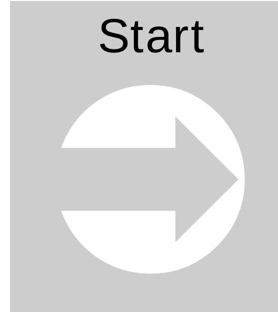
Exhibits



INTRODUCTION

This Water Quality Management Plan (WQMP) is a guidance document to assist in the design of projects in compliance with San Diego Regional Water Quality Control Board (San Diego Regional Board) requirements for Priority Development Projects (PDPs). These requirements are specified in the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit issued to the Riverside County Flood Control and Water Conservation District (District), County of Riverside (County), and Cities of Murrieta, Temecula, and Wildomar (Copermittees) in November 2010 (2010 SMR MS4 Permit). The area covered by this MS4 Permit is referred to as the Santa Margarita Region (SMR).

This WQMP is only applicable to projects in the cities of:

- Murrieta
- Temecula
- Wildomar

and

- Portions of unincorporated County of Riverside that are within the SMR.

Because every project is unique, development of a Project-Specific WQMP should begin by scheduling a pre-application meeting with the applicable staff of the Copermittee with jurisdiction over the project site to understand the specific submittal requirements.

Be sure to use the most recent version of this WQMP for each and every project, including updates and errata. The most recent version is available at www.rcflood.org/NPDES/Developers.aspx. This WQMP may be updated periodically based on the Copermittees' experience with implementation of this document. Any non-substantive updates to the WQMP will be provided in the Copermittee's Jurisdictional Runoff Management Plan (JRMP) Annual Report to the San Diego Regional Board. Substantive updates will be submitted to San Diego Regional Board staff for review and approval prior to implementation. If reading the WQMP on a computer, hyperlinks within this document can be used to navigate from section to section Internet references can be accessed directly via the internet. The hyperlinks are throughout the text, as well as in "References and Resources" sections (marked by the 🕮 icon).

To use the *WQMP* to guide development of a Project-Specific WQMP*,* start by reviewing Chapter 1 to find out whether and how the requirements apply to your PDP. Chapter 1 also provides an overview of the entire process of planning, design, construction, operation, and maintenance leading to compliance.

Terms and issues used in the *WQMP* are defined in the Glossary or in Chapter 2. Chapter 2 provides background on key stormwater concepts and water quality regulations, including technical criteria for the design and selection of Best Management Practices (BMPs). Defined terms that are included in the glossary are also capitalized in the text.

Then proceed to Chapter 3 and follow the step-by-step guidance to prepare a Project-Specific WQMP for your site. Note that the steps in Chapter 3 reference additional detail in Chapters 4 and 5. A preliminary Project-Specific WQMP is commonly required to be submitted with applications for entitlements and development approvals and must be approved by the Copermittee with jurisdiction over the project site before any approvals or entitlements will be granted. A final Project-Specific WQMP will be required to be submitted and approved prior to issuance of grading and building permits.

> **Construction Phase Controls**
> Your Project-Specific WQMP is a separate document from the Stormwater Pollution Prevention Plan (SWPPP). A SWPPP provides for temporary measures to control discharges of sediment and other Pollutants during construction at sites that disturb one acre or more, whereas a WQMP is required to address discharges from the post-construction use of the site.

Chapter 4 describes key ways to coordinate development of the Project-Specific WQMP with other site plans such as landscaping, grading and erosion control plans, and overseeing construction of BMPs.

Chapter 5 provides a description of the process for ensuring operation and maintenance of BMPs over the life of the PDP. The chapter includes step-by-step instructions for preparing a Project-Specific WQMP Operation and Maintenance Plan.

Throughout each chapter, you will find references and resources to help you understand the regulations, complete the Project-Specific WQMP, and design the PDP to be protective of water quality to the Maximum Extent Practicable (MEP).

PLAN AHEAD TO AVOID THE THREE MOST COMMON MISTAKES

The most common (and costly) errors made by Users for development approvals with respect to stormwater compliance are:

1. Not planning for compliance early enough. The strategy for compliance with WQMP requirements should be developed before completing a conceptual site design or sketching a layout of subdivision lots. It is highly recommended that the project team (civil engineers, planners, architects, landscape architects, etc.) meet and confer at project inception, and then regularly throughout the design, to discuss design strategies that meet the WQMP requirements. Section 4.0 discusses some of the elements of the Project-Specific WQMP that will need to be coordinated among the site plans that these professionals may develop.

2. Assuming proprietary Stormwater BMPs or Conventional Treatment BMPs will be adequate for compliance. Low Impact Development (LID) BMPs that maximize infiltration, harvest and use, evapotranspiration and/or bio-treatment, are now required for nearly all projects. In addition, Hydrologic Control BMPs and Sediment Control BMPs are required for all projects that are not exempt from the requirements set forth in the SMR HMP. See Chapter 2 for criteria affecting what Stormwater BMPs can be used on a project.

3. Not planning for long-term maintenance of the PDP BMPs, and inspections/verifications by the Copermittee. Consider who will own and who will maintain the BMPs in perpetuity and how they will obtain access, and identify which arrangements are acceptable to the Copermittee with jurisdiction over the project site (Chapter 5).

COMPLIANCE PROCESS AT A GLANCE

Users should follow these general steps to comply with the requirements of the 2010 SMR MS4 Permit:

1. Discuss WQMP requirements during a pre-application meeting with Copermittee staff, if possible. This can help you to confirm any requirements specific to the Copermittee with jurisdiction over the project site. Note that the Copermittee will require the User to certify that the project does or does not qualify as a PDP. The Copermittee with jurisdiction over the project site will nevertheless have the ultimate discretion as to whether a Project-Specific WQMP will be required for any particular project.

2. If the project is required to prepare a Project-Specific WQMP, review the instructions in this WQMP BEFORE the tentative map, preliminary site plan, drainage plan, and improvement plans are prepared. The requirements in this WQMP will affect each of these items. Neglecting to appropriately consider and address the requirements of this WQMP at all stages of project planning and design, will likely result in costly re-design being required.

3. When required by the Copermittee with jurisdiction over the project site, prepare a preliminary Project-Specific WQMP and submit it with applications for Discretionary Approvals (entitlements).

4. Following receipt of any Discretionary Approvals, the final Project-Specific WQMP can be developed as part of the plan to complete the detailed project design, incorporating the BMPs committed to in the preliminary Project-Specific WQMP.

5. Prepare a draft Project-Specific WQMP Operation and Maintenance Plan and submit both, together with the grading and improvement plans as part of the application for grading and/or building permits. Execute legal documents assigning responsibility for operation and maintenance of BMPs. Protect proposed Post-Construction BMPs (and underlying infiltration soils) during construction, and maintain them following construction.

6. Following construction, submit 'as-built' plans and a final Project-Specific WQMP Operation and Maintenance Plan and formally transfer responsibility for maintenance to the owner or permanent occupant. Typically the Copermittees will require the final Project-Specific WQMP Operation and Maintenance Plan prior to issuance of Certificate of Occupancy.

7. Following occupancy, the occupant or owner (as defined in the Project-Specific WQMP Operation and Maintenance Plan) must maintain records that all necessary maintenance of Post-Construction BMP facilities has been performed and allow periodic inspections of Structural BMPs by the Copermittee with jurisdiction over the project site. Where Copermittees allow or require self-certifications of Structural BMPs, the occupant or owner must certify that the Structural BMPs are properly maintained and submit reports, prepared and certified by a Professional Engineer, to the Copermittee staff upon their request.

8. Preparation of a complete and detailed Project-Specific WQMP is the key to cost-effective compliance and expeditious review of your project. Instructions for preparing a Project-Specific WQMP are in Chapter 3.

Consistent with Section F of the 2010 SMR MS4 Permit, each Copermittee has implemented a JRMP that identifies an implementation process to verify compliance with the SMR WQMP requirements. In each JRMP, the implementation process identifies roles and responsibilities of the Copermittee departments in the method to track post-construction BMPs, to ensure that appropriate easements and ownerships are properly recorded in public records and that the information is conveyed to all applicable parties when there is a change in project or site ownership. Figure 1-1 identifies the typical implementation process for Project-Specific WQMP approval adopted by the Copermittees. The User may refer to the JRMP of the Copermittee with jurisdiction over the project site to determine specific roles and responsibilities.

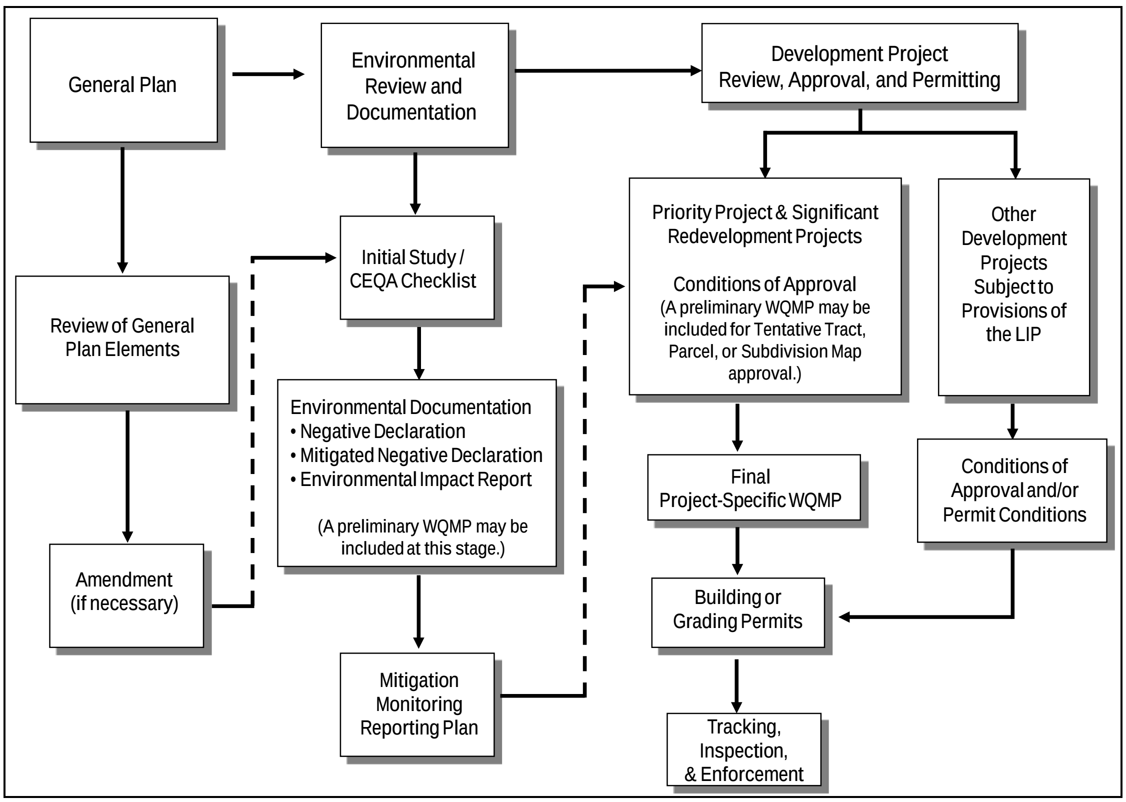


FIGURE 1-1: Development Process Flow Chart

Chapter
1

1.0 POLICIES AND PROCEDURES

Determine if your project requires a Project-Specific WQMP, and review the steps to compliance.

1.1. Projects Requiring a Project-Specific WQMP

This Document is specific to projects in the Santa Margarita Region of Riverside County.

> ☞*Before continuing use of this document, it is highly encouraged that the 'Locate your Watershed' tool available at www.rcflood.org/npdes, or SWCT2 (Stormwater & Water Conservation Tracking Tool - http://rivco.permitrack.com/)is used to verify that your project is within the Santa Margarita Region of Riverside County; which includes the incorporated Cities of Murrieta, Temecula and Wildomar, as well as the Unincorporated County of Riverside within the Santa Margarita Region.*

ICON KEY
☞ Helpful Tip
Submittal Requirement
Terms to Look Up
References & Resources

The 2010 SMR MS4 Permit (see Section 2.1.1) requires that a Project-Specific WQMP be prepared for all development projects within the SMR that meet the 'Priority Development Project' categories and thresholds listed in Table 1-1 (Section 1.1.1 below), and Redevelopment projects that meet the criteria in Section 1.1.2 below.

Additionally, the Project-Specific WQMP Applicability Checklist provided in Exhibit D, which is incorporated into each Copermittee's project application requirements, can be used as a means to document a conclusion that a project does or does not meet the criteria as a PDP. Note some thresholds are defined by square footage of impervious area; others by land area of development; others by total area disturbed. Exhibit E includes a Project-Specific WQMP Review Checklist that can be used to ensure that your Project-Specific WQMP submittal includes all required elements.

If the project is not a PDP, a Project-Specific WQMP is generally not required. Such projects, referred to as 'Other Development Projects' are still required to incorporate appropriate minimum Site Design, Source Control and LID BMPs which may or may not include Structural LID or Conventional Treatment Control BMPs. If your project is an Other Development Project, consult the Copermittee with jurisdiction over the project site to determine applicable requirements.

However, Copermittee staff may choose to require a Project-Specific WQMP for Other Development Projects, based on their assessment of the potential for the proposed project to impact stormwater quality.

When determining whether WQMP requirements apply, a "project" should be defined consistent with California Environmental Quality Act (CEQA) definitions of "project". That is, the "project" is the whole of an action which has the potential for adding or replacing or resulting in the addition or replacement of roofs, pavement, or other impervious surfaces. "Whole of an action" means the project may not be segmented or piecemealed into small parts if the effect is to reduce the quantity of impervious area for any part to below the applicable threshold.

1.1.1. New Priority Development Projects

New Development Projects are defined by the 2010 MS4 permit as a PDP if the project, or a component of the project, meets the categories and thresholds described in Table 1-1 below.

TABLE 1-1. Priority Development Project Categories

Category	Threshold	Development Project Description
New Development Projects	10,000 SF new Impervious surface	Development Projects that create 10,000 square feet or more of impervious surfaces (collectively over the entire project site) including commercial, industrial, residential, mixed-use, and public development projects. This category includes Development Projects on public or private land which fall under the planning and building authority of the Copermittees.
Automotive Repair Shops	Dependent on SIC Code	Development Projects that include automotive repair shops that are categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.
Restaurants	5,000 SF	Development Projects that will sell prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812), where the land area for development is greater than 5,000 square feet. Restaurants where land development is less than 5,000 square feet must meet all WQMP requirements except for the conventional treatment control BMP requirements of WQMP Section 3.5, and the Hydromodification requirements of WQMP Section 3.6.
Hillside Developments	5,000 SF	Hillside Development Projects greater than 5,000 square feet. This category is defined as any development project which creates 5,000 square feet of impervious surface and which is located in an area with known erosive soil conditions, where the development project will grade on any natural slope that is 25% or greater.

Category	Threshold	Development Project Description
Environmentally Sensitive Areas	2,500 SF Impervious surface	Development Projects located within, directly adjacent to or discharging directly to an Environmentally Sensitive Area (ESA) (where discharges from the Development Project site will enter Receiving Waters within the ESA), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed Development Project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage conveyance system that is composed entirely of flows from the subject Development Project site, and not commingled with flows from adjacent or upstream lands.
Parking Lots	5,000 SF Impervious surface	Development Projects with impervious parking lots 5,000 square feet or more and potentially exposed to runoff. Parking lot is defined as a land area or facility for the temporary parking or storage of motor vehicles used personally, for business or for commerce.
Streets, Roads, Highways and Freeways	5,000 SF Impervious surface	Private Development Projects that include any paved impervious surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles and other vehicles.
Retail Gasoline Outlets	5,000 SF or ADT >100	Retail Gasoline Outlets that meet either of the following criteria: (a) 5,000 square feet or more; or (b) a projected Average Daily Traffic of 100 or more vehicles per day.
Pollutant Generating projects disturbing over 1 acre	1 acre disturbed area	Development Projects that disturb over one acre of land, where the post-construction use of the site generate pollutants at levels greater than natural background levels.

1.1.1.a) Entire Project

Where a New Development Project feature, such as a parking lot, falls into a PDP Category as described in Table 1-1 above, the entire project footprint is subject to WQMP requirements.

1.1.2. Redevelopment Projects

Redevelopment projects are considered a PDP if:

- The project creates, adds, or replaces at least 5,000 square feet of impervious surfaces on an already developed site: AND
- The existing development AND/OR the proposed redevelopment project meets the criteria in Table 1-1 above.

1.1.2.a) The "50% Rule" for Redevelopment Projects

Redevelopment PDPs may not only be required to develop a Project-Specific WQMP for the new 'project' footprint, but may also be required to retrofit the existing portions of the site for compliance with this WQMP as well (including runoff from existing areas not otherwise being modified as part of the current project).

- Where a Redevelopment Project results in an increase of less than 50% of the impervious surfaces compared to the previously existing development, and the existing development was not subject to WQMP requirements, the Project-Specific WQMP applies only to the addition or replacement, and not to the entire development.

- Where a Redevelopment Project results in an increase of more than 50% of the impervious surfaces compared to the previously existing development, the Project-Specific WQMP applies to the entire development, including portions of the site not otherwise being modified or improved as part of the current project.

Copermittee staff will require submittal of sufficient information about the existing developed site and proposed additions/modifications, and to assess whether or not the proposed Redevelopment Project increases the collective impervious surfaces beyond the 50% threshold. Compliance with the Hydrologic Performance Standard (See Chapter 2.2.3) will be determined based on the naturally occurring condition, i.e. the native condition of the project site prior to any existing development.

1.2. WQMP Requirements for Projects in Progress

Requirements for preparing Project-Specific WQMPs have been in place for all applicable projects submitted to the Copermittee after July 13, 2005. The 2010 SMR MS4 Permit, however, includes new/additional requirements for Project-Specific WQMPs that are reflected in this revised WQMP. The following describes how these new requirements are to be applied to PDPs that have begun the process for securing approvals from the Copermittee.

The Project-Specific WQMP and HMP requirements described in this WQMP address the provisions of the 2010 SMR MS4 Permit and apply to all PDPs or phases of PDPs except those where:

- The project or phase has begun grading or construction activities at the time the updated WQMP and/or Hydromodification requirements go into effect*, or
- The Copermittee determines that lawful prior approval rights for a Development Project or project phase exist, whereby application of the updated requirements to the project is illegal.

If it appears that the project may meet either of these criteria, verify with the Copermittee with jurisdiction over the project site. Each Copermittee individually determines how and when a project will be allowed to be grandfathered.

1.3. Project-Specific WQMP Requirements for Phased Projects

Before occupancy will be granted for any phase of a multi-phase PDP, all requirements of the Project-Specific WQMP must be met for the current phase.

If any Structural BMPs necessary for the current phase of the PDP would be located in a future phase, occupancy for the current phase will not be granted until such 'offsite' BMPs have been constructed and are fully operational. In addition, the Operation and Maintenance requirements described in Section 5.0 must be fully met for all such 'offsite' BMPs.

1.4. Types of Project-Specific WQMPs

1.4.1. Preliminary Project-Specific WQMPs

If a Discretionary Approval would entitle construction of new or replaced improvements which, individually or in aggregate, would qualify as a PDP, then the User must prepare a preliminary Project-Specific WQMP. The level of detail in a preliminary Project-Specific WQMP will depend upon the level of detail known about the overall project design at the time project approval is sought.

> **Local Requirements**
> A Copermittee may have requirements that differ from, or are in addition to, this WQMP. Check with the Copermittee with jurisdiction over your project site.

For example, if approval of a tentative tract map application would entitle site improvements on individual lots that individually or in aggregate would exceed the thresholds for PDPs in Table 1-1, the User should prepare a preliminary Project-

* If your project site has been partially graded under an expired grading permit, consult the Copermittee with jurisdiction over your project site to determine whether the requirements in this document apply.

Specific WQMP. If particular plans for individual lots have not been identified, the preliminary Project-Specific WQMP may nevertheless be required to identify the type, size, location, and final ownership of Structural BMPs 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 Copermittee with jurisdiction over the project site will then condition approval of the map on implementation of a final Project-Specific WQMP that is in substantial conformance with the approved preliminary Project-Specific WQMP prior to issuance of grading / building permits.

If a Copermittee deems it necessary, the future improvements on one or more lots may be required to be limited by a deed restriction or dedication of an appropriate easement, to suitably restrict the future building of structures at each Structural BMP location.

In general, it is recommended Structural BMPs not be located on individual single-family residential lots to facilitate long-term maintenance, particularly when those BMPs manage runoff from streets or from common areas. However, local requirements may vary. Most often, it is better to locate Structural BMPs on one or more separate, jointly owned parcels such as a parcel owned by a homeowners association).

1.4.2. Final Project-Specific WQMPs

All PDPs are required to prepare a final Project-Specific WQMP, which the Copermittees require to be submitted together with associated grading and improvement plans, and approved prior to the issuance of any building or grading permits. The final Project-Specific WQMP must be in substantial conformance with any preliminary Project-Specific WQMP submitted and approved by the Copermittee with jurisdiction over the project site during the land use entitlement process.

Chapter
2

2.0 CONCEPTS AND CRITERIA

Technical background and explanations of policies and general design requirements.

2.1. Regulatory Requirements

2.1.1. 2010 SMR MS4 Permit

The San Diego Regional Board first issued a MS4 Permit to the Copermittees in the Santa Margarita Region in 1990. That permit has been reissued four times since then, with the most recent permit being issued in 2010. These permits have required the Copermittees to develop and implement a comprehensive program to prevent Stormwater Pollution to the MEP.

The 2010 SMR MS4 Permit mandates the LID approach described in this WQMP for management of the discharge of storm water pollutants from PDPs to the MEP. The 2010 SMR MS4 Permit also requires implementation of the SMR HMP to manage runoff discharge rates and durations from PDPs to avoid increased erosion of stream beds and banks in receiving waters.

This section (Section 2) explains the technical background of the Copermittees' approach to implementing both LID requirements and the SMR HMP requirements; and Chapter 3 describes how to prepare a Project-Specific WQMP (referred to as a SSMP in the 2010 MS4 Permit) that is in compliance with these requirements.

2.1.2. Maximum Extent Practicable

The Clean Water Act (CWA) Section 402(p)(3)(iii) sets the standard for control of Stormwater Pollutants as MEP, but the CWA does not quantitatively define this term. As implemented, MEP is varies with conditions. In general, to achieve the MEP standard, Copermittees must require deployment of whatever BMPs are technically feasible (that is, are likely to be effective) and are not cost prohibitive.[1]

Many stormwater controls, including LID, have proven to be practicable in most Development Projects. To achieve fair and effective implementation, criteria and guidance for those controls must be detailed and specific—while also offering the right amount of flexibility or exceptions for special cases. The 2010 SMR MS4 Permit includes various standards, reflected in this WQMP, which the San Diego Regional Board has found to provide "MEP" control.

2.1.3. Best Management Practices

CWA Section 402(p) and United States Environmental Protection Agency (USEPA) regulations (40 CFR 122.26) require the Copermittees to implement a program of "management practices" to control Stormwater Pollutants to the MEP. BMPs are schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. This document defines several categories of BMPs. The glossary includes definitions for each category of BMP.

2.1.4. TMDL

A TMDL, or 'Total Maximum Daily Load', is the maximum amount of a Pollutant that the Regional Board has established can be discharged into a waterbody from all sources (point and non-point) and still maintain Water Quality Standards. Under CWA Section 303(d), TMDLs must be developed for all waterbodies that do not meet Water Quality Standards after application of technology-based controls.

At this time, there are no adopted TMDLs in the SMR. As TMDLs are developed and adopted in the SMR, this WQMP will be updated as necessary.

2.2. Potential Impacts of Development

This section describes the potential impacts that Development Projects can have on streams, rivers and other water bodies.

[1] "Definition of Maximum Extent Practicable", memo by Elizabeth Jennings, Senior Staff Counsel, State Water Resources Control Board, February 11, 1993.

2.2.1. Imperviousness

Schueler (1995) proposed imperviousness as a "unifying theme" for the efforts of planners, engineers, landscape architects, scientists, and local officials concerned with urban watershed protection. Schueler argued (1) that imperviousness is a useful indicator linking urban land development to the degradation of aquatic ecosystems, and (2) imperviousness can be quantified, managed, and controlled during land development.

Imperviousness has long been understood as the key variable in urban hydrology. Peak runoff flow and total runoff volume from small urban catchments are usually calculated as a function of the ratio of impervious area to total area. The ratio correlates to the composite runoff factor, usually designated "C". Increased flows resulting from urban development tend to increase the frequency of small-scale flooding downstream.

Imperviousness has three major components: rooftops, transportation (including streets, highways, and parking areas) and other hardscape. The transportation component is most likely to be directly connected to the MS4.

The effects of imperviousness can be managed by disconnecting impervious areas from the MS4 and by making drainage conveyances *less* efficient—that is, by encouraging retention and detention of runoff near the point where it is generated, more closely mimicking pre-development runoff flows and durations and time of concentration.

2.2.2. Potential Water Quality Impacts Associated with Developments

Runoff from a developed site has the potential to contribute Pollutants to the MS4 and Receiving Waters. These Pollutants may originate as airborne dust, be washed from the atmosphere during rains or may be generated locally by automobiles and activities present at the site. Pollutants can be grouped in nine general categories as follows:

- Sediments are soils or other surficial materials that are eroded and then transported or deposited by the action of wind, water, ice, or gravity. Excessive discharge of sediments to waterbodies and streams can potentially increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organism survival rates, smother bottom dwelling organisms, and/or suppress aquatic vegetation growth.

- Nutrients are inorganic substances, such as nitrogen and phosphorus. They commonly exist in the form of mineral salts that are either dissolved or suspended in water. Primary potential sources of nutrients in runoff are fertilizers and eroded soils. Excessive discharge of nutrients to waterbodies and streams may cause excessive aquatic algae and plant growth. Such excessive production, referred to as cultural eutrophication, may lead to excessive decay of organic matter in the waterbody, loss of oxygen in the water, release of toxins in bed sediment, and/or the eventual death of aquatic organisms and fish kills.

- Metals are raw material components in both metal and non-metal products. Primary potential sources of metal pollution in stormwater are typically commercially-available metals and non-metal products such as fuels, adhesives, paints, and other coatings. Metal Pollutants may include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and cooling tower systems. Metals that naturally occur in soil are typically not toxic at low concentrations. However, at higher concentrations, certain metals can be toxic to aquatic life. Humans can be impacted from contaminated groundwater resources, and bioaccumulation of metals in fish and shellfish. Environmental concerns, regarding the potential for release of metals to the environment, have already led to restricted metal usage in certain applications.

- Toxic Organic Compounds are natural or synthetic carbon-based molecules that may be found in pesticides, solvents, and hydrocarbons. Organic compounds can, at certain concentrations, indirectly or directly constitute a hazard to life or health. When rinsing off objects, toxic levels of solvents and cleaning compounds can inadvertently be discharged to MS4 facilities. Dirt, grease, and grime retained in the cleaning fluid or rinse water may also adsorb levels of organic compounds that are harmful or hazardous to aquatic life.

- Trash (such as paper, plastic, polystyrene packing foam, and aluminum materials) and biodegradable organic matter (such as leaves, grass cuttings, and food waste) may impact the recreational value or other Beneficial Uses of a waterbody and/or aquatic habitat. Excess organic matter that may have been introduced as trash can create a high biochemical oxygen demand in a stream and thereby lower its water quality.

- Primary sources of oil and grease are petroleum hydrocarbon products, motor products from leaking vehicles, esters, oils, fats, waxes, and high molecular-weight fatty acids. Introduction of these Pollutants to the waterbodies can occur due to the wide uses and applications of some of these products in municipal, residential, commercial, industrial, and construction areas. Elevated oil and grease content can decrease the aesthetic value of the waterbody, as well as the water quality.

- Bacteria and Viruses are environmentally-ubiquitous microorganisms that thrive under certain ecological conditions. Their proliferation is often from natural or uncontrollable sources but can also be caused by the transport of animal or human fecal wastes from a watershed. Water containing excessive bacteria and viruses, can alter the aquatic habitat and create a harmful environment for humans and aquatic life.

- Pesticides (including herbicides) are chemical compounds commonly used to control nuisance growth or prevalence of organisms. Excessive or inappropriate application of a pesticide may result in runoff that may be toxic to aquatic life.

The 2010 MS4 Permit requires the Copermittees to require proposed PDPs to incorporate LID principles and LID BMPs, Conventional Treatment Control BMPs (where LID BMPs are technically infeasible), and Hydrologic Control BMPs that address potential water quality impacts.

2.2.3. Hydromodification Impacts

The 2010 SMR MS4 Permit defines Hydromodification as:

> *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, 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.*

Once altered, natural streams and their ecosystems may have diminished beneficial uses. However, the stream may reach a new geomorphic equilibrium if proper management measures are implemented, and beneficial uses may be partially or fully recovered. Managing runoff from a single development site may seem inconsequential, but by changing the way most sites are developed (and redeveloped), it may be possible to protect existing stream ecosystems downstream of urban and urbanizing areas.

2.2.4. Priority Pollutants of Concern

'Priority Pollutants of Concern' are those Pollutants that the proposed PDP has the potential to generate, and are also known to be impairing the downstream Receiving Waters. Identifying Priority Pollutants of Concern involves the following steps:

1. Identify Receiving Waters – Use the most recent version of the Water Quality Control Plan for the in the San Diego Region Basin to determine the PDPs proximate Receiving Waters. This information can be accessed from the following site: (http://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/)

2. Identify Impairments in those Receiving Waters by Reviewing:

the 303(d) listings for all downstream Receiving Waters:

http://waterboards.ca.gov/santaana/water_issues/programs/tmdl/303d.shtml

and any Pollutants being addressed by an adopted TMDL:

http://waterboards.ca.gov/santaana/water_issues/programs/tmdl/

3. Identify Pollutants associated with your site/project - This includes legacy Pollutants that may be present on the project site, as well as Pollutants that are listed for the category of development on Table 2-1 below. That table may be updated by the Copermittees periodically based on updated studies and information. Updates will be reported in the JRMP Annual Report to the San Diego Regional Board submitted by the Copermittee with Jurisdiction over the project site, and reflected in an update to this WQMP.

Table 2-1: Potential Pollutants by Land Use Type

Priority Development Project Categories and/or Project Features	General Pollutant Categories							
	Bacterial Indicators	Metals	Nutrients	Pesticides	Toxic Organic Compounds	Sediments	Trash & Debris	Oil & Grease
Detached Residential Development	P	N	P	P	N	P	P	P
Attached Residential Development	P	N	P	P	N	P	P	P(2)
Commercial/Industrial Development	P(3)	P	P(1)	P(1)	P(5)	P(1)	P	P
Automotive Repair Shops	N	P	N	N	P(4, 5)	N	P	P
Restaurants (>5,000 ft^2)	P	N	N	N	N	N	P	P
Hillside Development (>5,000 ft^2)	P	N	P	P	N	P	P	P
Parking Lots (>5,000 ft^2)	P(6)	P	P(1)	P(1)	P(4)	P(1)	P	P
Retail Gasoline Outlets	N	P	N	N	P	N	P	P

P = Potential
N = Not Potential
(1) *A potential Pollutant if non-native landscaping exists or is proposed onsite; otherwise not expected.*
(2) *A potential Pollutant if the project includes uncovered parking areas; otherwise not expected*
(3) *A potential Pollutant is land use involving animal waste*
(4) *Specifically petroleum hydrocarbons*
(5) *Specifically solvents*
(6) *Bacterial Indicators are routinely detected in pavement runoff*

2.3. Low Impact Development (LID)

The 2010 SMR MS4 Permit defines LID as follows:

> A stormwater 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.

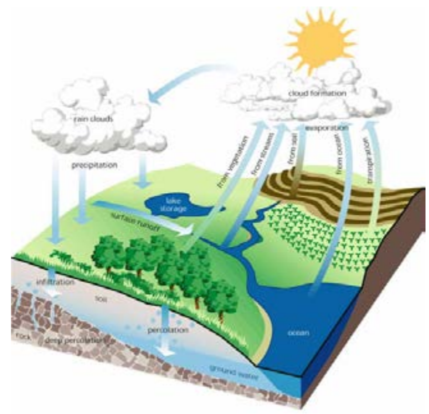
The Low Impact Development Manual for Southern California (SMC, 2010) further describes that there are two types of LID:

- LID Principles which are site design concepts that prevent or minimize the causes (or drivers) of post-construction impacts, and help mimic the pre-development hydrologic regime. LID Principles should be implemented to the MEP on all sites.

- LID BMPs which are Structural BMPs that help manage otherwise unavoidable post-construction impact; i.e., where implementation of LID Principles cannot fully address the Design Capture Volume for a particular portion of a site, LID

BMPs must be implemented. The User may also investigate the feasibility of using LID BMPs as Hydrologic Control BMPs to manage the increases in runoff discharge rates and durations that may cause Hydromodification impacts.

2.3.1. Benefits of LID



There are many potential benefits associated with the use of LID. Foremost, LID BMPs tend to retain runoff, thus reducing the amount of potentially Polluted runoff that can be transported to Receiving Waters. Additionally, LID BMPs have the advantage of supplementing the physical processes of interstitial settling and adsorption—common to all media filters—with additional complexation and adsorption to the biofilms that are developed, and for those that include vegetation, additional Pollutant removal through uptake through the plant roots. In addition, LID BMPs that integrate engineered/amended soils and/or vegetation benefit from the biological activity of bacteria, insects, and worms, which helps renew and maintain the media, increasing reliability and eliminating the need for frequent maintenance or re-setting of the filtration layers. LID BMPs also act as "sponges", absorbing the amount of Runoff from small storm events and some of the Runoff from larger events and retaining it so as to maximize infiltration and Evapotranspiration. This, in turn helps the post-development site's hydrologic regime mimic the pre-development hydrology and can be useful in achieving compliance with the HMP Performance Standards.

In addition to Stormwater management, LID implementation can result in environmental, economic, and community benefits:

Potential Environmental Benefits:

- Improved water quality
- Maintenance of predevelopment Runoff volume and discharge
- Groundwater recharge
- Terrestrial and aquatic habitat preservation
- Reduced potable water demand
- Recycling and beneficial reuse

- Reduction in urban heat island effect

Potential Economic Benefits:

- Reduced construction and maintenance costs
- Improved marketability
- Energy cost reduction and water conservation

Potential Community Benefits:

- Improved aesthetic value
- Provides "green job" opportunities
- Educational opportunities

LID BMPs have been shown in studies throughout the country to be effective and reliable at treating a wide range of Pollutants that can be found in Runoff, including those listed in Section 2.2.2 above. As such, the LID BMPs required in this WQMP are expected to treat discharges of urban-sourced Pollutants from PDPs with a high level of effectiveness, such that the runoff discharges from the PDP should not cause or contribute to an exceedance of Receiving Water Quality Objectives.

2.3.2. LID BMP Types and Prioritization

LID BMPs are a type of Structural BMP that provide many of the benefits described above. For the purposes of this WQMP, LID BMPs are categorized and prioritized as follows:

- Priority 1: LID Retention BMPs
  - LID Infiltration BMPs are designed to infiltrate captured runoff into the underlying native soils. As such, these LID Infiltration BMPs can be used only where soils are highly permeable. Review the assessment of constraints and opportunities in Step 2 to determine the applicability of LID Infiltration BMPs to the PDP. Typical LID Infiltration BMPs include infiltration basins, infiltration trenches and pervious pavements.
    - Pervious Pavements include pervious pavers, asphalt or concrete surfaces, or permeable modular block. Unlike traditional pavements that are impermeable, porous pavements reduce the volume and peak of Stormwater Runoff as well as manage

Pollutants from Stormwater Runoff by allowing precipitation to infiltrate into underlying soils. Permeable pavements can be designed as LID Infiltration BMPs, or as an LID Principle[1].

- Harvest and Use BMPs are used to facilitate capturing Stormwater Runoff for later use. Review the assessment of constraints and opportunities in Step 2 to determine the applicability of this LID BMP to the Development Project.

- Bioretention BMPs are engineered vegetated areas that are designed to receive runoff. These areas can be configured as free-form areas or planters to integrate with the landscape design. Bioretention BMPs are feasible on all soil types and distinguished from Biotreatment BMPs (below) by the fact that they capture and absorb the Design Capture Volume (DCV) entirely into a biologically active soil media. Water retained in this soil media is then evapotranspired by plants in the BMP, or slowly allowed to infiltrate into the underlying soils. This BMP inherently maximizes both infiltration and evapotranspiration of runoff based on the actual limitations of the soil and environment. In sufficiently drained soils, even when constructed with a subdrain, Bioretention BMPs will retain long term volumes of runoff. See the additional discussion of Retention vs. Bioretention in Section 2.3.3.

- Priority 2: Other LID BMPs

  - Bioretention BMPs while designed to be a LID Retention BMP, Bioretention BMPs can also be used in areas where infiltration characteristics of the soils will not allow full retention of the DCV. Bioretention BMPs may also be implemented to partially, if not fully, manage increases in runoff discharge rates and duration to meet the Hydrologic Performance Standard (Section 3.6.3). In this case, infiltration and evapotranspiration of Runoff will still be maximized based on the actual limitations of the soil and environment.

[1] When pervious pavement is designed primarily as a site design feature (i.e., it doesn't receive Runoff from more than 2 parts tributary impervious area to 1 part pervious pavement), the pervious pavement is considered a self-retaining area as described in Section 3.3.3. If additional area is drained onto the pervious pavement beyond the 2:1 ratio, the pervious pavement will be required to be constructed in accordance with a Copermittee approved Stormwater BMP design that allows for greater ratios, (such as the LID BMP Design Handbook). In this case, pervious pavement is considered a LID Infiltration BMP.

- Biotreatment BMPs are naturally-based LID BMPs, which can be used where soils are relatively impermeable. These BMPs are distinguished from LID Bioretention BMPs in that they are not designed to retain the DCV in an engineered soil media, however, they still provide similar functions and benefits to LID Bioretention BMPs by incorporation of features that provide for natural biological processes while still maximizing opportunities for infiltration and evapotranspiration. Biotreatment BMPs may also be implemented to partially, if not fully, manage increases in runoff discharge rates and duration to meet the Hydrologic Performance Standard (Section 3.6.3). Examples of Biotreatment Control BMPs include extended detention basins, bioswales, and constructed wetlands. Consult with the Copermittee with jurisdiction over the project site to determine approved LID Biotreatment BMPs.

Descriptions, illustrations, designs, and design criteria for the LID BMPs described herein can be found in the LID BMP Design Handbook (Exhibit C). A Copermittee may have its own designs for these same BMPs, or may specify other LID BMPs that Users may use.

2.3.2.a) LID Prioritization

Consistent with Provision F.1.d.(4) of the 2010 SMR MS4 Permit, each PDP must implement LID Retention BMPs that capture and retain onsite the DCV for each of the project's Drainage Management Areas (DMAs). If it has been shown to be technically infeasible to implement such LID Retention BMPs for some or all of DMAs on the site, other LID BMPs can be used to address the runoff from those DMAs.

2.3.3. LID Retention vs Bioretention

The 2010 SMR MS4 Permit requires that the DCV be retained onsite unless it is technically infeasible. The intent behind these prioritization requirements is to reduce the volume of runoff and Pollutant loads entering Receiving Waters. In cases where such retention practices are feasible, they may provide a significant benefit to runoff quality, and help the project mimic the pre-development hydrologic regime. Of particular interest is the contribution of LID BMPs towards managing potential increases in runoff discharge rates and durations caused by PDPs.

BMPs solely reliant on retention practices (infiltration, harvesting and use, or evapotranspiration) however, require a high level of confidence in the long-term reliability of water demand, the infiltration characteristics of the underlying soils, and of evapotranspiration rates, to ensure timely drawdown of the storage volume.

LID Bioretention BMPs, when properly designed such as shown in the LID BMP Design Handbook, also inherently meet the goal of capturing the required volume of runoff, and infiltrating and evapotranspiring that volume to the extent feasible given site soils and other conditions. In highly permeable soils, infiltration will meet or exceed the required DCV; in less permeable soils the proportion infiltrated will be smaller and the remaining proportion will either be evapotranspired or receive full biotreatment. Such LID Biotreatment BMPs will achieve the *maximum* feasible level of infiltration and evapotranspiration and achieve the *minimum* feasible (but highly biotreated) discharge.

> LID Bioretention BMPs provide the benefits of LID Retention BMPs, while providing a higher level of confidence that the captured volume will be drained within an acceptable timeframe to avoid nuisance conditions and ensure that subsequent storms will not bypass the BMP untreated.

A recent analysis of the monitored inflow and outflow data contained in the International Stormwater BMP Database showed an average long-term volume reduction on the order of 40% for biofilters, 30% for extended detention basins, and 60% for Bioretention BMPs. These performance figures are for installations on a variety of underlying soil types. The higher the infiltrative capacity of the underlying soils, the higher percentage of long term captured volume will be retained.

This means that a designer could substitute a LID Bioretention BMP designed to capture 100% of the DCV, instead of an identically sized LID Harvest and Use BMP that has insufficient demand - without impairing the long term retention of stormwater runoff of the PDP's system of BMPs. This is because, if the Harvest and Use BMP would, based on the demands present on the site, retain less than 40% of the *long term volume of runoff*, the LID Biotreatment BMP would end up retaining more than the Harvest and Use BMP.

☞ *To further validate the volume reduction resulting from LID BMPs in the semi-arid environment of western Riverside County, the District has constructed several categories of LID BMPs, including Bioretention BMPs, at their headquarters in Riverside, CA and is directly measuring the actual long term volume reductions.*

2.3.4. LID Infiltration Feasibility Criteria

In many areas of Riverside County, soils will support LID Infiltration BMPs. However, there are several factors that affect their feasibility that must be considered before utilizing such BMPs. Some of the factors will require a licensed Geotechnical Engineer to verify, as identified in the sub-sections below.

2.3.4.a) Downstream Impacts

If it is demonstrated that infiltrating the DCV would negatively impact downstream water rights or other Beneficial Uses, LID Infiltration BMPs are not required. Such a condition must be substantiated by sufficient modeling to demonstrate such an impact. Such an exemption would have to be approved by the Copermittee with jurisdiction over the project site and the San Diego Regional Board.

2.3.4.b) Groundwater Protection

The following restrictions on the use of centralized Infiltration BMPs are identified to ensure that the BMP does not cause or contribute to an exceedance of groundwater quality objectives. These restrictions do not apply to small infiltration systems dispersed throughout a PDP.

- LID Infiltration BMPs must not be used for areas of industrial or light industrial activity, and other high threat to water quality land uses and activities as designated by each Copermittee unless first treated or filtered to remove Pollutants prior to infiltration.
- The seasonal high groundwater mark must be at least 10 feet below the invert of the LID Infiltration BMP.
- Infiltration BMPs must be located a minimum of 100 feet horizontally from any water supply wells.
- No part of a LID Infiltration BMP should be within a 2:1 (horizontal: vertical) influence line extending from any septic leach line.
- LID Infiltration BMPs must not be located in soils that, according to a licensed Geotechnical Engineer, do not have adequate physical and chemical characteristics (such as appropriate cation exchange capacity, organic content, clay content and infiltration rate) for the protection of groundwater.

2.3.4.c) Public Safety and Offsite Impacts:

LID Infiltration BMPs must not be used in locations or in soils that may create a public safety or structural concern, such as but not limited to slope or structural instability, landslides, mudslides, liquefaction, seeps, adjacent to building foundations, or other geotechnical concerns. Such a determination must be in accordance with the recommendations of a licensed Geotechnical Engineer.

2.3.4.d) Infiltration Characteristics

BMPs entirely reliant on infiltration (such as infiltration basins or infiltration trenches) require a high level of confidence in the long-term reliability of the infiltration characteristics of the underlying soils. Adequate long-term infiltration capacity is the determining factor as to whether a LID Infiltration BMP will be effective for the protection of Receiving Water quality.

'In-Situ' tested infiltration rates (i.e., the Saturated Hydraulic Conductivity) can vary widely both spatially and temporally within a project site. It is not uncommon to find that the tested infiltration rates at one location can be an order of magnitude different from another test conducted a matter of feet away – even within the same BMP footprint. Additionally it is known that the infiltration rate is typically reduced after construction of the project (compared to exploratory/feasibility testing performed before construction) due to grading, cut and fill conditions; and that the infiltration rate continues to further degrade over time due to unavoidable/inadvertent clogging of the native soils.

If the actual long-term infiltration rates within the BMP are too low, excessive ponding may occur, which may result in two negative effects:

1) Mosquitoes and other vectors may begin breeding; and

2) Runoff from subsequent rainfall events may bypass the BMP, resulting in untreated runoff being discharged from the site and potential impacts to receiving waterbodies.

To avoid creation of these conditions, a maximum Drawdown Time of 72 hours has been established. To ensure that over the life of the BMP the actual Drawdown Time does not exceed 72 hours, and based on the typical infiltration basin depth of five (5) feet, the minimum long-term post-development infiltration rate must be at least 0.83 inch per hour (5ft * 12/72 hours = 0.83 inch/hour).

As discussed above, however, the long-term post-development infiltration rates can be much lower than the initial (pre development) infiltration rates that are measured for feasibility testing. As such, infiltration testing requirements have incorporated a minimum factor of safety of two for Infiltration BMPs. Incorporating the established minimum factor of safety, the tested pre-development infiltration rates must be greater than 1.6 inches per hour to be assured that over the life of the BMP, the actual infiltration rate will not degrade to a level that nuisance or vector conditions could be created. This will also ensure that the BMP will be adequately drained for back-to-back storms.[1]

Accordingly, the following feasibility criteria have been developed to ensure that the most effective and reliable BMPs are deployed:

- If the 'in-situ' tested infiltration rate for the site is less than 1.6 inches per hour, due to the uncertainty in infiltration rates as discussed above LID Infiltration BMPs (infiltration basins, infiltration trenches, etc.) must not be used. Infiltration testing must be performed using methodologies such as identified in the LID BMP Design Handbook, or Copermittee-approved alternative methods. If Harvest and Use is also not feasible, Bioretention BMPs can instead be used. Bioretention BMPs provide infiltration and evapotranspiration to the MEP as described in Section 2.3.3, while ensuring that the BMP drains appropriately and capacity is restored for subsequent storms.

While soil amendment practices can affect evapotranspiration rates, they do not have a substantial effect on infiltration rates to the surrounding native soils or overall retention in a LID Infiltration BMP, and as such are not appropriate to prevent vector concerns or ensure adequate drainage for subsequent storms. Amended soils may be appropriate for self-retaining areas (micro-infiltration areas) described in section 3.3.2, when sited on Group C or D soils.

If the project meets the following criteria:

Table 2-2: Small Project Criteria

Residential	Commercial, Institutional	Industrial
Less than 10 acres and less than 30 DU	Less than 5 acres and less than 50,000 SF Impervious	Less than 2 acres and less than 20,000 SF Impervious

Then the project is considered a small project. If the small project is underlain with Hydrologic Soils Group (HSG) "D" soils according to available regional soils maps, and

[1] The analysis used to determine the threshold infiltration rates was based on factors of safety used in the adopted Orange County WQMP/Technical Guidance Document (Appendix VII), standard engineering practices, experience with BMPs that rely solely upon infiltration in Contra Costa County, and best professional judgment.

no available data for the site is conflicting with such a designation, 'in-situ' testing of infiltration rates may not be required, at the discretion of the Copermittee. In this case, LID Infiltration BMPs cannot be used.

2.3.4.e) Cut / Fill Conditions

The soil beneath LID Infiltration BMPs must be thoroughly evaluated in a geotechnical report since such BMPs are reliant solely on the infiltration rates of the underlying soils for their long term performance. Because of this, the project proponent must be able to perform tests on the actual soils that will exist at the infiltration surface. It is impossible to test the infiltration rate of an engineered fill that does not yet exist. As such, LID Infiltration BMPs would be prohibited if the planned fill was so deep that the bottom of the BMP could not extend down through the fill and into the native soils. A similar situation exists for those areas that will be significantly excavated as part of the site grading process, and the testing cannot be performed at the future cut elevation. If there is no practicable way to verify infiltration rates at the final BMP infiltration surface, LID Infiltration BMPs may not be used. LID Infiltration BMPs may still be applicable for DMAs in other parts of a project site in which infiltration testing is feasible. Each DMA on a project site will be assessed accordingly.

2.3.4.f) Other Site Specific Factors

If the geotechnical investigation performed by a licensed engineer discovers other site-specific factors that would preclude effective and/or safe infiltration, such as, but not limited to, clay lenses, restrictive layers, or soils prone to liquefaction, LID Infiltration BMPs are not required in those areas.

2.3.5. LID Harvest and Use Feasibility Criteria

LID Harvest and Use BMPs may be employed on any site where it can be shown there is sufficient reliable and timely demand for non-potable water, subject to the following criteria:

2.3.5.a) Downstream Impacts

If harvesting and using Stormwater Runoff would demonstrably negatively impact downstream water rights or other Beneficial Uses, LID Harvest and Use BMPs are not required. Such a condition must be substantiated by sufficient modeling to demonstrate such an impact. Such an exemption would have to be approved by the Copermittee with jurisdiction over the project site and the San Diego Regional Board.

2.3.5.b) Reclaimed Water Use

Utilizing reclaimed water where available inherently reduces the amount of treated municipal effluent discharged to waterbodies. Further, utilizing the capacity of the reclaimed water system, where available, has a significantly larger benefit for offsetting potable water supply than LID Harvest and Use BMPs. If reclaimed water is available to the site, the use of reclaimed water will take precedence over the harvest and use of Stormwater Runoff.

If reclaimed water will be used on the project, there is no need to further evaluate the feasibility of LID Harvest and Use BMPs. Use of reclaimed water should be documented in the Project-Specific WQMP.[1]

2.3.5.c) Code Compliance

If a particular use of captured stormwater, and/or available methods for storage of captured stormwater would be contrary to building codes in effect at the time of approval of the preliminary Project-Specific WQMP, then an evaluation of harvesting and use for that use would not be required.

2.3.5.d) Minimum Demands

The evaluation of the feasibility of LID Harvest and Use BMPs is performed for three potential categories of use: toilet flushing, irrigation and other onsite non-potable uses as described in the following tables. Data presented in the tables were generated based upon a continuous simulation analysis and demand factors consistent with similar analyses prepared for the 2011 Orange County WQMP and Technical Guidance Document. Riverside County specific rainfall and evapotranspiration data was used to generate the analysis.

For evaluation of toilet flushing, flush volumes and use rates from the literature have been combined with a long-term continuous simulation to develop a minimum unit demand, referred to as the Toilet Users to Impervious Area ratio that would be required to achieve the minimum 40% long-term retention of Runoff. See Table 2-3 below, as well as the discussion of Retention vs. Bioretention BMPs above. If the proposed project does not meet or exceed this minimum demand, implementing this LID Harvest and Use BMP would be less

[1] Non-agricultural irrigation using recycled water must comply with the statewide permit for Landscape Irrigation Using Recycled Water and the State Department Health guidelines.

effective than a Bioretention BMP, and as such, this LID Harvest and Use BMP would not be required for the project.

Table 2-3: Harvest and Use Data for Toilet Use

Project type	Residential	Retail / Office Commercial	Industrial	Schools
Basis of Use Type	*Resident*	*Employee (non-visitor)*	*Employee (non-visitor)*	*Employee (non-student)*
Design Capture Storm depth, in	**Minimum Demand (toilet users per tributary impervious acre)**			
0.50	87	116	160	26
0.55	94	125	170	28
0.60	102	133	179	30
0.65	109	142	189	31
0.70	116	150	198	33
0.75	123	159	208	35
0.80	130	167	217	36
0.85	137	176	227	38
0.90	145	184	236	40
0.95	152	193	246	41
1.00	159	201	255	43
1.05	166	210	265	45
1.10	173	218	274	46
1.15	180	227	284	48
1.20	188	235	293	50

[A]Unit demands used in analysis: *Residential = 9.3 gal/resident/day*
Retail/office = 7 gal/employee/day
Industrial = 5.5 gal/employee/day
Schools = 33 gal/employee/day

[B]Design storm capture = 0.7 in. with Lake Elsinore rainfall; 1.0 in. with Temecula rainfall. Other values were linearly interpolated/extrapolated

For evaluation of irrigation, typical evapotranspiration and water demands have been combined with a long-term continuous simulation to develop a minimum ratio of Effective Impervious Area to Irrigated Area that would be required to achieve the minimum 40% long-term retention of Runoff. See Table 2-4 below, as well as the discussion of Retention vs. Bioretention BMPs above. If the proposed project cannot meet or exceed this ratio, implementing this LID Harvest and Use

BMP would be less effective than a LID Bioretention BMP, and as such this LID Harvest and Use BMP would not be required for the project.

Table 2-4: Harvest and Use Data for Irrigation Use[A]

General landscape type	Conservation Design: K_L^B=0.35	Active Turf Areas: K_L^B=0.70
Design Capture Storm Depth[C], in	**Minimum required irrigated area per tributary impervious acre for partial capture (ac/ac)**	
0.50	0.36	0.22
0.55	0.72	0.35
0.60	1.08	0.47
0.65	1.45	0.60
0.70	1.81	0.91
0.75	2.17	1.16
0.80	2.53	1.41
0.85	2.90	1.66
0.90	3.26	1.91
0.95	3.62	2.16
1.00	3.98	2.41
1.05	4.35	2.66
1.10	4.71	2.91
1.15	5.07	3.16
1.20	5.43	3.41

[A]ET data from the CIMIS station at Temecula used for this analysis

[B] (KL) incorporates plant species, microclimate and water management/irrigation practices, as described in the 2011 Orange County WQMP and Technical Guidance Document.

[C]Design storm capture = 0.7 in. was calculated using Lake Elsinore rainfall; 1.0 in. with Temecula rainfall. Other values were linearly interpolated/extrapolated

For evaluation of other non-potable uses such as industrial uses, a long-term continuous simulation of precipitation intensity and frequency has been performed to develop a table of minimum demands that would be required to achieve the minimum 40% long-term retention of runoff. See Table 2-5 below, as well as the discussion of Retention vs. Biotreatment above. If the proposed project cannot meet or exceed these minimum demands, implementing this LID Harvest and Use BMP would be less effective than a LID Bioretention BMP, and as such this LID Harvest and Use BMP would not be required for the PDP.

Table 2-5: Harvest and Use Data for other non-potable uses*

Design Capture Storm depth, in	Wet season demand required for minimum partial capture, gpd per impervious acre
0.50	880
0.55	932
0.60	985
0.65	1,037
0.70	1,089
0.75	1,141
0.80	1,194
0.85	1,246
0.90	1,298
0.95	1,350
1.00	1,403
1.05	1,455
1.10	1,507
1.15	1,559
1.20	1,612

**Design storm capture = 0.7 in. was calculated using Lake Elsinore rainfall; 1.0 in. with Temecula rainfall. Other values were linearly interpolated/extrapolated*

2.3.6. Feasibility of Other LID BMPs

Experience has shown implementation of other types of LID BMPs, such as Bioretention and/or Biotreatment is feasible on nearly all PDP sites with sufficient advance planning. Projects where LID Bioretention and/or Biotreatment BMPs may not always be feasible generally fall into one of the following two categories:

- Portions of sites which are not being developed or redeveloped, but which must be retrofitted in accordance with the "50% rule". For example if site-specific conditions preclude draining existing impervious surfaces on the newly developed portion of the site – and if the existing impervious surfaces cannot be otherwise retrofitted with other LID BMPs.

- Sites smaller than one acre approved for lot-line to lot-line development or redevelopment as part of a Copermittee's effort to preserve or enhance a pedestrian-oriented "smart-growth" type of urban design. For many scenarios, LID Biotreatment BMP options such as planters will be feasible.

If you believe specific conditions on your site preclude the use of LID BMPs, you must submit, in the Project-Specific WQMP, a detailed site-specific examination and demonstration that implementation of other LID BMPs is technically infeasible.

2.3.7. BMP Area Considerations

Most LID BMPs can be fit within planned landscaped areas of a project with proper planning and site and grading/drainage optimization.

Table 2-6 provides the recommended percentage of a PDP site that is required to be made available for LID BMPs. The PDP may provide more area for LID BMPs if desired. Table 2-6 is intended to be used as follows:

- If the percentage of the PDP site that would have to be made available for BMPs to meet the requirements in this WQMP exceeds the project-type specific minimum criteria shown in Table 2-6 below, then the remaining volume (beyond that which fits within the shown minimum criteria) must be addressed with other Conventional Treatment Control BMPs, Credits, Runoff Fund contributions, or waivers.
- If the percentage of the site provided for BMPs is lower than the value shown in Table 2-6 and the BMP requirements have not fully been met, a reviewer can request that additional area be made available for BMPs until either the percentage of the site in Table 2-6 is provided or the BMP requirements are met, whichever is less.

Table 2-6: Recommended Effective Area[1] Required to be made Available for LID BMPs (% of site)[2]

Priority Development Project Type	New Development	Redevelopment
SF/MF Residential < 7 du/ac	10%	5%
SF/MF Residential 7 – 18 du/ac	7%	3.5%
SF/MF Residential > 18 du/ac	5%	2.5%
Mixed Use, Commercial/Industrial w/ FAR < 1.0	10%	5%
Mixed Use, Commercial/Industrial w/ FAR 1.0 – 2.0	7%	3.5%
Mixed Use, Commercial/Industrial w/ FAR > 2.0	5%	2.5%
Podium (parking under > 75% of project)	3%	1.5%
Zoning allowing development to property lines	2%	1%
Transit Oriented Development[3]	5%	2.5%
Parking	5%	2.5%

[1] "Effective area" is defined as area which 1) is suitable for a BMP (for example, if infiltration is potentially feasible for the site based on infeasibility criteria, infiltration must be allowed over this area) and 2) receives runoff from impervious areas.

[2] Adapted from the San Bernardino County Stormwater Program Technical Guidance Document for Water Quality Management Plans.

[3] Transit oriented development is defined as a development with development center within one half mile of a mass transit center.

Key: du/ac = dwelling units per acre, FAR = Floor Area Ratio = ratio of gross floor area of building to gross lot area, MF = Multi Family, SF = Single Family

2.4. HYDROMODIFICATION

As land converts from natural land covers to developed land covers, runoff discharge rates and durations, and the delivery of Bed Sediment Supply from PDPs to the Receiving Waters may be altered. The alteration of both hydrology and sediment transport regimes may cause erosion or aggradation to channels. Where this occurs, this phenomenon is referred to as Hydromodification.

The 2010 SMR MS4 Permit specifies additional BMP requirements to help prevent Hydromodification impacts. Formerly referred to as 'Hydrologic Conditions of Concern', Hydromodification management approaches have evolved over time, with efforts first focused on managing peak flow rates, and have now shifted to matching or reducing the flow duration curves from post-development to pre-development, in some cases naturally occurring, conditions using continuous simulation approaches, and preserving the delivery of Bed Sediment Supply to the Receiving Waters. This can be accomplished through the use of Structural BMPs, or Hydrologic Control BMPs, and Site Design Principles, or Sediment Supply BMPs. Hydrologic Control BMPs are designed to control the post-construction Runoff hydrograph from the PDP site. Sediment Supply BMPs are implemented to preserve the delivery of Bed Sediment Load to the Receiving Waters.

Hydromodification requirements are separate from, but overlap, the LID requirements of the 2010 SMR MS4 Permit. The LID Design process described in this document will help to avoid potential Hydromodification impacts from a PDP, however may not lead to full compliance with the HMP Performance Standards.

2.5. HYDROLOGY FOR NPDES COMPLIANCE

2.5.1. Water Quality Hydrology

Most runoff, and therefore, most of the potential for conveyance of Pollutants, is produced by frequent storms of small or moderate intensity and duration. Accordingly, Structural BMPs are designed to treat smaller storms and the first flush of larger storms.

2.5.1.a) Design Storm

Methods that have historically been used to determine an MEP-based and cost effective volume of treatment involve continuous simulation of long term rainfall and corresponding runoff from a hypothetical one-acre area entering a basin designed to draw down in a specified amount of time. The simulation is iterated with varying unit basin sizes, and the results are graphed to find the point of diminishing returns (i.e., the 'knee' of the curve) where incrementally larger BMPs result in incrementally smaller benefits to treatment of runoff.

It has been found that the knee of the curve typically occurs with a basin designed for the 85th percentile 24-hour storm event. It has also been found that a basin of this size ends up treating about 80% of the total long-term volume of runoff that occurs during the simulation period.

To simplify design calculations (that is, to avoid the need to perform continuous simulation for design of all BMPs), 2010 SMR MS4 Permit has established the 85th percentile, 24-hour storm event as the "Design Storm", which is the standard used in this WQMP.

An updated Isohyetal map showing the 85th percentile 24-hour storm depth at different locations throughout western Riverside County, based on long-term rainfall data, is provided in Exhibit A.

2.5.1.b) *Composite Runoff Factor*

The sizing of both Volume-Based BMPs and Flow-Based BMPs is based on determination of a composite runoff factor, which varies depending on the land use covers tributary to the BMP. This composite runoff factor, C, is determined using the following equation

$$C = 0.858 \cdot {I_f}^3 - 0.78 \cdot {I_f}^2 + 0.774 * I_f + 0.04$$

where the Impervious Fraction, I_f is obtained from Table 2-7 below.

Table 2-7: Impervious Fraction Based on Various Land Use Covers

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

Where multiple surface types are present, a Composite Impervious Fraction, and therefore a Composite Runoff Factor can be calculated using the following equation:

$$I_{f\,composite} = \frac{\left[(I_f)_1 \cdot A_1\right] + \left[(I_f)_2 \cdot A_2\right] + [\ldots]}{A_T}$$

2.5.1.c) *Design Capture Volume (DCV or V_{BMP})*

The 2010 SMR MS4 Permit requires that all LID Retention BMPs, Other LID BMPs and Volume-Based Conventional Treatment BMPs be sized to address the volume of runoff from the Design Storm, referred to as

NOTE

The LID BMP Design Handbook (Exhibit C) includes calculation sheets that can be used to calculate and document the '**Design Capture Volume**,' and the **Design Flow Rate**. These should be documented as described in Section 3 herein.

the 'Design Capture Volume', or V_{BMP}. Use the LID BMP Design Handbook to calculate the DCV. For reference, the following equations are used by the LID BMP Design Handbook:

$$DCV = D_{85} \cdot C \cdot A_{TRIB}$$

Where:

DCV = Design Capture Volume (ft^3)

D_{85} = Design Storm depth (from Exhibit A)

C = Composite Runoff Factor (unitless, per 2.5.1.b)

A_{TRIB} = Area tributary to the BMP (acres, see Section 3.3)

2.5.1.d) Design Flow Rate (Q_{BMP})

For flow-based Conventional Treatment Control BMPs, use the LID BMP Design Handbook to calculate the design flow rate. For reference, the LID BMP Design Handbook is based on the rational method and uses the following equation:

$$Q_{BMP} = C \cdot i \cdot A_{TRIB}$$

Where:

Q_{BMP} = Design Flow Rate (cfs)

i = rainfall intensity (0.2 inches/hour)

C = Composite Runoff Factor (unitless, per 2.5.1.b))

A_{TRIB} = area tributary to the BMP (acres, see Section 3.3)

2.5.2. Hydromodification Hydrology

In addition to incorporating applicable LID BMPs to ensure water quality treatment of runoff, Users may be required to provide additional LID Principles, LID BMPs, or other Structural BMPs to manage Hydromodification.

2.5.2.a) Santa Margarita Region Hydrology Model

The 2010 SMR MS4 Permit states:

> *All PDPs must use continuous simulation to ensure that post-project runoff flow rates and durations for the PDP shall not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% over more than 10% the length of the flow duration curve, from 10% of the 2-year runoff event up to the 10-year runoff event.*

To comply with this provision, the Copermittees require Users to use the Santa Margarita Region Hydrology Model (SMRHM) to demonstrate compliance with the Hydrologic Performance Standard of the SMR HMP. The SMRHM is an integrated flow control sizing tool that performs continuous hydrologic simulations over the entire available rainfall record. The tool allows the User to size LID BMPs and match or reduce the flow duration curve of post-development to that of pre-existing, naturally occurring, conditions. Geomorphically significant flows that are embedded in SMRHM range from 10% of the 2-year runoff event up to the 10-year runoff event. The SMRHM is made available to Users at no cost.

Alternatively, the User may opt to develop its own model using publicly-available software, which performs continuous hydrologic simulation over the available period of rainfall record, consistent with the conditions set forth in Section 2.2.i of the SMR HMP. The use of a different model than SMRHM must receive prior approval from the Copermittee having jurisdiction over the PDP. User may also put forth other low-flow thresholds for individual PDPs, which will require site-specific justification, at the User's expense. General guidelines on how to develop a site-specific low-flow threshold are provided in Appendix I of the SMR HMP.

Compliance with the Hydrologic Performance Standard of the SMR HMP does not constitute full compliance with the HMP Performance Standards. The Copermittees also require Users to demonstrate compliance with the Sediment Supply Performance Standard defined in Section 3.6 to fulfill the requirements.

2.6. References and Resources

- *The Importance of Imperviousness* (Tom Scheuler, 1995)
  Site Planning for Urban Stream Protection, available from the Center for Watershed Protection)
- California Stormwater BMP Handbooks
  - Southern California LID Manual
  - *Urban Runoff Quality Management,* Water Environment Federation and American Society of Civil Engineers, 1998. ISBN 1-57278-039-8 ISBN 0-7844-0174-8.
  - *Stormwater Infiltration,* Bruce K. Ferguson, 1994. ISBN 0-87371-987-5

- Clean Water Act Section 402(p)
- 40 CFR 122.26(d)(2)(iv)(A)(2) – Stormwater Regulations for New Development
- *Restoring Streams in Cities* (Riley, 1998)
- *Stream Restoration: Principles, Processes, and Practices* (Federal Interagency Stream Restoration Working Group, 1998, revised 2001)
- *Municipal Handbook, Rainwater Harvesting Policies* (USEPA, 2008)
- *Green Roofs for Stormwater Runoff Control* (USEPA, 2009a)
- *Porous Pavements* (Ferguson, 2005)
- *Orange County WQMP and TGD, with errata, 2011*
- *CASQA LID Guidance Manual for Southern California*
- *RWQCB Water Quality Control Plan for the San Diego Basin (Basin Plan)*
- *Design Hansbook for Low Impact Development Best Management Practices,* Riverside County Flood Control and Water Conservation District, 2011.

Chapter
3

3.0 PREPARING PROJECT-SPECIFIC WQMPS

Step-by-step assistance to document compliance.

A Project-Specific WQMP is a document to demonstrate that a PDP complies with applicable requirements of the 2010 SMR MS4 Permit — to implement LID Principles and BMPs, manage Hydromodification, incorporate required Source Control BMPs, and provide for operation and maintenance of Structural BMPs.

ICON KEY

- ☞ Helpful Tip
- ✍ Submittal Requirement
- 1. Terms to Look Up
- 🕮 References & Resources

The Copermittees require a 'Project-Specific' WQMP for every PDP as described in Section 1.1. The Project-Specific WQMP must be submitted with the application for Discretionary Approvals (entitlements) and must have sufficient detail to ensure the stormwater design, site plan, and landscaping plan are congruent and will comply with the applicable LID and HCOC standards in the 2010 SMR MS4 Permit. Submitting a complete and thorough Project-Specific WQMP will facilitate quicker review and fewer cycles of review.

The procedure in this section is intended to facilitate, not substitute for, creative interplay among site design, landscape design, and drainage design. Several iterations may be needed to optimize your drainage design as well as aesthetics, circulation, and use of available area for the PDP site.

Structural BMPs should be planned and designed integrally with the site planning and landscaping for the PDP. It's best to start with general project requirements and preliminary site design concepts; then prepare the detailed site design, landscape design, and Project-Specific WQMP simultaneously. This will facilitate the development of a congruent site plan, landscape plan, grading plan and Project-Specific WQMP.

3.1. Assemble Project and Site Information

To perform the LID design, the designer needs to identify pertinent site and PDP characteristics, including information such as (but not limited to):

- Existing natural hydrologic features and natural resources, including any contiguous natural areas, wetlands, watercourses, seeps, or springs.
- Existing site topography, including contours of any slopes of 4% or steeper, general direction of surface drainage, local high or low points or depressions, and any outcrops or other significant geologic features.
- Zoning, including requirements for setbacks and open space.

- Soil types (including Hydrologic Soil Groups) and depth to groundwater, which may determine whether infiltration is a feasible option for managing site Runoff. Depending on site location and characteristics, and on the selection of Structural BMPs, site-specific information (e.g., from boring logs or geotechnical studies) may be required.
- Existing site drainage. For undeveloped sites, this should be obtained by inspecting the site and examining topographic maps and survey data. For previously developed sites, site drainage and connection to the MS4 can be located from site inspection, MS4 maps, and plans for previous development.
- Onsite Significant Sources of Bed Sediment and first order, or higher, channels, as defined in Section 2.3.i of the SMR HMP.
- Existing vegetative cover and impervious areas, if any.
- Project Design Features, including impervious surfaces, landscaped surfaces, parking lots, land uses, etc.

3.2. Optimize Site utilization (LID Principles)

Review the information collected in Section 3.1. Identify the principal constraints on site design as well as opportunities to reduce imperviousness and incorporate LID Principles into the PDP site and landscape design. For example, constraints might include impermeable soils, high groundwater, groundwater pollution or contaminated soils, steep slopes, geotechnical instability, high-intensity land use, heavy pedestrian or vehicular traffic, utility locations, or safety concerns. Opportunities might include existing natural areas, low areas, oddly configured or otherwise unbuildable parcels, easements and landscape amenities including open space and buffers (which may be able to double as locations for LID Bioretention BMPs), and differences in elevation (which may provide hydraulic head).

Apply the following LID Principles to the layout of the PDP. Putting thought upfront about how best to organize the various elements of PDP site can help to significantly reduce the PDP's potential impact on the environment and reduce the number of Structural LID and/or Conventional Treatment BMPs that must be implemented. Analyze the preliminary PDP site layout concepts, and look for opportunities to accommodate the following LID Principles within the PDP site layout. Performing this analysis and optimizing the layout for LID will come in handy during the remaining steps.

3.2.1. Preserve Existing Drainage Patterns

Integrating existing drainage patterns into the site plan may facilitate maintaining the PDPs predevelopment hydrologic function. Preserving existing drainage paths and depressions will not only help maintain the time of concentration and infiltration rates of Runoff, decreasing peak flows, but may also help preserve the contribution of Bed Sediment Supply from the PDP to the Receiving Water. The best way to define existing drainage patterns may be to visit the site of the PDP during a rain event and to directly observe runoff flowing over the site. If this is not possible, drainage patterns may be inferred from topographic data, though it should be noted that depression micro-storage features are often not accurately mapped in topographic surveys. Analysis of the existing site drainage patterns during the site assessment phase of the PDP can help to identify the best locations for buildings, roadways, and Structural BMPs.

Minimize unnecessary site grading that eliminates small depressions, which may provide storage of small volumes of runoff. Where appropriate, add additional depression "micro" storage throughout the site's landscaping. This is referred to in Section 3.3 as 'self-retaining areas'. Mild gradients may be used to extend the time of concentration, which reduces peak flows and increases the potential for additional infiltration. While risk of serious flooding must be limited, the persistence of temporary "puddles" during storms may be beneficial to infiltration.

- Where possible, conform the PDP site layout along natural landforms, avoid excessive grading and disturbance of vegetation and soils, and preserve or replicate the site's natural drainage features and patterns.
- Set back PDP improvements from creeks, wetlands, and riparian habitats.

- Use both existing and proposed site drainage patterns as a natural design element, rather than using expensive impervious conveyance systems. Use depressed landscape areas, vegetated buffers, and bioretention areas as amenities and focal points within the site and landscape design.

3.2.2. Protect Existing Vegetation and Sensitive Areas

Identify any areas of the PDP containing dense native vegetation or well-established trees, and try to avoid disturbing these areas. Soils with thick, undisturbed vegetation have a much higher capacity to store and infiltrate Runoff than do disturbed soils. Reestablishment of a mature vegetative community may take decades. Sensitive areas, such as streams and floodplains should also be avoided.

- Define the development envelope and protected areas, identifying areas that are most suitable for development and areas that should be left undisturbed.
- Establish setbacks and buffer zones surrounding sensitive areas.
- Preserve significant trees and other natural vegetation where possible.

3.2.3. Preserve Natural Infiltration Capacity

A key component of LID is taking advantage of a site's natural infiltration and storage capacity. A site survey and geotechnical investigation can help define areas with high potential for infiltration and surface storage. Identify opportunities to locate LID Principles and Structural BMPs in highly pervious areas. Doing so will maximize infiltration and limit the amount of runoff generated. Concentrate development on portions of the site with less permeable soils, and preserve areas that can promote infiltration.

3.2.4. Minimize Impervious Area

As discussed in Chapter 2, creation of impervious cover can be tied to potential environmental impacts due to runoff. Look for opportunities to limit impervious cover through identification of the smallest possible land area that can be practically impacted or disturbed during site development.

- Limit overall coverage of paving and roofs. This can be accomplished by designing compact, taller structures, narrower and shorter streets and sidewalks, clustering buildings and sharing driveways, smaller parking lots (fewer stalls, smaller stalls, and more efficient lanes), and indoor or underground parking.

- Examine site layout and circulation patterns and identify areas where landscaping can be substituted for pavement, such as for overflow parking.

- Inventory planned impervious areas on your preliminary site plan. Identify where permeable pavements, such as crushed aggregate, turf block, permeable modular blocks, pervious concrete or pervious asphalt could be substituted for impervious concrete or asphalt paving. This will help reduce the amount of Runoff that may need to be addressed through Structural BMPs.

- Consider green roofs. Green roofs are roofing systems that provide a layer of soil/vegetative cover over a waterproofing membrane. A green roof mimics pre-development conditions by filtering, absorbing, and evapotranspiring precipitation to help manage the effects of an otherwise impervious rooftop. Green roofs with growing media four inches or deeper are considered 'self-retaining areas' as defined in Step 3, and do not produce increased Runoff or Runoff Pollutants (i.e., any Runoff from a green roof requires no further LID or Hydrologic Control BMPs).

3.2.5. Disperse Runoff to Adjacent Pervious Areas

Look for opportunities to direct Runoff from impervious areas to adjacent landscaping or other pervious areas. This is sometimes referred to as reducing Directly Connected Impervious Areas.

- Direct roof runoff into landscaped areas such as medians, parking islands, planter boxes, etc., and/or areas of pervious paving. Instead of having landscaped areas raised above the surrounding impervious areas, design them as depressed areas that can receive Runoff from adjacent impervious pavement. For example, a lawn or garden depressed 3"-4" below surrounding walkways or driveways provides a simple but quite functional landscape design element. This is referred to as 'areas draining to self-retaining areas' in Section 3.3.

- Detain and retain Runoff throughout the site. On flatter sites, smaller Structural BMPs may be interspersed in landscaped areas among the buildings and paving.

- On hillside sites, drainage from upper areas may be collected in conventional catch basins and piped to landscaped areas and LID BMPs and/or Hydrologic Control BMPs in lower areas. Low retaining walls may also be used to create terraces that can accommodate LID BMPs. Wherever possible, direct drainage from landscaped slopes offsite and not to impervious surfaces like parking lots.
- Reduce curb maintenance and provide for allowances for curb cuts.

3.3. Delineate Drainage Management Areas

The delineation of DMAs is key to successfully implementing your LID design. The procedure begins with:

1. Careful delineation of pervious areas and impervious areas (including roofs) throughout the site, and then;
2. Dividing the entire PDP site into individual, discrete DMAs.

Typically, lines delineating DMAs follow grade breaks and roof ridge lines. The exhibits, tables, text, and calculations in the Project-Specific WQMP will illustrate, describe, and account for runoff from each of the areas of the PDP.

Where possible, establish separate DMAs for each surface type (e.g., landscaping, pervious paving, or roofs). Assign each DMA a unique code and determine its size in *square feet*. The total area of your site should total the sum of all of your DMAs.

Next, determine how drainage from each DMA will be handled. Each DMA will be classified as one of the following four types:

A. Self-treating areas.

B. Self-retaining areas (also called "zero-discharge" areas).

C. Areas that drain to self-retaining areas.

D. Areas that drain to BMPs.

The first three types of DMAs: Self-Treating, Self-Retaining, and draining to Self-Retaining, are ways to account for successful implementation of the LID Principles discussed in Step 1. Areas addressed by LID Principles are self-managing and do not require any further management measures. Further, these areas will not require specialized Operation and Maintenance procedures, and can typically be maintained with normal landscape and site maintenance.

The fourth type of DMA is a way to document the specific areas within the site layout that require additional mitigation measures through LID BMPs.

As more LID Principles are implemented, more of the site will mimic natural processes and become self-managing, resulting in less area that must be managed through structural LID BMPs.

3.3.1. Type 'A': Self-Treating areas

Self-Treating Areas are those that meet the following criteria:

- Are either undisturbed from their natural condition, or restored with Native and/or California Friendly vegetative covers, AND
- Are irrigated, if at all, with appropriate low water use irrigation systems to prevent irrigation runoff.
- Runoff from the area will not comingle with runoff from the developed portion of the site, or across other landscaped areas that do not meet the above criteria.

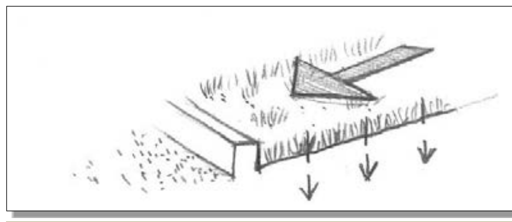


Figure 3-1: Self-Treating Areas

Examples include up-sloped undeveloped areas which are ditched and drained around a development, and landscaped areas (as described above) that drain offsite. Areas that do not meet the above criteria do not qualify as a Self-Treating Area. In general, Self-Treating Areas include no impervious areas, unless the impervious area is very small (e.g., 5% or less of the Self-Treating Area) and slopes are gentle enough to ensure Runoff from impervious areas will be absorbed into the vegetation and soil.

Table 3-1: Table for Documenting Self-Treating Areas (Type 'A' DMA)

DMA Name or ID	Area (Sq. Ft.)	Stabilization Type	Irrigation Type (if any)
A/1	*4,460*	*Undisturbed Natural*	*None*
A/2	*1,026*	*Native Low Water Use*	*Drip Irrigation*

Note: Example Data shown

3.3.2. Type 'B': Self-retaining Areas

Self-Retaining Areas are shallowly depressed 'micro infiltration' areas designed to retain the Design Storm rainfall that reaches the area, without producing any Runoff. The technique works best on flat, landscaped sites. It may be used on mild slopes if there is a reasonable expectation that design of the area will result in the Design Storm rainfall event producing no Runoff.

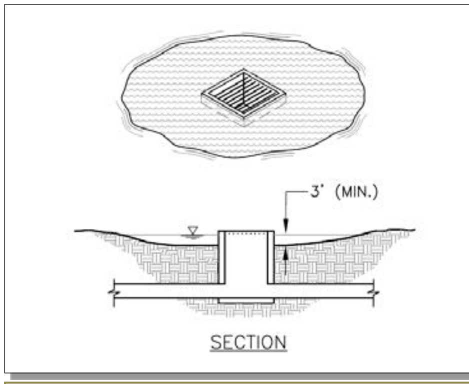


Figure 3-2 Self-Retaining Areas

To create Self-Retaining Areas in flat areas or on terraced slopes, either berm the area or depress the grade into a concave cross section so that there is a reasonable expectation that these areas will retain the Design Storm rainfall. Grade slopes, if any, toward the center of the pervious area.

Soils: Self-Retaining Areas are not recommended for soils that are not expected to be freely draining, so as not to create vector or nuisance conditions. Self-retaining areas within C or D soils must be constructed with appropriately amended soils to increase the shallow storage capacity of the soils such that surficial ponded water will not occur due to the design storm rainfall. All Self-Retaining Areas (regardless of soil type) should be protected during construction such that compaction is minimized or avoided entirely where possible. If compaction within a Self-Retaining area nevertheless occurs, the compacted surface must be re-tilled to a depth of at least six inches and amended as necessary to restore the infiltrative and storage capacity of the soil.

Inlet elevations of area/overflow drains, if any, should be clearly specified to be three inches or more above the low point to promote ponding. In setting elevations, account for mulch or other landscaping cover that could reduce available ponding depth. Construction documents must clearly specify the required elevation(s) of any overflow drain inlets.

Pervious pavements (e.g., crushed stone, porous asphalt, pervious concrete, or permeable pavers) can be self-retaining when constructed with a gravel base course four or more inches deep. This will ensure an adequate proportion of rainfall is infiltrated into native soils (including clay soils) rather than producing Runoff. Consult with a qualified (geotechnical) engineer regarding infiltration rates, pavement stability, and suitability for the intended traffic.

Drainage from green roofs is considered to be self-retained, however, an emergency overflow should be provided for extreme events. Drainage from green roofs should be routed to landscaping rather than being tied directly into MS4 facilities.

Table 3-2: Table for Documenting Self-Retaining Areas (Type 'B' DMAs)

Self-Retaining Area				**Type 'C' DMAs that are draining to the Self-Retaining Area**		
DMA Name/ ID	Post-project surface type	Area (square feet) [A]	Storm Depth (inches) [B]	DMA Name / ID	[C] from table 3-3 = [C]	Required Retention Depth (inches) [D]
B/1	*Planter*	*604*	*0.8*	*C/1, C/2*	*1100+80 =1180*	*2.4*
B/2	*Pervious patio*	*2,149*	*0.8*	*C/3*	*1946*	*1.5*
B/3	*Planter*	*1677*	*0.8*	*N/A*	*N/A*	*0.8*

Note: Example Data shown

$$[D] = [B] + \frac{[B] \cdot [C]}{[A]}$$

3.3.3. Type 'C': Areas Draining to Self-Retaining Areas

Runoff from impervious or partially pervious areas can be managed by routing it to Self-Retaining Areas consistent with the LID Principle discussed in Section 3.2.5 for 'Dispersing Runoff to Adjacent Pervious Areas'. For example, roof downspouts can be directed to lawns, and parking areas can be drained to landscaped areas.

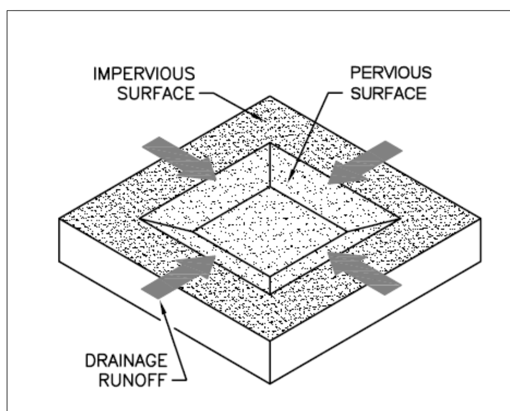


Figure 3-3: Areas draining to Self-Retaining Areas

For *impervious* areas such as pavements that drain to a nearby Self-Retaining Area, the maximum ratio, based upon past modeling efforts in California, is 2 parts impervious area for every 1 part pervious area.

For *partially* pervious areas draining to a Self-Retaining area the maximum ratio is:

$$\left(\frac{\mathbf{2}}{\boldsymbol{Impervious\ Fraction}}\right) : \mathbf{1}$$

(Tributary Area **:** Self-Retaining Area)

Special Case

If your self-retaining area is a **Permeable Pavement**, higher ratios than 2:1 can be used **IF** the pervious pavement is designed in accordance with the LID BMP Design Handbook or other standard approved by the Copermittee with jurisdiction over the project site. In this case, the area draining to the pavement will be considered a **Type D DMA** (area draining to a BMP).

Where the Impervious Fraction is obtained from Section 2.5.1.b).

The drainage from the tributary area must be directed to and dispersed within the Self-Retaining Area, and the area must be designed to retain the entire Design Storm runoff without flowing offsite. For example, if the ratio of 2 parts impervious area into 1 part pervious area is used, and the Design Storm is one inch, then the pervious area must absorb three inches of water over its surface before overflowing to an offsite drain (one inch of rainfall for the Self-Retaining Area itself, plus one inch for each of the 2 parts of tributary impervious area).

Prolonged ponding is a potential problem at higher impervious/pervious ratios. In your design, ensure that the pervious area soils can handle the additional run-on and are sufficiently well-drained, and/or amended as described in Section 3.3.2.

Table 3-3: Table for Documenting Areas Draining to Self-Retaining Areas (Type 'C' DMAs)

DMA					**Receiving Self-Retaining DMA**		
DMA Name/ ID	Area (square feet) [A]	Post-project surface type	Runoff factor [B]	Product [C] = [A] x [B]	DMA name /ID	Area (square feet) [D]	Ratio [C]/[D]
C/1	*1100*	*Roof*	*1*	*1100*			
C/2	*800*	*Pervious Walkway*	*0.1*	*80*			
				1180	*B/1*	*604*	*1.95 < 2*
C/3	*1946*	*Driveway*	*1*	*1946*	*B/2*	*2,149*	*0.91 < 2*

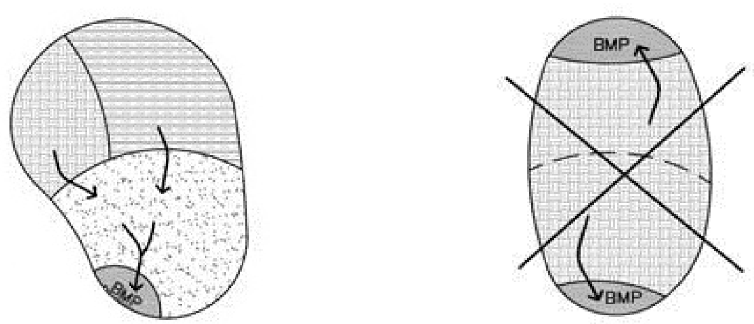
Note: Example Data shown

3.3.4. Type 'D': Areas Draining to BMPs

Areas draining to BMPs are those that could not be fully managed through LID Principles (DMA Types A through C) and will instead drain to a LID BMP and/or a Conventional Treatment BMP designed to manage water quality impacts from that area, and Hydromodification where necessary.

More than one DMA can drain to a single LID BMP, however, one DMA may not drain to more than one LID BMP. See Figures 3-4.

Where possible, design site drainage so only impervious roofs and pavement drain to LID BMPs. This yields a simpler, more efficient design, with minimized LID BMP requirements, and also helps protect LID BMPs from becoming clogged by sediment.



More than one DMA can drain to a single BMP.

One DMA cannot drain to multiple BMPs

Figure 3-4: Drainage from Multiple DMAs

Table 3-5, Example Format for Determining the Required DCV for BMPs, is discussed in Section 3.4.3.

3.4. IMPLEMENT LID BMPS

Type 'D' DMAs draining to BMPs, as defined in Section 2.3.4, must be addressed using LID BMPs according to the prioritization discussed in Section 2.3.2.

Special Note

The User may distinguish the four types of DMAs ('A', 'B', 'C', and 'D'), which identifies the type and magnitude of LID principles incorporated into the site drainage, from the Hydrologic Soil Group Types (A,B,C, and D), which designate the minimum rate of infiltration obtained for bare soil after prolonged wetting.

3.4.1. LID BMP Selection

3.4.1.a) LID Infiltration BMP Assessment

An assessment of the feasibility of utilizing LID Infiltration BMPs is required for all Development Projects, except *w*here it can be shown that Harvest and Use BMPs can and will be implemented to address the DCV (see the Harvest and Use assessment below).

A site-specific evaluation of the feasibility of LID Infiltration BMPs must at minimum incorporate consideration of the criteria identified in Section 2.3.4. If one or more of the infiltration criteria indicate that LID Infiltration BMPs are not feasible for the PDP site, the other remaining infiltration criteria do not need to be assessed.

3.4.1.b) LID Harvest and Use BMP Assessment

An assessment of the feasibility of implementing harvesting and use BMPs is required for all PDPs, *except:*

- Where reclaimed water will be used for the non-potable water demands for the PDP, or where downstream water rights may be impacted by Harvest and Use (see Harvest and Use discussion in Chapter 2).

- Where it can be shown that the LID design can reliably provide for infiltration or evapotranspiration of the DCV (see the infiltration assessment below). In such a case, Harvest and Use BMPs can still be implemented for the DCV if desired, but it would not be required if the DCV will be infiltrated or evapotranspired.

If neither of the above criteria applies, follow the steps below to assess the feasibility of:

- Irrigation use
- Toilet use
- Other non-potable uses (i.e., industrial use)

☞ NOTE: It is important to note that harvested water demand calculations differ in purpose and methods from water demand calculations done for water supply planning. When designing harvest and use systems for stormwater management, a reliable method of quickly regenerating storage capacity (i.e., using water) must exist to provide storage capacity for subsequent storms. Therefore, demand calculations for LID Harvest and Use BMPs should attempt to estimate the actual demand that is reliably present to drain stormwater cisterns during the wet season, additionally considering that during a short time frame (a week to a couple of weeks) a series of storms may occur. This objective is fundamentally different from the objectives of water demand forecasting calculations done for water supply planning, which may err toward higher estimates of demand to provide conservatism to account for uncertainty. Harvested water demand calculations used to determine the feasibility of LID Harvest and Use BMPs must be based on estimates of actual expected demand that are reliably present to drain the cistern/vault during the wet season.

To assess the feasibility of implementing Harvest and Use BMPs, complete the following steps:

1. Document the following potential demands for the site, as applicable:

   a. ***The total area of irrigated landscape.*** It will be necessary to determine the type of landscaping that will be implemented on the site. For the purposes of this assessment, landscaping will either be a 'Conservation Design' (low water use, native species, etc.), or 'Active Turf areas' (higher water use, ornamental species such as conventional sod). Determine the irrigated landscape area in acres.

   b. ***The expected number of toilet users.*** This should be based on the average number of daily toilet users (building occupants) during the Wet Season and should account for any periodic shut downs/lapses in occupancy (e.g., for vacations, maintenance, or other reasons). This requires close coordination with the project architect to accurately reflect the number of daily users.

c. ***Other non-potable water demands.*** Identify any other onsite non-potable demand (in gallons per day) that is anticipated on an *average daily basis* during the Wet Season. Sources of demand should only be included if they are reliably and consistently present during the Wet Season.

2. Identify the planned ***total of all impervious areas*** on the proposed Development Project from which Runoff might be feasibly captured and stored. Depending on the configuration of buildings and other impervious areas on the PDP site, you may consider the site as a whole, or parts of the site, to evaluate reasonable scenarios for capturing and storing Runoff and directing the stored Runoff from the potential use(s) identified in Step 1 above. Identify the total impervious area in acres.

3. Enter the Design Storm depth for the PDP site (see Exhibit A) into the left column of Tables 2-1 through 2-3 in Section 2.3.5 to determine, respectively: a) the minimum number of toilet users per tributary impervious acre, b) the minimum square footage of effective irrigated area per tributary impervious acre, and c) the minimum demand for other non-potable uses per tributary impervious acre.

4. Multiply the unit values obtained from Step 3 by the total of impervious areas from Step 2, to develop the minimum demand that would be required for the various forms of LID Harvest and Use BMPs to be feasible on the PDP. Then compare minimum demand values to the anticipated demands identified in Step 1.

☞ If any of the anticipated demands exceed the applicable minimum values, LID Harvest and Use BMPs are feasible for that demand type.

☞ If all of the anticipated demands are less than the applicable minimum values, LID Harvest and Use BMPs are not required, however, other LID Retention BMPs, such as infiltration must be assessed and where applicable used – before LID Biotreatment BMPs can be used.

3.4.1.c) LID BMP Selection Matrix

Once the above assessments for LID Infiltration and Harvest and Use BMPs have been completed, the following table can be used to determine the applicable LID BMPs for the PDP site. Refer to Table 3-4 below for determining LID BMPs that may be applicable to the PDP.

Table 3-4: LID BMP Selection Matrix

LID BMP Type	Are LID Retention BMPs Feasible?		
	Yes	**No**, but 'Other LID BMPs' are feasible, and	
		0.3"/hr. < K_{SAT} < 1.6"/hr.	K_{SAT} < 0.3"/hr.
Harvest and Use	✓(A)		
Infiltration	✓(B)		
Permeable Pavement	✓(C)		
Bioretention	✓(D)	✓(E)	✓
Biotreatment			✓

Notes for Table 4-5:

(A): LID Harvest and Use BMPs may be used where it can be shown that there is sufficient demand for harvested water. See Sections **LID Harvest and Use Feasibility Criteria** and **LID Harvest and Use BMP Assessment 3.4.1.b)**..

(B): LID Infiltration BMPs may be used in locations where the tested infiltration rate of underlying soils is at least 1.6 in. per hour and no restrictions on infiltration apply to these locations. See Sections **LID Infiltration Feasibility Criteria and LID Infiltration BMP Assessment 3.4.1.a)**.

(C) Permeable Pavement is a form of LID Infiltration BMP. However, when designed with a 2:1 ratio of impervious area to pervious pavement areas, or less, permeable pavement is considered a self-retaining area, and is not considered a LID BMP for the purposes of this table. This table focuses on the 'special case' included in the Section **3.3.3**, where a project proponent can choose to design the pervious pavement as a LID BMP in accordance with an approved design, such as the LID BMP Design Handbook, and perform any necessary infiltration testing; and in return drain additional impervious area onto the pervious pavement beyond the 2:1 ratio.

(D) As discussed in Section 2.3.3., in well drained soils, water captured in LID Bioretention BMPs can be fully retained via infiltration and evapotranspiration.

(E) In this range of infiltration rates, LID Bioretention BMPs will be more reliable than LID Infiltration BMPs, but will still infiltrate and evapotranspire captured runoff to the maximum extent feasible based on in-situ actual characteristics.

3.4.2. Laying out LID BMPs on the PDP site

Finding the right location for LID BMPs on the PDP site involves a careful and creative integration of several factors:

- To make the most efficient use of the site and to maximize aesthetic value, integrate LID BMPs with site landscaping. Many local zoning codes may require landscape setbacks or buffers, or may specify that a minimum portion of the site be landscaped. It may be possible to locate some or all LID BMPs within this same area, or within utility easements or other non-buildable areas.

- Use permeable pavements wherever possible. These pavement systems are not only aesthetically pleasing but they also minimize the amount of runoff that needs to be treated.

- LID Bioretention BMPs must be level or nearly level all the way around. When configured in a linear fashion (similar to swales) LID Bioretention BMPs may be gently sloped end to end, but opposite sides must be at the same elevation. BMPs on steeper slopes must be terraced or provided with check dams.

- For effective, low-maintenance operation, locate LID BMPs so drainage into and out of the device is by gravity flow. Many LID BMPs require three feet or more of hydraulic head.

- LID BMPs require excavations three or more feet deep, which can conflict with underground utilities.

- If the property is being subdivided now or in the future, the BMP should be in a common, accessible area. In particular, avoid locating LID BMPs on private residential lots. Even if the LID BMP will serve only one site owner or operator, make sure the BMP is located for ready access for inspection by the Copermittee with jurisdiction over the project site and the local mosquito and vector control agency. The goal is to ensure that LID BMPs are maintained and functional, to assure a properly functioning maintenance mechanism since the ability of individual homeowners to provide maintenance is variable, and to avoid residential property rights issues for inspections and verifications. While the specific maintenance mechanism will be provided on a project by project basis, many Copermittees are pursuing methods to allow residential LID BMPs to be maintained by a public entity. Maintenance via a public maintenance mechanism will require BMPs to be located in common areas and not in individual lots.

- The LID BMP must be accessible to equipment needed for its maintenance. Access requirements for maintenance will vary with the type of BMP selected. LID Bioretention BMPs will typically need access for the same types of equipment used for landscape maintenance.

Document site layout and site design decisions in the Project-Specific WQMP. This will provide background and context for how the design meets the quantitative LID

BMP design criteria. Once the LID BMPs have been laid out, calculate the square footage set aside on the site plan for each BMP.

3.4.3. Calculate Minimum LID BMP Sizes

LID BMPs must at minimum be sized to address the DCV. LID BMPs can be additionally sized and configured to meet Hydromodification Criteria described in Section 3.6, if applicable.

3.4.3.a) Design Capture Volume

Appendix F of the LID BMP Design Handbook contains worksheets that can be used for calculating the required DCV (aka V_{BMP}) for LID BMPs. The User may also compute V_{BMP} and Q_{BMP} using the LID BMP interface of SMRHM. Refer to the SMRHM Guidance Document (Appendix G of SMR HMP) for complementary information).

If neither the worksheet nor the LID BMP interface of SMRHM are used, your calculations should be in tables using the following format:

Table 3-5: Example Format for Determining the Required DCV for BMPs

DMA Type/ID	DMA Area (square feet)	Post-Project Surface Type	Effective Impervious Fraction, I_f	DMA Runoff Factor	DMA Areas x Runoff Factor	*Enter BMP Name / Identifier Here*		
	[A]		[B]	[C]	[A] x [C]	*Design Storm Depth (in)*	*Design Capture Volume, V_{BMP} (cubic feet)*	*Proposed Volume on Plans (cubic feet)*
	$A_T = \Sigma[A]$				Σ= [D]	[E]	$[F] = \frac{[D]x[E]}{12}$	[G]

[B], [C] are obtained as described in Section 2.5.1.b)
[E] is obtained from Exhibit A
[G] is obtained from a design procedure sheet, such as in LID BMP Design Handbook. Maintain a completed design procedure sheet for each LID BMP.

3.4.3.b) Hydromodification

The User should consider the full suite of Hydrologic Control BMPs to manage runoff from the post-development condition and meet the Hydrologic Performance Standard identified in Section 3.6. The User may consider the following in identifying the Hydrologic Control BMPs for incorporation in the design of the PDP:

- LID principles as defined in Section 3.2;
- Structural LID BMPs that may be modified or enlarged, if necessary, beyond the DCV;
- Structural Hydrologic Control BMPs are distinct from the LID BMPs. The LID BMP Design Handbook provides information not only on Hydrologic Control BMP design, but also on BMP design to meet the combined LID and Hydromodification requirements. The Handbook specifies the type of BMPs that can be used to meet the Hydrologic Performance Standard.

LID principles, structural LID BMPs, and structural Hydrologic Control BMPs can each be modeled in the SMRHM.

Refer to Section 3.6 to determine if the PDP is subject to the HMP Performance Standards, and Section 2.5.2 for acceptable methodologies to demonstrate compliance with the Hydrologic Performance Standard.

3.4.4. Specify Design Details

Preliminary design details sufficient to demonstrate that the area, volume, and other criteria of each can be met within the constraints of the PDP site are required in the preliminary Project-Specific WQMP.

The final Project-Specific WQMP and the construction and grading plans will need to include final design details consistent with your approved preliminary Project-Specific WQMP. These final details must demonstrate that the required DCV, potential HMP Performance Standards, and any other requirements specified by the Copermittee with jurisdiction over the project site, have been met. Ensure these details are consistent with preliminary site plans, landscaping plans, and architectural plans submitted with your application for planning and zoning approvals.

The User may elect to use SMRHM to select and design LID BMPs and Hydrologic Control BMPs, where required, selection and design of Hydrologic Control BMPs is an iterative process that can be facilitated using the SMRHM. The SMRHM has a comprehensive menu of site design LID BMPs and Hydrologic Control BMPs that can be selected for PDPs. The design standards for these Hydrologic Control BMPs have been pre-incorporated into SMRHM and can be modified to an extent based on site constraints. The User must verify that the design details of LID BMPs and Hydrologic Control BMPs defined in SMRHM are consistent with the BMP standards set forth in the LID BMP Design Handbook.

The LID BMP Design Handbook includes standard configurations, details and sizing calculator worksheets that are available for the LID BMPs referenced in this WQMP. Check with the Copermittee with jurisdiction over the project site to determine if this or alternative standards should be used for your PDP. The information in the LID BMP Design Handbook is designed to address the DCV and includes alternative designs and sizes for managing Hydromodification.

The planning, building, and public works officials of the Copermittee with jurisdiction over the project site have final review and approval authority over the project design.

3.4.5. Determine if BMP Area and Volume are Adequate

Sizing and configuring BMPs is typically an iterative process. After specifying the preliminary design details as described in Section 3.4.4, review the site plan to determine if the reserved BMP locations are sufficient for each of the LID BMPs.

If so, the planned BMPs will meet the WQMP sizing requirements for water quality.

If not, revise the plan accordingly. Revisions may include:

- Reducing the overall imperviousness of the PDP site. For example, consider incorporating additional permeable pavements to reduce the imperviousness of the site.
- Changing the grading and drainage to redirect some Runoff toward other BMPs which may have excess capacity.

- Making tributary landscaped DMAs self-treating or self-retaining (may require changes to grading).
- Expanding BMP surface area.
- Revision to the square footage of a BMP typically requires a corresponding revision to the square footage of the surrounding or adjacent DMA.
- The Hydromodification Performance Standards described in Section 3.6 are separate and additional standards that must be met by applicable PDPs. Even if the PDP has demonstrated compliance with the DCV standard, such Development Projects may need to implement additional and/or larger BMPs to meet the Hydromodification Performance Standards.

Section 3.5 describes alternative compliance measures that can be implemented if it has been demonstrated that it is technically infeasible to address all required Type 'D' DMAs with LID BMPs.

3.4.6. Unpaved Roads

If the PDP includes unpaved roads, ensure that appropriate erosion and sediment control BMPs are incorporated to manage runoff and erosion during the post-construction life of the unpaved roads. At a minimum, the BMPs must include the following or alternative BMPs that are equally effective:

- Practices to minimize road related erosion and sediment transport;
- Grading of unpaved roads to slope outward where consistent with road engineering safety standards;
- Installation of water bars as appropriate; and
- Unpaved roads and culvert designs that do not impact creek functions and where applicable, that maintain migratory fish passage.

3.5. Document any Alternative Compliance Measures (LID Waiver Program)

As discussed in Section 2.3.6, LID BMPs are expected to be feasible on virtually all PDPs. Where LID BMPs have been demonstrated to be infeasible, a LID waiver must be granted by the Copermittee with jurisdiction over the project site, and the minimum alternative compliance measures described in this section must be implemented for the remaining Type D DMAs not addressed with LID BMPs.

3.5.1. LID Waiver

If you believe specific conditions on your site preclude the use of LID, you must submit, in the Project-Specific WQMP, a detailed site-specific examination and demonstration that implementation of other LID BMPs (as discussed in Sections 2.3.2 and 2.3.6) is infeasible. A site-specific determinations must be approved by the Copermittee with jurisdiction over the PDP site. Some Copermittees may require that the determination be performed by a Professional Civil Engineer registered in the State of California

- If a site-specific infeasibility determination for Other LID BMPs will be submitted, it is highly recommended to discuss this with the Copermittee with jurisdiction over the project site early on, as such site-specific determinations are expected to be highly scrutinized and LID Waivers are only granted in truly extenuating circumstances.
- If a Copermittee grants a LID Waiver from implementation of LID BMPs for particular DMAs:
  - LID BMPs are required to be used for all other DMAs where LID is feasible.
  - Other Conventional Treatment Control BMPs approved by the Copermittee with jurisdiction over the project site must be implemented, and the pollutant loads expected to be discharged due to not implementing LID Retention BMPs must be fully managed, as described in Sections 3.5.2 through 3.5.5.

3.5.2. Identify Priority Pollutants of Concern

The first step to identifying adequate alternative compliance measures is to identify the specific pollutants generated by the PDP that are also impairing the downstream receiving waters, referred to as 'Priority Pollutants of Concern'. Follow the process identified in Section 2.2.4 to identify the Priority Pollutants of Concern for your project.

3.5.3. Required Pollutant Load Mitigation

All projects participating in the Alternative Compliance Program must fully manage the Pollutant loads for the Priority Pollutants of Concern that are expected to be discharged due to not implementing LID Retention BMPs. Table 3-6 below provides estimated Pollutant concentrations that may be associated with various land use types, and has been compiled based on a study performed by the Southern California Coastal Water Research Project (SCCWRP) in the Los Angeles area watersheds (SCCWRP, TR510), assessments performed by the County of Los Angeles, and the National Stormwater Quality Database. However, there is currently insufficient data to accurately model land use wash-off rates for all potential Priority Pollutants of Concern that may potentially be discharged from development land uses in Southern California. Accordingly, Total Suspended Solids (TSS) should be used as a surrogate for any Priority Pollutants of Concern that are not identified in Table 3-6.

Table 3-6: Potential Untreated Median Concentration of Stormwater Runoff from Various Land Use Categories

Constituent	Residential	Commercial	Industrial	Transportation	Open Space
Sediments					
TSS (mg/L)	100	18	74	50	134
Pathogens					
Fecal Coliform (mpn/100 mL)	55426	22291	39595	2500	25565
Nutrients					
NH3 (mg/L)	0.25	0.25	0.26	0.14	0.05
N02+NO3 (mg/L)	0.51	0.50	0.58	0.45	0.99
Phos., total (mg/L)	0.32	0.28	0.30	0.32	0.05
Metals					
Cadmium, total (µg/L)	Non-detect	0.50	Non-detect	0.50	Non-detect
Chromium, total (µg/L)	Non-detect	2.5	2.5	2.5	Non-detect
Copper, total (µg/L)	18	17	33	39	8.0
Iron, total (µg/L)	546	587	600	512	233
Lead, total (µg/L)	8.0	4.0	19	2.5	1.0
Manganese, total (µg/L)	Non-detect	Non-detect	Non-detect	Non-detect	50
Zinc, total (µg/L)	103	156	550	218	23

Notes: TSS, fecal coliform, copper, lead, zinc data from Stein et al (2007), except for Transportation category data. Other data from County of L.A. monitoring data (http://dpw.lacounty.gov/wmd/NPDES/IntTC.cfm), except for Transportation fecal coliform which is from the National Stormwater Quality Database (Pitt and Maestre, 2005).

As discussed in Section 2.3.3, LID Retention BMPs sized to capture the runoff from the 85th percentile 24-hour storm, retain, on average, 80% of the long term runoff volume.

Therefore, to provide equivalent Pollutant load reduction as LID Retention BMPs, management measures must reduce 80% of the Pollutant loads identified in Table 3-6 above for TSS (at minimum), and additionally any other Pollutant that is identified as a Priority Pollutant of Concern for which data is available.

3.5.4. Stormwater Credits

Certain types of development practices may provide broad scale environmental benefits to communities, which will reduce overall Pollutant loadings into Receiving Waters. For example, a PDP that will redevelop a brownfield site could reduce discharges of legacy Pollutants into Receiving Waters and/or groundwater. Section 101 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601) defines "brownfield site" as real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Alternatively, a transit-oriented development would reduce car trips, which also reduces Pollutant loadings.

3.5.4.a) Applying Water Quality Credits

The following water quality credits have been established for particular smart growth project categories. To determine the amount of credit a project would qualify for, the first step is to calculate the Pollutant loads that would need to be managed as described in Section 3.5.3. Any credits shown in Table 3-7 below would then be taken as a reduction to this required mitigation.

Table 3-7: Water Quality Credits for Applicable PDP Categories

PDP Category	Water Quality Credit
Redevelopment Projects that reduce the overall impervious footprint of the existing project site	*Percentage of site imperviousness reduced*
Historic district, historic preservation area, or similar areas	*10%*
Brownfield redevelopment	*25%*
Higher density development, 7 units/acre or more	*5%*
Higher density development, vertical density	*20%*
Mixed use development, transit oriented development or live-work development	*20%*
In-fill development	*10%*
[1] *Maximum total of water quality credits for a project is 50%*	

If more than one category applies to a particular PDP, the credit percentages would be additive. Applicable performance criteria depend on the number of LID water quality credits claimed by the proposed PDP. Water quality credits can be additive up to a 50% reduction (50% reduction maximum) from a proposed PDP's obligation for sizing Conventional Treatment Control BMPs, contributing to an urban runoff/mitigation fund, or offsite mitigation projects. The volume credit would be calculated as the DCV of the proposed condition multiplied by the sum of the percentages claimed above.

3.5.5. Conventional Treatment Control BMPs

Conventional Treatment Control BMPs are typically proprietary devices that provide treatment mechanisms for Pollutants in runoff, but do not reduce the volume of runoff.

3.5.5.a) Selection and Sizing of Conventional Treatment Control BMPs

Conventional Treatment Control BMPs must be implemented and sized to meet the following criteria:

- At minimum, all Conventional Treatment Control BMPs must be sized to address the DCV or the Design Flow Rate, as applicable to the BMP type, as described in Section 2.5.1. Document minimum size of the Conventional Treatment Control BMPs in the Project-Specific WQMP using the table below.

Table 3-8: Example Format for Conventional Treatment Control BMPs

DMA Type/ID	DMA Area (square feet)	Post-Project Surface Type	Effective Impervious Fraction, I_f	DMA Runoff Factor	DMA Areas x Runoff Factor	*Enter BMP Name / Identifier Here*		
	[A]		[B]	[C]	[A] x [C]			
						Design Storm Depth (in)	*DCV or Design Flow Rate (cubic feet or cfs)*	*Minimum DCV, adjusted for any Water Quality Credits (cubic feet or cfs)*
	$A_T = \Sigma[A]$				$\Sigma = [D]$	[E]	$[F] = \frac{[D]x[E]}{[G]}$	[H]

[B], [C] are obtained as described in Section 2.5.1.b)
[E] is obtained from Exhibit A
[G] for Flow-Based Treatment BMPs [G] = 43,560, for Volume-Based Treatment BMPs, [G] = 12.
[H] = [F], reduced by the project's total water quality credit percentage.

- Additionally, the onsite or offsite BMPs must fully manage the required pollutant loads as calculated from Sections 3.5.3 and 3.5.4. Meeting this standard may require additional or larger Conventional Treatment Control BMPs to be incorporated into the design, or the construction of / participation in an offsite mitigation project, if available.

- Pollutant load removal efficiencies of any selected Conventional Treatment Control BMP must be substantiated by independent third-party 'in-situ' testing of the specific Conventional Treatment Control BMPs being considered, such as provided on the references included in the BMP Performance Report Library, located at:

  http://rcflood.org/NPDES/BMPPerformance.aspx

Document that all Type D DMAs that have not been addressed using LID BMPs have been fully managed with Conventional Treatment Control BMPs and any additional onsite or offsite mitigation in the Project-Specific WQMP as described above.

3.6. Address Hydromodification

Section 3.6 identifies the critical questions and steps that the User must fulfill to meet the HMP requirements, defined as HMP Performance Standards in the SMR HMP. The SMR HMP serves as the supporting document to the outlined methodology; the User may refer to the SMR HMP for complementary information to that described in this section. The major steps to be fulfilled include:

- Identify if the project is subject to the HMP Performance Standards;
- Understand the HMP Performance Standards;
- Incorporate Hydrologic Control BMPs and Sediment Supply BMPs, where required

3.6.1. Projects Subject to HMP Performance Standards

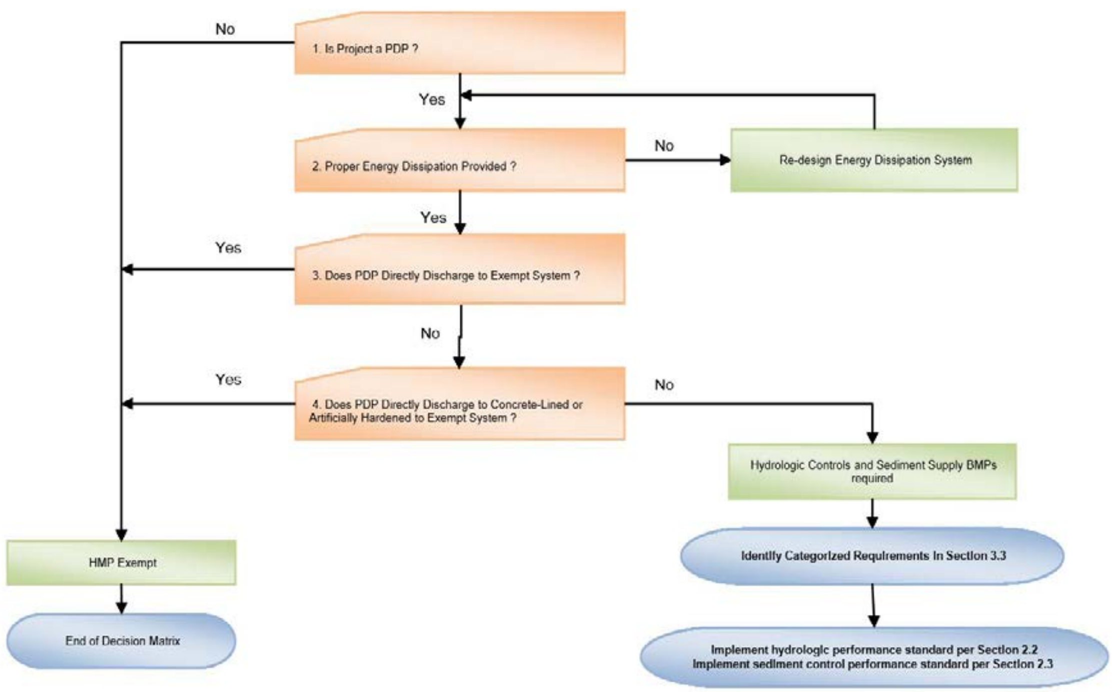
If the User determines that a Project-Specific WQMP based on the conditions described in Section 1.1, the User may use the Decision Matrix (Figure 3-5) to determine if the PDP is subject to HMP Performance Standards. Non-Priority Projects, as identified in Section 1.1, are exempt from HMP requirements. Other exemptions may be granted under each of the following conditions:

- If the project is not classified as PDP per Section 1.1;
- If the PDP discharges runoff directly to an exempt river reach, or an exempt reservoir (Vail Lake, Skinner Lake). Or if the PDP discharges to a concrete-lined or artificially hardened channel that exetends to an exempt river reach or reservoir, as defined in Section 3.2.i of the SMR HMP;
- If the PDP discharges to a large river large river as defined in Section 3.2.ii of the SMR HMP.

It should be noted that all PDPs are subject to the 2010 SMR MS4 Permit's LID and water quality treatment requirements even if Hydrologic Control BMPs and Sediment Supply BMPs are not required.

In addition, the User should note that properly designed energy dissipation systems are required for all project outfalls to unlined channels (See Section 3.6.6). The User should refer to the HMP Decision Matrix in Figure 3-6 to identify if the project is subject to the requirements of the HMP.

Figure 3-5: HMP Decision Matrix



3.6.2. HMP Performance Standards

PDPs that are subject to HMP requirements must demonstrate compliance with the HMP Performance Standards, consisting of the Hydrologic Performance Standard and the Sediment Supply Performance Standard.

The Hydrologic Performance Standard consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event). The Sediment Supply Performance Standard consists of maintaining the pre-project Bed Sediment supply to the channel receiving runoff from the project site (Receiving Channel).

HMP Performance Standards are also applicable to those PDPs that are unable to implement flow duration controls onsite or via a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries, but seek compliance through offsite Hydrologic Control BMP projects. The offsite Hydrologic Control BMP project must be capable of matching or reducing the equivalent flow duration curves from the PDP.

In addition, the HMP offers an alternate Hydrologic Performance Standard to those PDPs that are unable to implement flow duration matching onsite and offsite, only if the infeasibility is demonstrated and documented to the Copermittee with jurisdiction over the project site. The alternative Hydrologic Performance Standard consists of implementing projects to restore or rehabilitate channels with historic Hydromodification that are tributary to documented low or very low Index of Biotic Integrity scores. The performance equivalency of a restoration project must be demonstrated to the Copermittee.

To obtain approval from the Copermittee with jurisdiction over the project site, PDPs must either meet both the Hydrologic Performance Standard and the Sediment Supply Performance Standard OR qualify for the alternate performance standard.

3.6.3. Hydrologic Performance Standard Compliance *F.1.h.(1)*

The User must design and implement onsite Hydrologic Control BMPs to meet the Hydrologic Performance Standard. Hydrologic Control BMPs must be sized to mitigate flow rates and durations from the post-development condition to the Permit standards. As identified in Section 2.5.2, the User is required to use the SMRHM tool, which is an HSPF model overlaid with an interactive and user-friendly interface, to demonstrate compliance with the Hydrologic Performance Standard. A manual to this tool, the SMRHM Guidance Document (Appendix G of the SMR HMP), describes the specifics and functionality of the SMRHM and is available to all Users at no cost.

The User should consider the full suite of Hydrologic Control BMPs to manage runoff from the post-development condition and meet the Hydrologic Performance Standard identified in this section. The intent of this WQMP is not to specify the types of Hydrologic Control BMPs that can be used but rather identify the criteria that must be met, allowing flexibility for PDPs to use the full suite of BMPs to meet the Hydrologic Performance Standard. The User may consider the following in identifying the Hydrologic Control BMPs for incorporation in the design of the PDP:

- LID principles as defined in Section 3.2;

- Structural LID BMPs that may be modified or enlarged, if necessary, beyond the DCV;

- Structural Hydrologic Control BMPs are distinct from the LID BMPs. The LID BMP Design Handbook provides information not only on Hydrologic Control BMP design, but also on BMP design to meet the combined LID requirement and Hydrologic Performance Standard. The Handbook specifies the type of BMPs that can be used to meet the Hydrologic Performance Standard.

LID principles, structural LID BMPs, and structural Hydrologic Control BMPs can be modeled in the SMRHM. SMRHM can be employed by the User not only to meet the Hydrologic Performance Standard, but also to meet the LID requirements. SMRHM incorporates additional BMPs that may be investigated by the User. For example, buffer zones for those PDPs adjacent to channels can be modeled and sized the meet the Hydrologic Performance Standard.

3.6.3.a) HMP Waiver Program F.1.h.(3)

For some PDPs, the implementation of onsite Hydrologic Control BMPs may not be feasible due to site constraints. A technical feasibility study is required to provide technical justification as to why onsite Hydrologic Control BMPs cannot be incorporated into the PDP. The technical feasibility study will be submitted to the Copermittee with jurisdiction over the project site for review as part of the Preliminary Project-Specific WQMP. The feasibility analysis for both Hydrologic Control BMPs and LID BMPs will be integrated into one technical feasibility study for the PDP and submitted with the Preliminary Project-Specific WQMP.

The technical feasibility study should:

- Provide a narrative regarding the applicability of LID principles onsite as described in Section 3.2;

- Evaluate the feasibility of infiltration to capture partially or in its entirety the DCV based on the presence of either low infiltrating soils or high groundwater level, proximity to a water well or a contaminated plume, or a geotechnical report precluding effective and safe infiltration, consistent with the conditions set forth in Section 2.2.3;

- Evaluate the feasibility of harvest-and-use BMPs based on local water demands, consistent with the conditions set forth in Section 2.2.4;

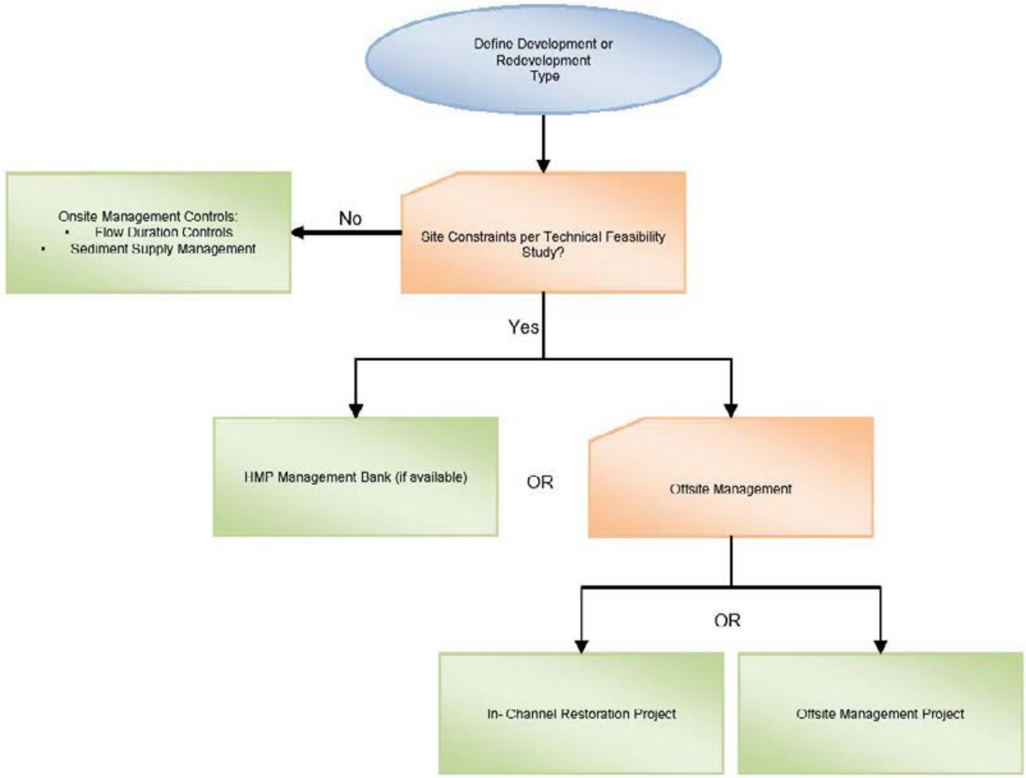
- Evaluate the feasibility of implementing detention or retention BMPs onsite based on critical geotechnical considerations such as collapsible soil, expansive soil, slopes, liquefaction and other factors identified by a registered Geotechnical Engineer that may prohibit the detention of large volumes of runoff. The feasibility to implement Hydrologic Control BMPs and meet the Hydrologic Performance Standard onsite may be principally dictated by the geotechnical considerations.

There are two alternative compliance options for PDPs that cannot implement onsite Hydromodification Control BMPs. The User may identify and construct off-site Hydrologic Control BMPs within the same channel system as the PDP; or implement an in-channel restoration project for the Receiving Channel.

The SMR HMP includes the additional option of participating into a HMP Management Bank that will develop regional HMP BMP projects where PDPs can buy HMP management credits. The User may only pursue this option if an HMP Management Bank is available to the PDP. The User should consult with the Copermittee with jurisdiction over the project site to determine an HMP Management Bank is available.

The decision matrix that Users should follow to meet the Hydrologic Performance Standard is presented in Figure 3-7.

Figure 3-6: Hydrologic Performance Standard – Decision Matrix



3.6.3.b) *Off-Site Mitigation*

For those PDPs where the technical feasibility study demonstrating the infeasibility of onsite Hydrologic Control BMPs has been approved by the Copermittee with jurisdiction over the project site, Users have the option to either (a) implement an offsite Hydrologic Control BMP project within the Receiving Channel, or (b) implement an in-channel restoration project for the Receiving Channel. The process for these two options is detailed hereafter.

Option a(1) - Implement offsite Hydrologic Control BMP projects within the Receiving Channel

In choosing this option, the PDP must investigate potential locations for implementation of an offsite Hydrologic Control BMP project within the Receiving Channel. If the User demonstrates that an offsite Hydrologic Control BMP project is not feasible in the Receiving Channel, then an offsite Hydrologic Control project in the same Hydrologic Unit as the PDP may be approved. The offsite Hydrologic Control BMP project must manage the incremental impact from not achieving the pre-development (naturally occurring) runoff flow rates and durations for the project site. Sizing of offsite Hydrologic Control BMP projects may be accomplished using the SMRHM. The User will evaluate and identify potential sites in the Receiving Channel, and if not feasible, then evaluate projects in the same Hydrologic Unit for implementation of an offsite Hydrologic

Control BMP project that has the supplemental capacity to manage the PDPs Hydrologic Performance Standard. If an adequate site is identified in the Receiving Channel, the User will submit a report detailing:

- That the offsite Hydrologic Control BMP project manages the incremental impact from the pre-development (naturally occurring) runoff flow rates and durations for the project site;
- Conceptual plans for the offsite Hydrologic Control BMP project as part of an amended Project-Specific WQMP for review and approval;
- If the PDP is a redevelopment project, that the post-project runoff flow rates and durations do not exceed pre-project runoff flow rates and durations; and
- If no potential offsite Hydrologic Control BMP project sites are identified in the Receiving Channel, that there is an offsite Hydrologic Control BMP project in the same Hydrologic Unit.

If no potential offsite Hydrologic Control BMP project sites are identified in the same Hydrologic Unit as the PDP, the PDP must implement Option a(2), a restoration or rehabilitation project in the Receiving Channel with historic Hydromodification.

Option a(2) – Implement In-Channel Restoration or Rehabilitation of the Receiving Channel

In choosing this option, the PDP investigates the potential for implementation of an in-channel restoration or rehabilitation project for the Receiving Channel. It must be determined that the Receiving Channel has experienced historic Hydromodification. The in-channel restoration or rehabilitation project must be located in the Receiving Channel. The PDP must submit a report detailing the historic Hydromodification, as well as conceptual plans for the in-channel restoration or rehabilitation project to the Copermittee with jurisdiction over the project site for review. The Copermittee is responsible for verifying that the level of restoration or rehabilitation is adequate given the potential Hydromodification impacts of the PDP. Copermittees maintain individual processes consistent with their approval procedures to ensure that the User's obligations under the HMP alternative compliance process are completed prior to approval of the PDP.

Once the project conceptual plans have been approved by the Copermittee with jurisdiction over the project site, it is the responsibility of the User to obtain required permits from the appropriate regulatory agencies (e.g., SDRWQCB, California Department of Fish and Wildlife, USACE). If the PDP identifies no opportunities for in-channel restoration or rehabilitation in the Receiving Channel, then the PDP must implement Option a(1), an offsite Hydrologic Control BMP project within the same Hydrologic Unit as the PDP.

3.6.4. Meet the Sediment Supply Performance Standard

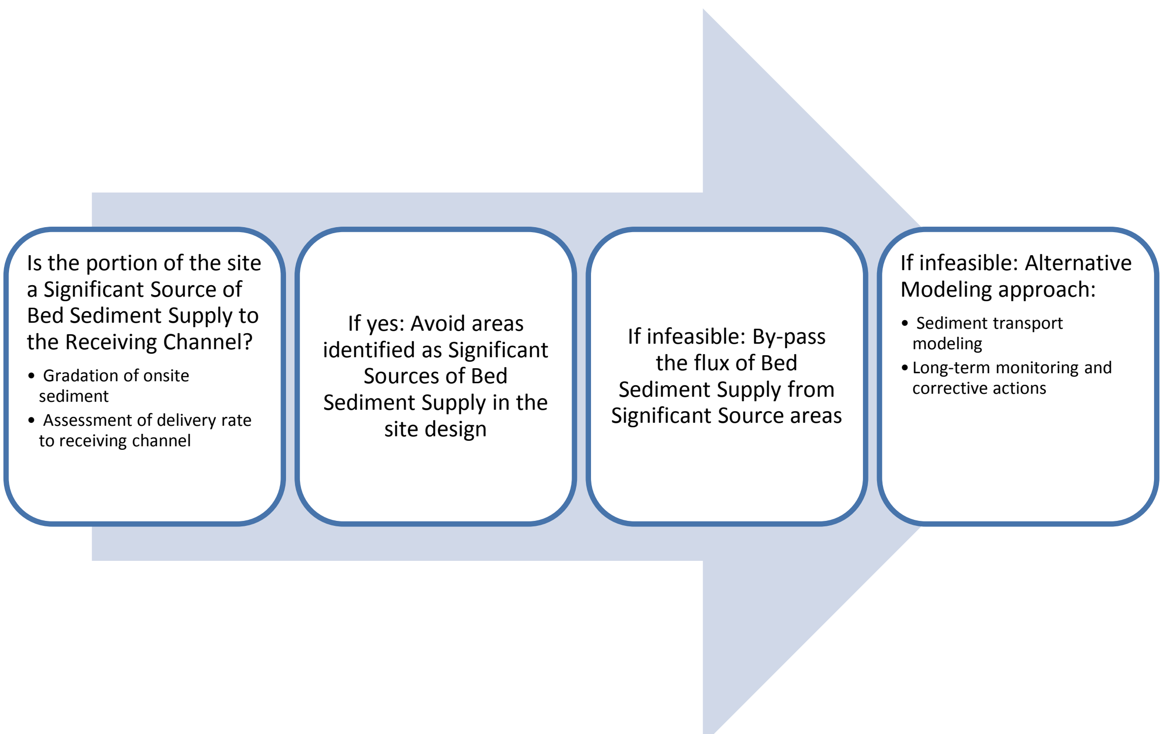
Bed Sediment Supply to a Receiving Channel during construction may increase as land surface is cleared and the potential for erosion is increased. Once the land surface is urbanized, the potential for Bed Sediment Supply may be reduced as compared to the pre-development condition. The purpose of the Sediment Supply Performance Standard is to maintain the pre-development supply of Bed Sediment to the Receiving Channel following urban development.

The User must perform a stepwise assessment to ensure the maintenance of the pre-project Bed Sediment Supply:

- Determine whether the site or a portion of the site is a Significant Source of Bed Sediment Load to the Receiving Channel;
- Avoid areas identified as Significant Sources of Bed Sediment Supply in the PDP design;
- Site specific alternative compliance measures.

The stepwise assessment that Users should follow to meet the Sediment Supply Performance Standard is conceptualized in Figure 3-7.

Figure 3-7: Sediment Supply Performance Standard - Stepwise Approach



The User must determine the location of the downstream alluvial Receiving Channel that may be impacted by the PDP. The first downstream conveyance that is unlined (invert, side slopes or both) will serve as the Receiving" Channel for the PDP. The stepwise assessment will be used to ensure that the PDP does not adversely impact the delivery of Bed Sediment Supply to the Receiving Channel. The User may refer to Section 2.3.i of the SMR HMP for additional information on the stepwise assessment.

The analyses from the stepwise assessment must be documented and submitted to the Copermittee with jurisdiction over the project site along with the Preliminary Project-Specific WQMP for approval.

STEP 1:

A triad approach must be completed to determine whether the site is a Significant Source of Bed Sediment Supply to the Receiving Channel and include the following components:

A. Site soil assessment, including an analysis and comparison of Bed Sediment in the Receiving Channel and the onsite channel, if any;
B. Determination of the capability of the channels, if any, on the project site to deliver the site Bed Sediment (if present) to the receiving channel;
C. Present and potential future condition of the Receiving Channel.

STEP 2:
If the analysis in Step 1 indicates that some or all of the channels on the project site must be preserved as a source of Bed Sediment Supply to the Receiving Channel, the site plan must be developed to avoid impacting the identified channels. The User will designate channels on the project site that should be avoided to preserve the discharge of Bed Sediment Supply from the site.

STEP 3:
If it is infeasible to avoid channels on the project site that are Significant Sources of Bed Sediment Supply in the design of the site plan, the drainage(s) may be by-passed to maintain the Bed Sediment Supply to the Receiving Channel. The Engineer will need to prepare specific designs to achieve this objective.

ALTERNATIVE STEP:
The alternative compliance program can only be pursued if the replacement of Bed Sediment Supply to the Receiving Channel is deemed infeasible by the Copermittee with jurisdiction over the project site, or if the project site design requires significant alteration of onsite channels. The infeasibility of the different Sediment Supply BMPs stated in the general approach can only be demonstrated and documented by the User in the preliminary Project-Specific WQMP for approval. The User must also demonstrate the expected feasibility of the alternative compliance methodology.

The alternative compliance option allows the User to model numerically the site conditions and the Receiving Channel and provide additional mitigation in site runoff to compensate for the estimated reduction (or addition) of Bed Sediment Load in the Receiving Channel. The alternative compliance option will generally trigger the necessity to implement a long-term monitoring program, with potential corrective measures to be identified and implemented as needed in response to findings from the monitoring program. The User may refer to Section 2.3.ii of the SMR HMP for additional guidelines on the alternative compliance approach.

Fulfilling the objectives of the stepwise assessment constitutes compliance with the Sediment Supply Performance Standard.

3.6.5. Specific Requirements for PDPs Smaller Than One Acre and Copermittee Roadway Projects *Permit Reference?*

PDPs that are smaller than one acre and Copermittee Roadway Projects are typically completed within a limited right-of-way, making it unlikely for the User to implement onsite Hydrologic Control BMPs. Those projects are allowed to submit, if necessary, a simplified Technical Feasibility Study to the Copermittee having jurisdiction over the PDP. The simplified Technical Feasibility Study must be developed to explain why the HMP Performance Standards cannot be met onsite and must include:

- The soil conditions of the PDP site;
- A demonstration of the lack of available space for onsite controls; and
- An explanation of prohibitive costs to implement onsite controls.
- A written opinion from a California Registered Geotechnical Engineer, who will identify the infeasibility due to geotechnical concerns.

Once the simplified technical feasibility study is accepted by the jurisdiction of the PDP, the User may pursue either an off-site mitigation project or an in-stream restoration project as detailed in Section 3.6.3.a) and Section 3.6.3.b). The off-site mitigation project or in-stream restoration project must meet the HMP Performance Standards.

3.7. Specify Source Control BMPs

Some everyday activities–such as trash recycling/disposal and washing vehicles and equipment–may generate Pollutants that tend to find their way into the MS4. These Pollutants can be minimized by applying Source Control BMPs.

Source Control BMPs include Permanent, structural features (Source Control BMPs) that may be required in your Development Project plans—such as roofs over and berms around trash and recycling areas—and Operational BMPs, such as regular sweeping and "housekeeping", that must be implemented by the site's occupant or user. The MEP standard typically requires both types of BMPs. In general, Operational Source Control BMPs cannot be substituted for a feasible and effective Source Control BMP.

Use the following procedure to specify Source Control BMPs for the PDP site:

1. Identify Pollutant Sources. Review the PDP site plan to identify potential Pollutant sources such as, but not limited to:

   - Storm Drain Inlets
   - Floor Drains

- Sump Pumps
- Pets Control/Herbicide Application
- Pools, Spas, Fountains and other water features
- Food Service Areas
- Trash Storage Areas
- Industrial Processes
- Outdoor storage areas
- Vehicle and Equipment Cleaning and Maintenance/Repair Areas
- Fueling areas
- Loading Docks
- Fire Sprinkler Test/Maintenance water
- Plazas, Sidewalks and Parking Lots

2. Identify in the Project-Specific WQMP the permanent Source Control BMPs, as applicable, for each identified source.

3. Using Table 3-9 as a model, identify in the Project-Specific WQMP the Operational Source Control BMPs, for each source, which should be implemented as long as the anticipated activities continue at the site. Copermittee Stormwater Ordinances require that applicable Source Control BMPs be implemented; the same BMPs may also be required as a condition of a use permit or other revocable Discretionary Approval for use of the site.

Table 3-9: Format for Table of Structural and Operational Source Control BMPs

Potential source of Runoff Pollutants	*Structural Source Control BMPs*	*Operational Source Control BMPs*

3.8. Coordinate your Project-Specific WQMP Design with Other Site Plans

Follow the guidance in Section 4.0 to verify that the Project-Specific WQMP, including all LID Principles, LID BMPs, Alternative Compliance measures, Hydrologic Control BMPs, and Source Control BMPs are properly identified on and coordinated with all other site plans, such as Architectural Plans, Improvement Plans, Construction Plans, and Landscaping Plans.

3.9. Develop an Operation and Maintenance Plan

All Structural Control BMPs must be maintained and functional throughout the life of the project to ensure their ongoing effectiveness for protecting runoff quality and quantity. As required by the 2010 SMR MS4 Permit, the Copermittee with jurisdiction over the project site will periodically verify that Structural Control BMPs on your site are maintained and continue to operate as designed.

To make this possible, the Copermittee with jurisdiction over the project site will also require preparation and submittal of a Project-Specific WQMP Operation and Maintenance Plan.

Details of these requirements, and instructions for preparing a Project-Specific WQMP Operation and Maintenance Plan are provided in Section 5.0.

Chapter
4

4.0 COORDINATION WITH OTHER SITE PLANS

Guidance for coordinating the Project-Specific WQMP with other site plans, including Architectural Plans, Grading Plans, Construction SWPPPs, and Landscaping Plans.

The Project-Specific WQMP must contain enough detail to demonstrate the planned LID Principles, LID BMPs, Alternative Compliance measures, Hydrologic Control BMPs, and Source Control BMPs are feasible and are coordinated with the project construction plan, architectural renderings, grading plan, landscape design, and other information submitted with your application for development approvals.

4.1. Prepare a Project-Specific WQMP Site Plan

To help ensure that the PDP design has fully met the WQMP requirements and is coordinated with your other project plans, Users are required to prepare and submit a Project-Specific WQMP Site Plan with the Project-Specific WQMP. At a minimum, the Project-Specific WQMP Site Plan should include the following:

- Vicinity and location maps
- Drainage Management Areas
- Proposed Structural BMPs
- Drainage paths
- Drainage infrastructure, inlets, overflows
- Source Control BMPs
- Buildings, roof lines, downspouts
- Impervious surfaces
- Standard labeling

Use discretion on whether or not you may need to show additional information and/or to create multiple sheets to appropriately accommodate these features. Keep in mind that the Copermittee plan reviewer must be able to easily analyze your Project-Specific WQMP and Site plan, and compare those to your other plans and maps as described below.

4.2. Coordination with Architectural Plans

If the User is required by the Copermittee(s) having jurisdiction over the project site to submit information and presentations to design review committees, planning commissions, and other decision-making bodies, the User may be required to incorporate relevant aspects of the BMP design. In particular:

- The visual impact of Structural BMPs adjacent to building foundations and any terracing or retaining walls required for the BMP design should be shown in renderings and other architectural drawings.
- Renderings and representation of street views should incorporate Structural Control BMPs located in street-side buffers and setbacks.
- Potential conflicts with local development standards should be identified and resolved.
- Verify that the selected BMPs do not create conflicts with pedestrian access between parking and building entrances.
- Verify that potential conflicts with local development standards have been identified and resolved.

4.3. Coordination with Improvement Plans

Details of how the project BMPs are constructed can be critical to proper operation. A misplaced inlet, an overflow at the wrong elevation, or the wrong soil mix used in an LID BMP may delay project approvals and incur additional expenses.

Additional details identified in this section must be shown on plans submitted with applications for building and grading permits. During construction and at completion, Copermittee inspectors will verify the installation of BMPs against the approved plans.

LID principles and LID BMPs have been routinely incorporated into PDPs for only a few years. Land development professionals and Copermittee staff continue to compile and analyze "lessons learned" from their experiences. The following guidance is based on those lessons.

4.3.1. What to Show on Improvement Plans

With few exceptions, the plan set should include separate sheets specifically incorporating the BMPs described in the Project-Specific WQMP. The information on these sheets should be carefully coordinated and made consistent with grading plans, utility plans, landscaping plans, and (in many cases) architectural plans. Consider including the grading plan (screened) as background for the BMP sheets. It may also be appropriate to show portions of the roofing plan wherever roof ridges define DMAs. Additionally, utilizing different colors with associated legends will help the Copermittee reviewers differentiate the details shown on the construction plans with respect to grading and runoff management.

In particular, verify that relevant aspects of the BMP design are properly incorporated into your construction documents, including:

4.3.1.a) BMP Reference Table

The Copermittee plan checker will compare the Building and Grading plans with the Project-Specific WQMP. To facilitate the plan checker's comparison and speed review of your project, a WQMP Checklist should be prepared for your PDP.

Table 4-1: Format for BMP Reference Table

Project-Specific WQMP Page #	*BMP Identifier and Description*	*See Plan Sheet #s*

Here's how:

1) Create a table similar to Table 4-1. Number and list each measure or BMP specified in the Project-Specific WQMP in Columns 1 and 2 of the table. Leave Column 3 blank. <u>Incorporate the table into the Project-Specific WQMP.</u>

2) When you submit construction plans, duplicate the table (by photocopy or electronically). Now fill in Column 3, identifying the plan sheets where the BMPs are shown. List all plan sheets on which the BMP appears. Submit the updated table with your construction plans so that the plan checker can quickly locate the Structural Control BMPs that were committed to in the Project-Specific WQMP.

Note that the updated table—or Construction Plan WQMP Checklist—is only a reference tool to facilitate comparison of the construction plans to the Project-Specific WQMP. The Copermittee plan checker can advise regarding the process required to propose changes, if any, to the approved Project-Specific WQMP.

4.3.1.b) Grading is Key

Copermittee plan checkers typically require grading plans to show each BMP in addition to the delineation of DMAs. Elevations, including the following, should be called out:

- Curbs, inlets, grade breaks and other features of the drainage design consistent with the delineation of the DMAs.
- Top of paving at curb cut inlets, top of curb and top of the bioretention soil layer.
- Grate elevation at overflow grates and the adjacent top of soil elevation.
- Piped inlets.

Show how DMAs follow grade breaks, consistent with the grading plan and the Project-Specific WQMP.

4.3.1.c) Show How Runoff Moves

As needed for clarity, show the direction of Runoff flow across roofs and pavement and into BMPs. For runoff conveyed via pipes or channels, show locations, slopes, and elevations at the beginning and end of each run.

For roof drainage, show the routing of roof downspouts, use drawings or notes to make clear how drainage from leaders is routed under walkways, across pavement, through drainage pipes, or by other means to reach the BMP.

Show pipes or channels connecting the BMP underdrain and overflow to the site drainage system, MS4, or other approved discharge point. Call out slopes and key elevations.

4.3.1.d) Landscaping and Utility Plans

- The 2010 SMR MS4 Permit *(Order No. R9-2010-0016 NPDES No. CAS0108766)* requires the Copermittees to prohibit irrigation runoff. Any instance of irrigation water reaching the MS4 or Receiving Water is a violation of the Copermittees' ordinances. Ensure that irrigation systems are designed to avoid the potential for irrigation runoff. For example, drip irrigation may be an appropriate technology to meet this objective.

- Vaults and utility boxes should be accommodated outside BMPs and not placed within Structural BMPs in a manner that may interfere with their performance and/or operation and maintenance.

- Landscaping plans, including planting plans, should identify locations of Structural BMPs and the plant requirements must be consistent with the engineered soils and conditions in the BMPs. For more information on plant species appropriate for LID Bioretention BMPs, see Appendix A of the LID Manual for Southern California:

https://www.casqa.org/resources/lid/socal-lid-manual

4.3.1.e) Show LID Principles and Structural BMPs in Cross-Section

Use one or more cross section drawings to illustrate details and key BMP elevations, including bottom of excavation, top of gravel layer, top of soil layer, edge treatments, inlet elevations, overflow grate elevations, rim elevations, locations of rock for energy dissipation, moisture barriers, and other information. If structural BMPs include gravel and soil mix, call out specifications or refer to specifications elsewhere for gravel and soil mix.

- Any area drains within Type B Self-Retaining areas should be identified with elevations of the inlet into the drain, such that the required retention depth will be provided.

- The top edge (overflow) of each BMP provides for the required ponding depth.

4.4. Coordination with Construction Activities

Successful construction of BMPs requires attention to detail during every stage of the construction process, from initial layout to rough grading, installation of utilities, construction of buildings, paving, landscaping, and final clean-up and inspection.

Construction project managers need to understand the purpose and function of BMPs and know how to avoid common missteps that can occur during construction. For LID BMPs, the following operating principles should be noted at a pre-construction meeting.

- Runoff flow from the intended tributary DMA must flow into the BMP.
- The surface reservoir must fill to its intended volume during high inflows.
- Runoff must filter rapidly through the filtration/soil layer.
- Filtered Runoff must infiltrate into the native soil to the extent feasible (or allowable).
- Remaining Runoff must be captured and drained to a storm drain or other approved location.

4.4.1. Coordination with Erosion and Sediment Control Plan/SWPPP

BMPs may not perform as designed if the BMP and the BMP location are not protected during site construction. It is important to specify that appropriate measures be taken by construction staff to protect these areas and BMPs. Be sure that all construction site staff is aware of these requirements, because historical construction habits may take time to change.

- Avoid intentional or unintentional compaction of planned landscaped areas, particularly areas that have been designated for infiltration such as Self-Retaining Areas, LID Infiltration and LID Bioretention BMPs. If these areas are compacted, or even just used as an access path for heavy equipment during site grading, then the soil structure and infiltration characteristics will be destroyed, and the BMP will not perform as designed. If this occurs, require re-tilling and/or soil amendments as necessary to restore the infiltrative capacity of the underlying soils.
- Once any BMP is constructed, surround the BMP with Sediment Control BMPs, and maintain them until site occupancy is granted. Even small amounts of construction sediment can significantly affect the performance of the Sediment Control BMPs.

- Construct pervious pavements as the last order of work, if possible, to minimize the risk of clogging the constructed pervious pavement by sediment and debris generated from additional construction activities.

4.4.2. Items to Be Inspected During Construction

Verify that the project contract documents are sufficiently detailed to provide for the proper construction of the elements of the BMPs specified in the Project-Specific WQMP. See the example construction checklist on the following pages for ideas of items that may need to be verified in the contract documents and during construction.

EXAMPLE BMP CONSTRUCTION CHECKLIST

Staking

- ❐ Square footage of BMPs meets or exceeds minimum shown in Project-Specific WQMP
- ❐ Site grading and grade breaks are staked consistent with and sufficient to define the boundaries of the tributary Drainage Management Area(s) (DMAs) shown in the Project-Specific WQMP
- ❐ Inlet elevation of the BMP is low enough to receive drainage from the entire tributary DMA
- ❐ Locations and elevations of overland flow or piping, including roof leaders, from impervious areas to the BMP have been laid out and any conflicts resolved
- ❐ Rim elevation of the BMP is staked consistent with plans
- ❐ Locations for vaults, utility boxes, and light standards have been identified so that they will not conflict with BMPs

EXCAVATION (to be confirmed prior to backfilling or pipe installation)

- ❐ Excavation conducted with materials and techniques to minimize compaction of soils within the BMP area
- ❐ Excavation is to accurate area and depth
- ❐ Slopes or side walls protected from sloughing of native soils into the BMP
- ❐ Moisture barrier, if specified, has been added to protect adjacent pavement or structures
- ❐ Native soils at bottom of excavation are ripped or loosened to promote infiltration

OVERFLOW OR SURFACE CONNECTION TO MS4
(to be confirmed prior to backfilling with any materials)

- ❐ Overflow is at specified elevation (typically no lower than two inches below BMP rim)
- ❐ No knockouts or side inlets are in overflow riser
- ❐ Overflow location selected to minimize surface flow velocity (near, but offset from, inlet recommended)
- ❐ Grating excludes mulch and litter (beehive or atrium-style grates with ¼" openings recommended)
- ❐ Overflow structures are located away from inlets to the BMP
- ❐ Overflow is connected to storm drain or other specified outlet via appropriately sized piping

UNDERGROUND CONNECTION TO MS4 /OUTLET ORIFICE
(to be confirmed prior to backfilling BMP with any materials)

- ❐ Perforated pipe underdrain is installed with holes facing down
- ❐ Perforated pipe is connected to the specified discharge point
- ❐ Underdrain pipe is at elevation shown on plans. In facilities allowing infiltration, preferred elevation is above native soil but low enough to still be covered by the underdrain rock; in bioretention facilities that are sealed or with liners, preferred elevation is as near bottom as possible
- ❐ Cleanouts are in accessible locations and connected via sweeps
- ❐ Structures (arches or large diameter pipes) for additional surface storage are installed as shown in plans and specifications and have the specified volume

(continued)

Figure 4-1: Example BMP Construction Checklist

EXAMPLE BMP CONSTRUCTION CHECKLIST (CONTINUED)

DRAIN ROCK/SUBDRAIN (to be confirmed prior to installation of soil mix)

- ❒ Rock is installed as specified.
- ❒ Rock is smoothed to a consistent top elevation. Depth and top elevation are as shown in plans
- ❒ Slopes or side walls protected from sloughing of native soils into the BMP
- ❒ No filter fabric is placed between the subdrain and soil mix layers

SOIL MIX (FOR BIORETENTION)

- ❒ Soil mix is as specified. Quality of mix is confirmed by delivery ticket or onsite testing as appropriate to the size and complexity of the BMP
- ❒ Mix is not compacted during installation but may be thoroughly wetted to encourage consolidation
- ❒ Mix is smoothed to a consistent top elevation. Depth of mix and top elevation are as shown in plans, accounting for depth of mulch to follow and required reservoir depth

IRRIGATION

- ❒ Irrigation system is installed so it can be controlled separately from other landscaped areas. Smart irrigation controllers and drip emitters are recommended
- ❒ Spray heads, if any, are positioned to avoid direct spray into outlet structures

PLANTING

- ❒ Plants are installed consistent with approved planting plan
- ❒ Any trees and large shrubs are staked securely
- ❒ No clayey material, including inappropriate native soils are used in the BMP
- ❒ 1"-2" mulch may be applied following planting; mulch selected to avoid floating
- ❒ Final elevation of soil mix, including mulch, is maintained following planting
- ❒ Curb openings are free of obstructions

FINAL ENGINEERING INSPECTION

- ❒ Drainage Management Area(s) are free of construction sediment and landscaped areas are stabilized
- ❒ Inlets are installed to provide smooth entry of Runoff from adjoining pavement, have sufficient reveal (drop from the adjoining pavement to the top of the mulch or soil mix, and are not blocked
- ❒ Inflows from roof leaders and pipes are connected and operable
- ❒ Temporary flow diversions are removed
- ❒ Rock or other energy dissipation at piped or surface inlets is adequate
- ❒ Overflow outlets are configured to allow the BMP to flood and fill to near rim before overflow
- ❒ Plantings are healthy and becoming established
- ❒ Irrigation is operable
- ❒ If rains have occurred: BMP drains rapidly; no surface ponding is evident
- ❒ Any accumulated construction debris, trash, or sediment is removed from BMP
- ❒ Certification Statement from design professional that all BMPs have been constructed and/or installed in accordance with the approved plans and specs.

Chapter 5

5.0 PROJECT-SPECIFIC WQMP OPERATION & MAINTENANCE

How to prepare a customized Project-Specific WQMP Operation & Maintenance Plan for the BMPs on your PDP site.

Provision F.1.f(2)(b) of the 2010 SMR MS4 Permit requires that each Copermittee must verify that Structural BMPs are adequately maintained. Copermittees must report the results of these verifications to the San Diego Regional Board annually.

Structural BMPs installed as part of the PDP will be incorporated into the Copermittee's verification program. This is a five-stage process:

1) Determine who will own the Structural BMPs and be responsible for its maintenance in perpetuity and document this in the Project-Specific WQMP. The Project-Specific WQMP must also identify the means by which ongoing maintenance will be assured (for example, a maintenance agreement that runs with the land).

2) Identify project-specific maintenance requirements, allow for these requirements in your project planning and preliminary design, and document the typical maintenance requirements in the Project-Specific WQMP.

3) Prepare a Project-Specific WQMP Operation and Maintenance Plan (WQMP O&M Plan) for the site incorporating detailed requirements for each LID, Conventional Treatment and Hydrologic Control BMP. Other types of LID Principles, such as self-retaining areas may also require operation and maintenance to ensure that they continue to function as designed. Typically, a draft Project-Specific WQMP Operation and Maintenance Plan must be submitted with the Final Project-Specific WQMP, and a final Project-Specific WQMP Operation and Maintenance Plan must be submitted to and approved by the Copermittee with jurisdiction over the project site prior to issuance of a

certificate of occupancy. Local requirements vary as to schedule. Check with Copermittee staff.

4) Maintain the Structural BMPs from the time they are constructed until ownership and maintenance responsibility is formally transferred to the site owner/operator.

5) **Maintain** the BMPs in perpetuity and comply with the Copermittee's self-inspection, reporting, and verification requirements.

Table 5-1: Schedule for Planning the Project-Specific WQMP Operation and Maintenance Plan

Stage	*Description*	*Where documented*	*Schedule*
1	Determine BMP ownership and maintenance responsibility	Preliminary Project-Specific WQMP	Discuss with project owner at initial project planning phase
2	Identify Project-Specific maintenance requirements	Preliminary Project-Specific WQMP	Submit with planning & zoning application
3	Develop detailed operation and maintenance plan	Final Project-Specific WQMP	Submit draft with Building Permit application; final due before building permit final and applying for a Certificate of Occupancy
4	Interim operation and maintenance of BMPs	As required by Copermittee O&M verification program	During and following construction including warranty period
5	Ongoing maintenance and compliance with inspection & reporting requirements	As required by Copermittee O&M verification program	In perpetuity

5.1. Stage 1: Ownership and Maintenance Responsibility

Ownership & maintenance responsibility for Structural BMPs should be discussed as early as due diligence and definitely at the beginning of project planning. Experience has shown that provisions to implement and finance maintenance of Structural BMPs can be a major stumbling block to project approval, particularly for small residential subdivisions.

Your Project-Specific WQMP must specify:

1) Who will be responsible for maintaining the site in conformance with the WQMP Operation & Maintenance Plan.

2) The means for financing the maintenance of Structural BMPs in perpetuity once the BMP is implemented and the Development Project is complete. This should include the mechanisms for the eventual replacement of the BMP or elements of the BMP.

3) How the maintenance obligations will carry over to subsequent owners, as further described in Sections 5.1.1 through 5.1.3 below.

5.1.1. Private Ownership and Maintenance

The Copermittee may require—as a condition of project approval—that a maintenance agreement be executed and recorded against the title of the property. Consult with the Copermittee with jurisdiction over the project site for a copy of any required maintenance agreement.

The agreement will thereby "run with the land", so the maintenance agreement executed by a developer is binding on the owners of the subdivided lots and subsequent owners. The agreement must be recorded prior to conveyance of the subdivided property.

5.1.2. Transfer to Public Ownership

Some Copermittees may have developed a process by which a Structural BMP can be deeded to the public in fee or as an easement, for public maintenance. The Copermittee may recoup the costs of maintenance through a special tax, assessment district, or similar mechanism.

☞ Check with the Copermittee with jurisdiction over the project site to determine if any such 'public maintenance' mechanisms are in place, and for any associated requirements.

Transferring a LID BMP to Public Ownership may create additional design constraints, however, it removes the burden from the site owner/operator from having to maintain the BMP in perpetuity. Because PDP sites typically drain to the street, it may be possible to locate a BMP parallel to the street and within road right of way, or on a common, publically accessible lot.

Even if the Structural BMP is to be deeded or transferred to the Copermittee after construction is complete, it is still the responsibility of the User, to maintain the BMP in accordance with the Project-Specific WQMP O&M Plan until that responsibility is formally transferred to the subsequent owner.

5.1.3. Copermittee Projects

Public projects (such as Public Works/Capital Improvement Projects) implemented by a Copermittee will be maintained by the Copermittee in accordance with a Facility Pollution Prevention Plan as described in the Copermittees' JRMP.

5.2. Stage 2: Identify Maintenance Requirements

Include in the Project-Specific WQMP a description of the maintenance requirements for each Structural BMP, including for any self-retaining and/or landscaped self-treating areas. This will help ensure that:

- Ongoing costs of Structural BMP maintenance have been considered in BMP selection and design.
- Site and landscaping plans provide for access for inspections and by maintenance equipment.
- Landscaping plans incorporate irrigation requirements for Structural BMP plantings as appropriate.
- Initial maintenance and replacement of Structural BMP plantings is incorporated into landscaping contracts and guarantees.

Fact sheets in the LID BMP Design Handbook describe typical maintenance requirements for many of the Structural BMPs described in this WQMP. Use this information, or other requirements specified by the Copermittee to specify the maintenance requirements for each of the Structural BMPs, including LID BMPs, Conventional Treatment Control BMPs, Hydrologic Control BMPs, and Source Control BMPs identified in the Project-Specific WQMP. In addition, identify any necessary maintenance requirements for any other LID Principles that were incorporated into the project, such as buffer areas, etc.

5.3. Stage 3: Develop Project-Specific WQMP Operations & Maintenance Plan

Submit a draft Project-Specific WQMP O&M Plan with your final Project-Specific WQMP included with the application for permits to begin grading or construction on the site. A final Project-Specific WQMP O&M Plan (updated as necessary) will be required to be submitted with the 'as-built' plans and approved before occupancy is granted.

The final Project-Specific WQMP O&M Plan should incorporate solutions to any problems noted or changes that occurred during construction.

The Final Project-Specific WQMP O&M Plan and 'as-built' plans must be submitted to and approved by the Copermittee with jurisdiction over the project site before a building permit can be made final and a certificate of occupancy issued.

The Project-Specific WQMP and WQMP O&M Plan must be kept onsite for use by maintenance personnel and during site inspections.

The following step-by-step guidance will help you prepare each required section of your WQMP O&M Plan. Preparation of the Plan will require familiarity with the Structural BMPs as they have been designed/constructed and a fair amount of "thinking through" plans for their operation and maintenance. The text and forms provided here will assist you, but are no substitute for thoughtful planning.

5.3.1. Step 1: Designate Responsible Individuals

To begin creating the Project-Specific WQMP O&M Plan, the User must designate and identify:

- The individual who will have direct responsibility for the maintenance of the BMPs identified in the Project-Specific WQMP O&M Plan. This individual should be the designated contact with Copermittee inspectors and should sign self-inspection reports and any correspondence with the Copermittee regarding verification inspections. The Copermittee may accept self-certification or third-party certification by a California licensed Professional Engineer.
- Employees or contractors who will report to the designated contact and are responsible for conducting all required operation and maintenance.
- The corporate officer authorized to negotiate and execute contracts that might be necessary for future changes to operation and maintenance of the BMPs identified in the Project-Specific WQMP O&M Plan or to implement remedial measures if problems occur.
- The designated respondent to problems with the BMPs, such as clogged drains or broken irrigation mains, that would require immediate response should they occur during off-hours.

Include an organization chart to show the relationships of authority and responsibility between the individuals responsible for Project-Specific WQMP operation and maintenance. This need not be elaborate, particularly for smaller organizations.

Describe how funding for operation and maintenance will be assured, including sources of funds, budget category for expenditures, process for establishing the annual maintenance budget, and process for obtaining authority should unexpected expenditures for major corrective maintenance be required.

Describe how training of staff or contractors regarding the purpose, mode of operation, and maintenance requirements for the BMPs Identified in the Project-Specific WQMP O&M Plan will be provided. Also, describe how ongoing training will be provided as needed and in response to staff changes.

5.3.2. Step 2: Summarize Drainage and BMPs

Incorporate the following information from the Project-Specific WQMP into the Project-Specific WQMP O&M Plan:

- Figures delineating and designating DMAs
- Figures showing locations of BMPs on the site
- Tables of the DMAs served by each Structural BMP

Verify that these figures incorporate changes that may have occurred during planning and zoning review, building permit review, or construction.

5.3.3. Step 3: Document BMPs 'As-Built'

Once each Structural BMP is constructed, plans for the BMP must be 'as-built' by a licensed civil/geotechnical engineer registered in the State of California and submitted to the Copermittee, and also included as part of the Project-Specific WQMP O&M Plan. The information contained on the 'as-built' plans must be consistent with standard engineering practice. Following is a list of types of information that should be documented on 'as-built' plans as applicable and appropriate:

- Plans, elevations, and details of all Structural BMPs. Annotate if necessary with designations used in the Project-Specific WQMP.
- Design information or calculations submitted in the detailed design phase (i.e., not included in the Project-Specific WQMP).
- Specifications of construction of the Structural BMPs, including sand or soil, compaction, pipe materials, and bedding.

In the final Project-Specific WQMP O&M Plan, incorporate field changes to design drawings, including changes to any of the following:

- Location and layouts of inflow piping, flow splitter boxes, and piping to offsite discharge.

- Depths and layering of soil, sand, or gravel.
- Placement of filter fabric or geotextiles.
- Changes or substitutions in soil or other materials.
- Natural soils encountered (e.g., sand or clay lenses).
- Vegetation type within or around the BMP.
- Changes in tree types.
- Fencing around the BMP.
- Etc.

5.3.4. Step 4: Prepare Customized Maintenance Plans

Prepare a maintenance plan, schedule, and inspection checklists (e.g. routine, annual, and after major storms) for each Structural BMP including for any self-retaining and/or landscaped self-treating areas. Plans and schedules for two or more similar BMPs on the same site may be combined.

Use the following resources to prepare the customized maintenance plan, schedule, and checklists.

- Specific information noted in Steps 2 and 3, above.
- Other input from the Structural BMP designer, Copermittee staff, or other sources.
- BMP Fact Sheets in the LID BMP Design Handbook, as applicable.

Note any particular characteristics or circumstances that may require attention in the future, and include any troubleshooting advice.

Also include in an appendix any manufacturer's data, operating manuals, and maintenance requirements for any:

- Pumps or other mechanical equipment.
- Proprietary devices used as or in conjunction with BMPs.

Manufacturers' publications should be referenced in the text (including models and serial numbers where available). Copies of the manufacturers' publications should be included as an attachment in the back of the Project-Specific WQMP O&M Plan or as a separate document.

5.3.5. Step 5: Compile O&M Plan

The Project-Specific WQMP O&M Plan should follow the general outline below.

> **Note** that for Copermittee Projects, the WQMP O&M Plan requirements will be incorporated into a new or existing, Facility Pollution Prevention Plans (FPPP).

I. Inspection and Maintenance Log

II. Updates, Revisions and Errata

III. Introduction

Narrative overview describing the site; drainage areas, routing, and discharge points; and Structural BMPs

IV. Responsibility for Maintenance

A. General

1) Name and contact information for responsible individual(s).

2) Organization chart or charts of the maintenance function and location within the overall organization.

3) Reference to Operation and Maintenance Agreement (if any). A copy of the agreement should be attached.

4) Maintenance Funding

a. Sources of funds for maintenance

b. Budget category or line item

c. Description of procedure and process for ensuring adequate funding for maintenance

B. Staff Training Program

C. Records

D. Safety

V. Summary of DMAs and BMPs

A. DMAs

1) Drawings showing pervious and impervious areas (copied or adapted from Project-Specific WQMP)

2) Designation and description of each DMA and how flow is routed to the corresponding BMP

B. Structural BMPs

1) Drawings showing location and type of each Structural Post-Construction BMP

2) General description of each BMP (consider a table if more than two BMPs)

(b) DMA and routing of discharge

(c) BMP type and size

VI. BMP Design Documentation

A. 'As-built' drawings of each Structural BMP (design drawings in the draft Plan).

B. Manufacturer's data (as applicable) including manuals, and maintenance requirements for pumps, mechanical or electrical equipment, and proprietary facilities (include a "placeholder" in the draft Project-Specific WQMP Operations and Maintenance Plan for information not yet available at the draft phase).

C. Specific operation and maintenance concerns and troubleshooting.

VII. Maintenance Schedule or Matrix

A. Maintenance Schedule for each Structural BMP with specific requirements for:

(1) Routine inspection and maintenance

(2) Annual inspection and maintenance

(3) Inspection and maintenance after major storms

B. Service Agreement Information

Assemble and make copies of the Project-Specific WQMP O&M Plan. One or more copies must be submitted to the Copermittee, including one electronic copy. At least one copy must be kept onsite. Following are some suggestions for formatting the Project-Specific WQMP O&M Plan:

- Format plans to 8½" x 11" to facilitate duplication, filing, and handling
- Include the revision date in the footer on each page
    - Scan graphics and incorporate with text into a single electronic file. Keep the electronic file backed up so that copies of the Project-Specific WQMP O&M Plan can be made if the hard copy is lost or damaged.

5.3.6. Step 6: Updates

The Stormwater Control Operation and Maintenance Plan (or Facility Pollution Prevention Plan for Copermittee projects) will be a living document and, thus, will require periodic updates by the Facility/Activity Manager at least annually. There are two types of updates, each with their own implications as noted below. Note that these are examples of minimum thresholds that should be verified with the Copermittee with jurisdiction over the PDP site for specific direction and advisement.

- Minor Updates – Turnover of named maintenance personnel, mechanical equipment, addition of maintenance procedures, etc.
- Major Updates – Relocation of BMPs, modification of maintenance schedule(s) of BMPs, change in legal ownership and/or party responsible for maintaining the BMPs in perpetuity, major site re-grading or re-paving that can affect DMAs, changing one BMP for an alternative BMP, etc.

Updates may be transmitted to the Copermittee with jurisdiction over the project site at any time. However, at a minimum, updates to the O&M Plan must be maintained, implemented, and available to Copermittee inspectors. These updates should reference the sections of the O&M Plan being changed. In addition, major updates may necessitate a revision to the Project-Specific WQMP and as such may cause the need for the document to be re-recorded. Consult with the Copermittee with jurisdiction over the project site before performing any major updates to the approved and implemented Project-Specific WQMP. Conversely, updates may not require re-recordation if they are consistent with the original, executed agreement.

Failure to maintain an up-to-date copy of the O&M Plan may be a violation of Copermittee requirements subject to fines and/or other penalties.

5.4. STAGE 4: INTERIM OPERATION & MAINTENANCE

The User is responsible for interim operation and maintenance of Stormwater BMPs until such time as this responsibility is formally transferred to a subsequent property owner. Users may be required to warranty Stormwater BMPs against lack of performance due to flaws in design or construction for a minimum of two rainy seasons following completion of construction. The warranty may need to be secured by a bond or other financial instrument if required by the Copermittee.

5.5. STAGE 5: OPERATION & MAINTENANCE VERIFICATION

Each Copermittee implements a program to ensure that the Structural BMPs are operating and are maintained properly and all BMPs are working effectively to remove Pollutants in Runoff from the site. This may include periodic site inspections, or requirements for self-certifications by a licensed professional engineer. This program will be described by each Copermittee in their respective JRMP.

5.6. REFERENCES AND RESOURCES

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- *Best Management Practices Guide* (Public Telecommunications Center for Hampton Roads, 2002).
- Operation, Maintenance, and Management of Stormwater Management Systems (Watershed Management Institute, 1997)

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EXHIBIT A:

Isohyetal Map for the 85th Percentile 24-hour Storm Event

EXHIBIT B:

Project-Specific WQMP Template

EXHIBIT C:

LID BMP Design Handbook

Please Visit

www.rcflood.org/npdes/developers

to access the current Handbook.

EXHIBIT D:

WQMP Applicability Checklist

EXHIBIT E:

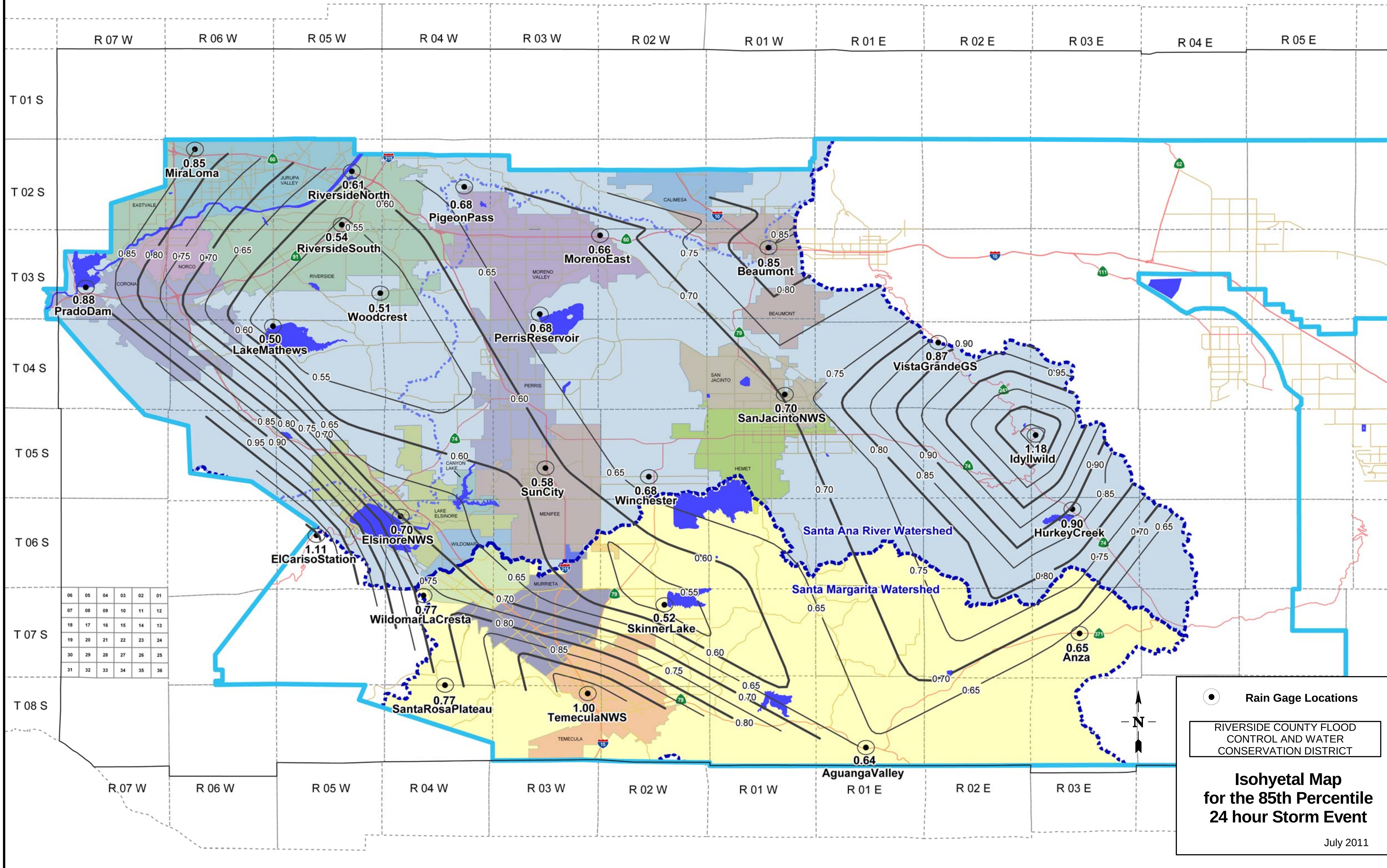
WQMP Review Checklist

EXHIBIT F:

Santa Margarita Region Hydromodification Management Plan

EXHIBIT G:

Glossary



Rain Gage Locations
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
Isohyetal Map for the 85th Percentile 24 hour Storm Event
July 2011
Santa Ana River Watershed
Santa Margarita Watershed
0.85 MiraLoma
0.61 RiversideNorth
0.68 PigeonPass
0.54 RiversideSouth
0.66 MorenoEast
0.85 Beaumont
0.88 PradoDam
0.51 Woodcrest
0.68 PerrisReservoir
0.50 LakeMathews
0.87 VistaGrandeGS
0.70 SanJacintoNWS
1.18 Idyllwild
0.58 SunCity
0.68 Winchester
0.70 ElsinoreNWS
1.11 ElCarisoStation
0.90 HurkeyCreek
0.77 WildomarLaCresta
0.52 SkinnerLake
0.65 Anza
0.77 SantaRosaPlateau
1.00 TemeculaNWS
0.64 AguangaValley
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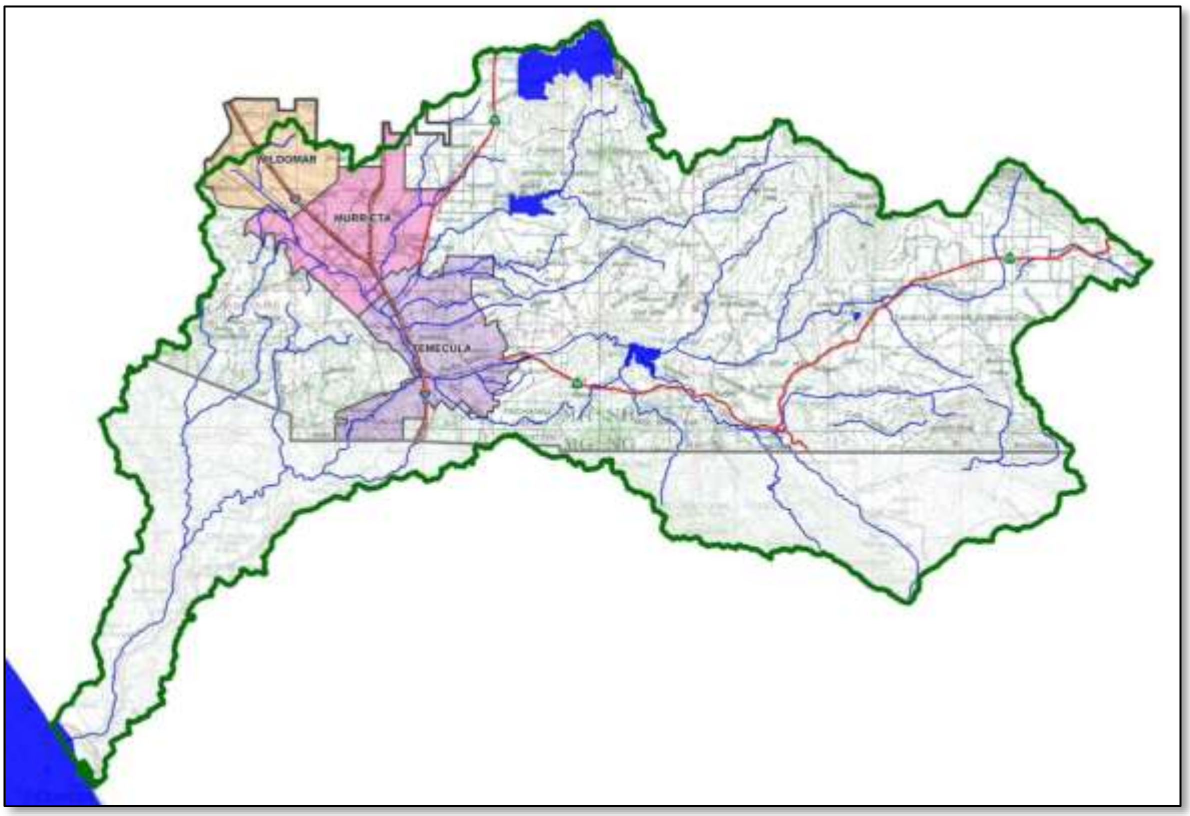
Project Specific Water Quality Management Plan

A Template for preparing Project Specific WQMPs for Priority Development Projects located within the ***Santa Margarita Region*** *of Riverside County*

Project Title: Insert text here

Development No: Insert text here

Design Review/Case No: Insert text here



Contact Information:

Prepared for: Insert Developer Name, Address, and Phone Number

Prepared by: Insert Name and Title of Preparer, address, and Phone Number

☐ **Preliminary**
☐ **Final**

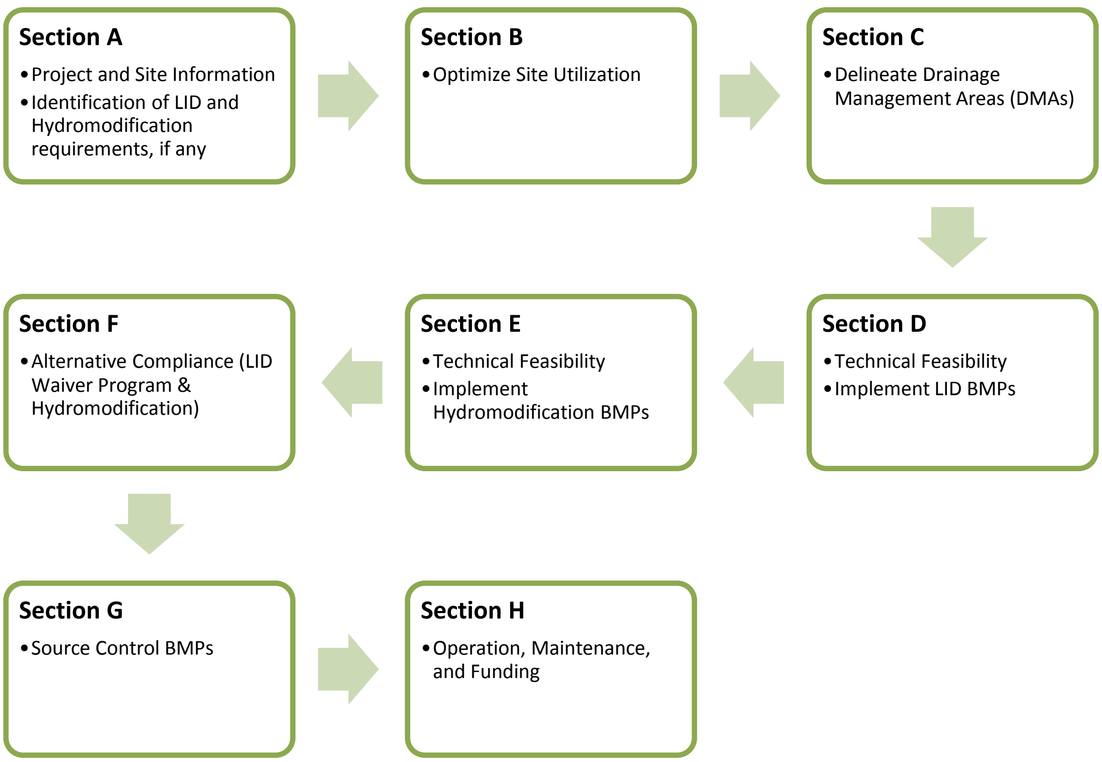
Original Date Prepared: Insert text here

Revision Date(s): Insert text here

Prepared for Compliance with
Regional Board Order No. **R9-2010-0016**

A Brief Introduction

The Municipal Separate Stormwater Sewer System (MS4) Permit[1] for the **Santa Margarita Region** (SMR) requires preparation of a Project-Specific Water Quality Management Plan (WQMP) for all Development Projects as defined in section F.1.d.(1) of the Permit. This Project-Specific WQMP Template for Development Projects in the **Santa Margarita Region** has been prepared to help document compliance and prepare a WQMP submittal. Below is a flowchart for the layout of this Template that will provide the steps required to document compliance.



[1] Order No. R9-2010-0016, NPDES No. CAS0108766, Waste Discharge Requirements for Discharges from the MS4 Draining the County of Riverside, the Incorporated Cities of Riverside County, and the Riverside County Flood Control and Water Conservation District within the San Diego Region, California Regional Water Quality Control Board, November 10, 2010.

OWNER'S CERTIFICATION

This Project-Specific WQMP has been prepared for <Owner's Name> by <Preparer's Name> for the <Project Name> project.

This WQMP is intended to comply with the requirements of <Insert City or County Name> for <Insert Ordinance No.> which includes the requirement for the preparation and implementation of a Project-Specific WQMP.

The undersigned, while owning the property/project described in the preceding paragraph, shall be responsible for the implementation and funding of this WQMP and will ensure that this WQMP is amended as appropriate to reflect up-to-date conditions on the site. In addition, the property owner accepts responsibility for interim operation and maintenance of Stormwater Best Management Practices until such time as this responsibility is formally transferred to a subsequent owner. This WQMP will be reviewed with the facility operator, facility supervisors, employees, tenants, maintenance and service contractors, or any other party (or parties) having responsibility for implementing portions of this WQMP. At least one copy of this WQMP will be maintained at the project site or project office in perpetuity. The undersigned is authorized to certify and to approve implementation of this WQMP. The undersigned is aware that implementation of this WQMP is enforceable under <Insert City or County Name> Water Quality Ordinance (Municipal Code Section).

"I, the undersigned, certify under penalty of law that the provisions of this WQMP have been reviewed and accepted and that the WQMP will be transferred to future successors in interest."

Owner's Signature | Date

Owner's Printed Name | Owner's Title/Position

PREPARER'S CERTIFICATION

"The selection, sizing and design of stormwater treatment and other stormwater quality and quantity control Best Management Practices in this plan meet the requirements of Regional Water Quality Control Board Order No. **R9-2010-0016** and any subsequent amendments thereto."

Preparer's Signature | Date

Preparer's Printed Name | Preparer's Title/Position

Preparer's Licensure:

Table of Contents

List of Tables

List of Appendices

Section A: Project and Site Information

PROJECT INFORMATION		
Type of Project:	Insert text here (e.g., commercial, residential, etc.)	
Planning Area:	Insert text here	
Community Name:	Insert text here	
Development Name:	Insert Planning Area / Community Name/ Development Name, if known	
PROJECT LOCATION		
Latitude & Longitude (DMS): Insert coordinates here		
Project Watershed and Sub-Watershed: Insert text here		
APN(s): Insert text here		
Map Book and Page No.: Insert text here		
PROJECT CHARACTERISTICS		
Proposed or potential land use(s)		Insert text here
Proposed or Potential SIC Code(s)		Insert text here
Area of Impervious Project Footprint (SF)		Insert text here
Total area of proposed Impervious Surfaces within the Project Limits (SF)/or Replacement		Insert text here
Total Project Area (ac)		Insert text here
Does the project consist of offsite road improvements?		☐ Y ☐ N
Does the project propose to construct unpaved roads?		☐ Y ☐ N
Is the project part of a larger common plan of development (phased project)?		☐ Y ☐ N
Is the project exempt from HMP Performance Standards?		☐ Y ☐ N
EXISTING SITE CHARACTERISTICS		
Total area of existing Impervious Surfaces within the project limits (SF)		Insert text here.
Is the project located within any Multi-Species Habitat Conservation Plan (MSHCP Criteria Cell?		☐ Y ☐ N
If so, identify the Cell number:		Insert text here.
Are there any natural hydrologic features on the project site?		☐ Y ☐ N
Is a Geotechnical Report attached?		☐ Y ☐ N
If no Geotech. Report, list the Natural Resources Conservation Service (NRCS) soils type(s) present on the site (A, B, C and/or D)		Insert text here.
What is the Water Quality Design Storm Depth for the project?		Insert text here.

A.1 Maps and Site Plans

When completing your Project-Specific WQMP, include a map of the Project vicinity and existing site. In addition, include all grading, drainage, landscape/plant palette and other pertinent construction plans in Appendix 2. At a **minimum**, your WQMP Site Plan should include the following:

- Drainage Management Areas (DMAs)
- Proposed Structural Best Management Practices (BMPs)
- Drainage Path
- Source Control BMPs
- Buildings, Roof Lines, Downspouts
- Impervious Surfaces
- Standard Labeling

- Drainage infrastructure, inlets, overflows

Use your discretion on whether or not you may need to create multiple sheets or can appropriately accommodate these features on one or two sheets. Keep in mind that the Copermittee plan reviewer must be able to easily analyze your Project utilizing this template and its associated site plans and maps.

A.2 Identify Receiving Waters

Using Table A.1 below, list in order of upstream to downstream, the Receiving Waters that the Project site is tributary to. Continue to fill each row with the Receiving Water's 303(d) listed impairments (if any), designated Beneficial Uses, and proximity, if any, to a RARE Beneficial Use. Include a map of the Receiving Waters in Appendix 1. *(http://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/)*

Table A.1 Identification of Receiving Waters

Receiving Waters	USEPA Approved 303(d) List Impairments	Designated Beneficial Uses	Proximity to RARE Beneficial Use
Insert name of 1st receiving water	List any 303(d) impairments of 1st receiving water, including Approved TMDL pollutant limitations	Insert designated beneficial use of 1st receiving water	Insert distance of project to RARE-designated waters (indicate whether feet, yards, or miles)
insert name of 2nd receiving water	List any 303(d) impairments of 2nd receiving water, including Approved TMDL pollutant limitations	Insert designated beneficial use of 2nd receiving water	Insert distance of project to RARE-designated waters (indicate whether feet, yards, or miles)
Insert name of 3rd receiving water	List any 303(d) impairments of 3rd receiving water, including Approved TMDL pollutant limitations	Insert designated beneficial use of 3rd receiving water	Insert distance of project to RARE-designated waters (indicate whether feet, yards, or miles)

A.3 Drainage System Susceptibility to Hydromodification

Using Table A.2 below, list in order of the point of discharge at the project site down to the Santa Margarita River, each drainage system or receiving water that the project site is tributary to. Continue to fill each row with the material of the drainage system, the storm drain susceptibility using the SWCT2 (Stormwater & Water Conservation Tracking Tool - http://rivco.permitrack.com/) or Map 2 of the Hydromodification Susceptibility Documentation Report and Mapping: Santa Margarita Region (Appendix D of the SMR HMP), and the condition for exempting the drainage system, if applicable. If the exemption includes receiving waters that were not evaluated in Appendix D, provide supporting documentation in Appendix 7 to demonstrate that they classify as Engineered, Fully Hardened and Maintained (EFHM) channels, consistent with the definition provided in Appendix D. Include a map exhibiting each drainage system and the associated susceptibility in Appendix 1.

Table A.2 Identification of Susceptibility to Hydromodification

Drainage System	Drainage System Material	Susceptibility of Drainage System	Hydromodification Exemption
Insert name and length (in miles) of 1st drainage system	Identify either (1) the type of material of bed and bank for open channels; or (2) the material of storm drain pipes and conduits	Identify the susceptibility to hydromodication of 1st drainage system	Insert exemptions the 1st receiving water may qualify for. If none, insert NONE.
Insert name and length (in miles) of 2nd drainage system	Identify either (1) the type of material of bed and bank for open channels; or (2) the material of storm drain pipes and conduits	Identify the susceptibility to hydromodication of 2nd drainage system	Insert exemptions the 2nd receiving water may qualify for. If none, insert NONE.

Drainage System	Drainage System Material	Susceptibility of Drainage System	Hydromodification Exemption
Insert name and length (in miles) of 3rd drainage system	Identify either (1) the type of material of bed and bank for open channels; or (2) the material of storm drain pipes and conduits	Identify the susceptibility to hydromodication of 3rd drainage system	Insert exemptions the 3rd receiving water may qualify for. If none, insert NONE.

A.4 Additional Permits/Approvals required for the Project:

Table A.3 Other Applicable Permits

Agency	Permit Required	
State Department of Fish and Game, 1602 Streambed Alteration Agreement	☐ Y	☐ N
State Water Resources Control Board, Clean Water Act Section 401 Water Quality Certification	☐ Y	☐ N
US Army Corps of Engineers, Clean Water Act Section 404 Permit	☐ Y	☐ N
US Fish and Wildlife, Endangered Species Act Section 7 Biological Opinion	☐ Y	☐ N
Statewide Construction General Permit Coverage	☐ Y	☐ N
Statewide Industrial General Permit Coverage	☐ Y	☐ N
Western Riverside MSHCP Consistency Approval (e.g., JPR, DBESP)	☐ Y	☐ N
Other *(please list in the space below as required)*	☐ Y	☐ N

If yes is answered to any of the questions above, the Copermittee may require proof of approval/coverage from those agencies as applicable including documentation of any associated requirements that may affect this Project-Specific WQMP.

Section B: Optimize Site Utilization (LID Principles)

Review of the information collected in Section 'A' will aid in identifying the principal constraints on site design and selection of LID BMPs as well as opportunities to reduce imperviousness and incorporate LID Principles into the site and landscape design. For example, **constraints** might include impermeable soils, high groundwater, groundwater pollution or contaminated soils, steep slopes, geotechnical instability, high-intensity land use, heavy pedestrian or vehicular traffic, utility locations or safety concerns. **Opportunities** might include existing natural areas, low areas, oddly configured or otherwise unbuildable parcels, easements and landscape amenities including open space and buffers (which can double as locations for LID Bioretention BMPs), and differences in elevation (which can provide hydraulic head). Prepare a brief narrative for each of the site optimization strategies described below. This narrative will help you as you proceed with your Low Impact Development (LID) design and explain your design decisions to others.

The 2010 SMR MS4 Permit further requires that LID Retention BMPs (Infiltration Only or Harvest and Use) be used unless it can be shown that those BMPs are infeasible. Therefore, it is important that your narrative identify and justify if there are any constraints that would prevent the use of those categories of LID BMPs. Similarly, you should also note opportunities that exist which will be utilized during project design. Upon completion of identifying Constraints and Opportunities, include these on your WQMP Site plan in Appendix 1.

Site Optimization

The following questions are based upon Section 3.2 of the WQMP Guidance Document. Review of the WQMP Guidance Document will help you determine how best to optimize your site and subsequently identify opportunities and/or constraints, and document compliance.

Did you identify and preserve existing drainage patterns? If so, how? If not, why?

Insert narrative here

Did you identify and protect existing vegetation? If so, how? If not, why?

Insert narrative here

Did you identify and preserve natural infiltration capacity? If so, how? If not, why?

Insert narrative here

Did you identify and minimize impervious area? If so, how? If not, why?

Insert narrative here

Did you identify and disperse runoff to adjacent pervious areas? If so, how? If not, why?

Insert narrative here

Section C: Delineate Drainage Management Areas (DMAs)

Utilizing the procedure in Section 3.3 of the WQMP Guidance Document which discusses the methods of delineating and mapping your project site into individual DMAs, complete Table C.1 below to appropriately categorize the types of classification (e.g., Type A, Type B, etc.) per DMA for your Project site. Upon completion of this table, this information will then be used to populate and tabulate the corresponding tables for their respective DMA classifications.

Table C.1 DMA Classifications

DMA Name or Identification	Surface Type(s)[1]	Area (Sq. Ft.)	DMA Type

[1]Reference Table 2-1 in the WQMP Guidance Document to populate this column

Table C.2 Type 'A', Self-Treating Areas

DMA Name or Identification	Area (Sq. Ft.)	Stabilization Type	Irrigation Type (if any)

Table C.3 Type 'B', Self-Retaining Areas

Self-Retaining Area				Type 'C' DMAs that are draining to the Self-Retaining Area		
DMA Name/ ID	Post-project surface type	Area (square feet) [A]	Storm Depth (inches) [B]	DMA Name / ID	[C] from Table C.4 = [C]	Required Retention Depth (inches) [D]

$$[D] = [B] + \frac{[B] \cdot [C]}{[A]}$$

Table C.4 Type 'C', Areas that Drain to Self-Retaining Areas

DMA					Receiving Self-Retaining DMA		
DMA Name/ ID	Area (square feet)	Post-project surface type	Runoff factor	Product	DMA name /ID	Area (square feet)	Ratio
	[A]		[B]	[C] = [A] x [B]		[D]	[C]/[D]

Note: (See Section 3.3 of WQMP Guidance Document) Ensure that partially pervious areas draining to a Self-Retaining area do not exceed the following ratio:

$$\left(\frac{\mathbf{2}}{\boldsymbol{Impervious\ Fraction}}\right)\mathbf{:1}$$

(Tributary Area**:** Self-Retaining Area)

Table C.5 Type 'D', Areas Draining to BMPs

DMA Name or ID	BMP Name or ID

Note: More than one DMA may drain to a single LID BMP; however, one DMA may not drain to more than one BMP.

Section D: Implement LID BMPs

D.1 Infiltration Applicability

An assessment of the feasibility of utilizing Infiltration BMPs is required for all projects, *except in the following case:*

- ☐ Harvest and Use BMPs will be implemented to address the Design Capture Volume (see the Harvest and Use Assessment below) for all Drainage Management Areas AND the project is exempt from HMP Performance Standards (*Proceed to Section D.2 and Section E*).

If the above box remains unchecked, perform a site-specific evaluation of the feasibility of Infiltration BMPs using each of the applicable criteria identified in Chapter 3.4.1 of the WQMP Guidance Document and complete the remainder of Section D.1.

Is there an infiltration concern (see discussion in Chapter 2.3.4 of the WQMP Guidance Document for further details)? ☐ Y ☐ N

If yes has been checked, both Infiltration BMPs and Hydrologic Control BMPs that include an infiltration functionalities may not be feasible for the site. It is recommended that you contact your Copermittee to verify whether or not infiltration within the Project is infeasible.

Geotechnical Report

A Geotechnical Report or Phase I Environmental Site Assessment may be required by the Copermittee to confirm present and past site characteristics that may affect the use of Infiltration BMPs. In addition, the Copermittee, at their discretion, may not require a geotechnical report for small projects as described in Chapter 2 of the WQMP Guidance Document. If a geotechnical report has been prepared, include it in Appendix 3. In addition, if a Phase I Environmental Site Assessment has been prepared, include it in Appendix 4.

Is this project classified as a small project consistent with the requirements of Chapter 2 of the WQMP Guidance Document? ☐ Y ☐ N

Infiltration Feasibility

Table D.1 below is meant to provide a simple means of assessing which DMAs on your site support Infiltration BMPs and is discussed in the WQMP Guidance Document in Chapter 2.3.4. Check the appropriate box for each question and then list affected DMAs as applicable. If additional space is needed, add a row below the corresponding answer.

Table D.1 Infiltration Feasibility

Does the project site…	YES	NO
…have any DMAs with a seasonal high groundwater mark shallower than 10 feet?		
If Yes, list affected DMAs:		
…have any DMAs located within 100 feet of a water supply well?		
If Yes, list affected DMAs:		
…have any areas identified by the geotechnical report as posing a public safety risk where infiltration of stormwater could have a negative impact?		
If Yes, list affected DMAs:		
…have measured in-situ infiltration rates of less than 1.6 inches / hour?		
If Yes, list affected DMAs:		

…have significant cut and/or fill conditions that would preclude in-situ testing of infiltration rates at the final infiltration surface?		
If Yes, list affected DMAs:		
…have any contaminated groundwater plume in the vicinity of the site?		
If Yes, list affected DMAs:		
…geotechnical report identifies other site-specific factors that would preclude effective and safe infiltration?		
Describe here:		

If you answered “Yes” to any of the questions above for any DMA, Infiltration BMPs should not be used for those DMAs and you should proceed to the assessment for Harvest and Use below.

D.2 Harvest and Use Assessment

Please check what applies*:*

☐ Reclaimed water will be used for the non-potable water demands for the Project.

☐Downstream water rights may be impacted by Harvest and Use as approved by the Regional Board (verify with the Copermittee).

☐The Design Capture Volume (DCV) will be addressed using Infiltration Only BMPs. In such a case, Harvest and Use BMPs are still encouraged, but it would not be required if the DCV will be infiltrated or evapotranspired.

If any of the above boxes have been checked, Harvest and Use BMPs need not be assessed for the site. If neither of the above criteria applies, follow the steps below to assess the feasibility of irrigation use, toilet use and other non-potable uses (e.g., industrial use).

Irrigation Use Feasibility

Complete the following steps to determine the feasibility of harvesting stormwater runoff for Irrigation Use BMPs on your site:

Step 1: Identify the total area of irrigated landscape on the site, and the type of landscaping used.

Total Area of Irrigated Landscape: Insert Area (Acres)

Type of Landscaping (Conservation Design or Active Turf): List Landscaping Type

Step 2: Identify the planned total of all impervious areas on the proposed project from which runoff might be feasibly captured and stored for irrigation use. Depending on the configuration of buildings and other impervious areas on the site, you may consider the site as a whole, or parts of the site, to evaluate reasonable scenarios for capturing and storing runoff and directing the stored runoff to the potential use(s) identified in Step 1 above.

Total Area of Impervious Surfaces: Insert Area (Acres)

Step 3: Cross reference the Design Storm depth for the project site (see Exhibit A of the WQMP Guidance Document) with the left column of Table 2-4 in Chapter 2 to determine the minimum area of Effective Irrigated Area per Tributary Impervious Area (EIATIA).

Enter your EIATIA factor: EIATIA Factor

Step 4: Multiply the unit value obtained from Step 3 by the total of impervious areas from Step 2 to develop the minimum irrigated area that would be required.

Minimum required irrigated area: Insert Area (Acres)

Step 5: Determine if harvesting stormwater runoff for irrigation use is feasible for the project by comparing the total area of irrigated landscape (Step 1) to the minimum required irrigated area (Step 4).

Minimum required irrigated area (Step 4)	**Available Irrigated Landscape (Step 1)**
Insert Area (Acres)	Insert Area (Acres)

Toilet Use Feasibility

Complete the following steps to determine the feasibility of harvesting stormwater runoff for toilet flushing uses on your site:

Step 1: Identify the projected total number of daily toilet users during the wet season, and account for any periodic shut downs or other lapses in occupancy:

Projected Number of Daily Toilet Users: Number of daily Toilet Users

Project Type: Enter 'Residential', 'Commercial', 'Industrial' or 'Schools'

Step 2: Identify the planned total of all impervious areas on the proposed Project from which runoff might be feasibly captured and stored for toilet use. Depending on the configuration of buildings and other impervious areas on the site, you may consider the Project site as a whole, or parts of the site, to evaluate reasonable scenarios for capturing and storing runoff and directing the stored runoff to the potential use(s) identified in Step 1 above.

Total Area of Impervious Surfaces: Insert Area (Acres)

Step 3: Enter the Design Storm depth for the project site (see Exhibit A) into the left column of Table 2-3 in Chapter 2 to determine the minimum number or toilet users per tributary impervious acre (TUTIA).

Enter your TUTIA factor: TUTIA Factor

Step 4: Multiply the unit value obtained from Step 3 by the total of impervious areas from Step 2 to develop the minimum number of toilet users that would be required.

Minimum number of toilet users: Required number of toilet users

Step 5: Determine if harvesting stormwater runoff for toilet flushing use is feasible for the Project by comparing the Number of Daily Toilet Users (Step 1) to the minimum required number of toilet users (Step 4).

Minimum required Toilet Users (Step 4)	**Projected number of toilet users (Step 1)**
Insert Area (Acres)	Insert Area (Acres)

Other Non-Potable Use Feasibility

Are there other non-potable uses for stormwater runoff on the site (e.g. industrial use)? See Chapter 2 of the Guidance for further information. If yes, describe below. If no, write N/A.

Insert narrative description here.

Step 1: Identify the projected average daily non-potable demand, in gallons per day, during the Wet Season and accounting for any periodic shut downs or other lapses in occupancy or operation.

Average Daily Demand: Projected Average Daily Use (gpd)

Step 2: Identify the planned total of all impervious areas on the proposed Project from which runoff might be feasibly captured and stored for the identified non-potable use. Depending on the configuration of buildings and other impervious areas on the site, you may consider the

Project site as a whole, or parts of the site, to evaluate reasonable scenarios for capturing and storing runoff and directing the stored runoff to the potential use(s) identified in Step 1 above.

Total Area of Impervious Surfaces: Insert Area (Acres)

Step 3: Enter the Design Storm Depth for the Project site (see Exhibit A) into the left column of Table 2-5 in Chapter 2 to determine the minimum demand for non-potable uses of stormwater runoff per tributary impervious acre.

Enter the factor from Table 2-3: Enter Value

Step 4: Multiply the unit value obtained from Step 4 by the total of impervious areas from Step 3 to develop the minimum gpd of non-potable use that would be required.

Minimum required use: Minimum use required (gpd)

Step 5: Determine if harvesting stormwater runoff for other non-potable use is feasible for the Project by comparing the Number of Daily Toilet Users (Step 1) to the minimum required number of toilet users (Step 4).

Minimum required non-potable use (Step 4)	**Projected average daily use (Step 1)**
Minimum use required (gpd)	Projected Average Daily Use (gpd)

If Irrigation, Toilet and Other Use feasibility anticipated demands are less than the applicable minimum values, Harvest and Use BMPs are not required and you should proceed to utilize LID Bioretention and Biotreatment BMPs, unless a site-specific analysis has been completed that demonstrates technical infeasibility as noted in D.3 below.

D.3 Bioretention and Biotreatment Assessment

Other LID Bioretention and Biotreatment BMPs as described in Chapter 2.3 of the WQMP Guidance Document are feasible on nearly all development sites with sufficient advance planning.

Select one of the following:

☐ LID Bioretention/Biotreatment BMPs will be used for some or all DMAs of the Project as noted below in Section D.4

☐ A site-specific analysis demonstrating the technical infeasibility of all LID BMPs has been performed and is included in Appendix 5. If you plan to submit an analysis demonstrating the technical infeasibility of LID BMPs, request a pre-submittal meeting with the Copermittee with jurisdiction over the Project site to discuss this option. Proceed to Section E to document your alternative compliance measures.

D.4 Other Limiting Geotechnical Conditions

Onsite retention may not be feasible due to specific geotechnical concerns identified in the Geotechnical Report. If any, describe below. If no, write N/A:

Insert narrative description here.

Table D.2 Geotechnical Concerns for Onsite Retention Table

Type of Geotechnical Concern	DMAs Feasible (By Name or ID)	DMAs Infeasible (By Name or ID)
Collapsible Soil		
Expansive Soil		
Slopes		
Liquefaction		
Other		

D.5 Feasibility Assessment Summaries

From the Infiltration, Harvest and Use, Bioretention and Biotreatment Sections above, complete Table D.3 below to summarize which LID BMPs are technically feasible, and which are not, based upon the established hierarchy.

Table D.3 LID Prioritization Summary Matrix

DMA Name/ID	LID BMP Hierarchy				No LID (Alternative Compliance)
	1. Infiltration	2. Harvest and use	3. Bioretention	4. Biotreatment	
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

For those DMAs where LID BMPs are not feasible, provide a brief narrative below summarizing why they are not feasible, include your technical infeasibility criteria in Appendix 5, and proceed to Section E below to document Alternative Compliance measures for those DMAs. Recall that each proposed DMA must pass through the LID BMP hierarchy before alternative compliance measures may be considered.

Insert narrative description here.

D.6 LID BMP Sizing

Each LID BMP must be designed to ensure that the DCV will be addressed by the selected BMPs. First**,** calculate the DCV for each LID BMP using the V_{BMP} worksheet in Appendix F of the LID BMP Design Handbook. Second**,** design the LID BMP to meet the required V_{BMP} using a method approved by the Copermittee with jurisdiction over the Project site. Utilize the worksheets found in the LID BMP Design Handbook or consult with the Copermittee to assist you in correctly sizing your LID BMPs. Complete Table D.4 below to document the DCV and the Proposed Volume for each LID BMP. Provide the completed design procedure sheets for each LID BMP in Appendix 6. You may add additional rows to the table below as needed.

Table D.4 DCV Calculations for LID BMPs

DMA Type/ID	**DMA (square feet)**	**Post-Project Surface Type**	**Effective Impervious Fraction, I_f**	**DMA Runoff Factor**	**DMA Areas x Runoff Factor**	***Enter BMP Name / Identifier Here***		
	[A]		[B]	[C]	[A] x [C]			
						Design Storm Depth (in)	*DCV, $\mathbf{V_{BMP}}$ (cubic feet)*	*Proposed Volume on Plans (cubic feet)*
	$A_T = \Sigma[A]$				$\Sigma = [D]$	[E]	$[F] = \frac{[D]x[E]}{12}$	[G]

[B], [C] is obtained as described in Section 2.5 of the WQMP Guidance Document
[E] is obtained from Exhibit A in the WQMP Guidance Document
[G] is obtained from a design procedure sheet, such as in LID BMP Design Handbook and placed in Appendix 6

Each LID BMP must be designed to ensure that the Design Capture Volume (DCV) will be addressed by the selected BMPs. First**,** calculate the Design Capture Volume for each LID BMP using the 'V_{BMP}' worksheet in Appendix F of the LID BMP Design Handbook. Second**,** design the LID BMP to meet the required V_{BMP} using a method approved by the Copermittee. Utilize the worksheets found in the LID BMP Design Handbook or consult with your Copermittee. Complete Table D.5 below to document the Design Capture Volume and the Proposed Volume for each LID BMP. You can add rows to the table as needed. Alternatively, the Santa Margarita Hydrology Model (SMRHM) can be used to size LID BMPs to address the DCV and, if applicable, to size Hydrologic Control BMPs to meet the Hydrologic Performance Standard of the SMR HMP, as identified in Section E.

Table D.5 LID BMP Sizing

BMP Name / ID	DMA No.	BMP Type / Description	Design Capture Volume (ft^3)	Proposed Volume (ft^3)

Section E: Implement Hydrologic Control BMPs and Sediment Supply BMPs

If a completed Table A.2 demonstrates that the project is exempt from HMP Performance Standards, specify N/A of proceed to Section F, if applicable, and Section G.

E.1 Onsite Feasibility of Hydrologic Control BMPs

An assessment of the feasibility of implementing onsite Hydrologic Control BMPs is required for all projects.

Select one of the following:

☐ Yes – The implementation of Hydrologic Control BMPs is feasible onsite. *(Proceed to Step E.3 and Step E.4)*

\- *Or* -

☐ No – The project site is larger than one acre and the implementation of Hydrologic Control BMPs is not feasible onsite. *(Proceed to Step E.5 and Step F for Alternative Compliance upon approval of the Technical Feasibility Assessment by the Copermittee)*

☐ No – The project site is smaller than one acre and the implementation of Hydrologic Control BMPs is not feasible onsite. *(Proceed to Step E.2)*

If the reasons for infeasibility are different from those listed in Section D.1, describe the technical or spatial reasons that preclude the implementation of onsite Hydrologic Control BMPs. If none, write N/A:

Insert narrative description here.

Approval of the condition for infeasibility, if any, is required by the Copermittee. Has the condition for infeasibility been approved by the Copermittee?

☐ Y ☐ N ☐ N/A

E.2 Meeting the HMP Performance Standard for Small Project Sites

Select one of the following:

☐ Yes – The project site is equal to or larger than one acre. *(Proceed to Step E.3, Step E.4, and Step E.5)*

\- *Or* -

☐ No – The project site is less than one acre. *(Follow the remainder of Step E.2)*

Only a Simplified Technical Feasibility Study is required from the applicant. Complete the Simplified Technical Feasibility Study in Appendix 7, which must include, at a minimum, the soil conditions at the PDP, a demonstration of the lack of available space for onsite Hydrologic Control BMPs, an explanation of prohibitive costs to implement Hydrologic Control BMPs, and a written opinion from a Registered Geotechnical Engineer identifying the infeasibility due to geotechnical concerns.

Select one of the following:

☐ Yes – Onsite Hydrologic Control BMPs are feasible. *(Proceed to Step E., Step E.4, and Step E.5)*

\- *Or* -

☐ No – Onsite Hydrologic Control BMPs are not feasible per the Simplified Technical Feasibility Study. *(Proceed to Section E.5 for Sediment Supply Performance Standard and Section F for Alternative Compliance)*

E.3 Hydrologic Control BMP Selection

Capture of the DCV and achievement of the Hydrologic Performance Standard may be met by combined and/or separate structural BMPs. Similarly, compliance with the two identified requirements may be fully or partially achieved onsite.

For each DMA, identify in Table E.1 if the DCV is fully or partially captured onsite, if the Hydrologic Performance Standard is fully or partially met onsite (by using the SMRHM identified in Step E.4), and if structural BMPs for compliance with the LID requirement and the Hydrologic Performance Standard are combined.

Table E.1 LID & Hydromodification BMP Location

DMA	LID BMP	Hydrologic Control BMP	Combined BMP	BMP type and ID
	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Yes ☐ No	Identify the ID and type of Hydrologic Control BMP to mitigate 1st DMA
	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Yes ☐ No	Identify the ID and type of Hydrologic Control BMP to mitigate 2nd DMA
	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Onsite ☐ Partially Onsite ☐ Offsite ☐ None Required	☐ Yes ☐ No	Identify the ID and type of Hydrologic Control BMP to mitigate 3rd DMA

For each DMA provide a narrative describing if the DCV and the Hydrologic Performance Standard are to be fully managed onsite. If not, the narrative should detail how and where offsite structural BMPs will achieve management of the DCV and the Hydrologic Performance Standard.

DMA #1 - Insert narrative description here

DMA #2 - Insert narrative description here

DMA #3 - Insert narrative description here

E.4 Hydrologic Control BMP Sizing

Each Hydrologic Control BMP must be designed to ensure that the flow duration curve of the post-development DMA will not exceed that of the pre-existing, naturally occurring, DMA by more than ten percent over a one-year period. Using SMRHM, the applicant shall demonstrate that the performance of each designed Hydrologic Control BMP complies with the Hydrologic Performance Standard. Complete Table E.2 below and identify, for each DMA, the type of Hydrologic Control BMP, if the SMRHM model confirmed the management (Identified as "passed" in SMRHM), the total volume capacity of the Hydrologic Control BMP, the Hydrologic Control BMP footprint at top floor elevation, and the drawdown time of the Hydrologic Control BMP. SMRHM summary reports should be documented in Appendix 7. Refer to the SMRHM Guidance Document for additional information on SMRHM. You can add rows to the table as needed.

Table E.2 Hydrologic Control BMP Sizing

BMP Name / ID	DMA No.	BMP Type / Description	SMRHM Passed	BMP Volume (ac-ft)	BMP Footprint (ac)	Drawdown time (hr)
			☐			
			☐			
			☐			
			☐			

E.5 Implement Sediment Supply BMPs

The applicant may refer to Section 2.3 of the SMR HMP for a comprehensive description of the methodology to meet the Sediment Supply Performance Standard. Complete the following steps to determine compliance with the Sediment Supply Performance Standard:

Step 1: Identify if the site is a Significant Source of Bed Sediment Supply to the receiving channel

☐ Step 1.A – Is the Bed Sediment of onsite streams similar to that of receiving streams?

Rate the similarity: ☐ High
☐ Medium
☐ Low

Results from the geotechnical and sieve analysis to be performed both onsite and in the receiving channel should be documented in Appendix 7. Of particular interest, the results of the sieve analysis, the soil erodibility factor, a description of the topographic relief of the project area, and the lithology of onsite soils should be reported in Appendix 7.

☐ Step 1.B – Are onsite streams capable of delivering Bed Sediment Supply from the site, if any, to the receiving channel?

Rate the potential: ☐ High
☐ Medium
☐ Low

Results from the analyses of the sediment delivery potential to the receiving channel should be documented in Appendix 7 and identify, at a minimum, the Sediment Source, the distance to the receiving channel, the onsite channel density, the project watershed area, the slope, length, land use, and rainfall intensity.

☐ Step 1.C – Will the receiving channel adversely respond to a change in Bed Sediment Load?

Rate the need for bed sediment supply:
☐ High
☐ Medium
☐ Low

Results from the in-stream analysis to be performed both onsite should be documented in Appendix 7. The analysis should, at a minimum, quantify the bank stability and the degree of incision, provide a gradation of the Bed Sediment within the receiving channel, and identify if the channel is sediment supply-limited.

☐ Step 1.D – Summary of Step 1

Summarize in Table E.3 the findings of Step 1 and associate a score (in parenthesis) to each step. The sum of the three individual scores determines if a stream is a significant contributor to the receiving stream.

- Sum is equal to or greater than eight - Site is a significant source of sediment bed material – all on-site streams must be preserved or by-passed within the site plan. The applicant shall proceed to Step 2 for all onsite streams.
- Sum is greater than five but lower than eight. Site is a source of sediment bed material – some of the on-site streams must be preserved (with identified streams noted). The applicant shall proceed to Step 2 for the identified streams only.
- Sum is equal to or lower than five. Site is not a significant source of sediment bed material. The applicant may advance to Section F.

Table E.3 Triad Assessment Summary

Step	Rating			Total Score
1.A	☐ High (3)	☐ Medium (2)	☐ Low (1)	
1.B	☐ High (3)	☐ Medium (2)	☐ Low (1)	
1.C	☐ High (3)	☐ Medium (2)	☐ Low (1)	
Significant Source Rating of Bed Sediment to the receiving channel(s)				

Step 2: Preservation of Identified Onsite Channels

Onsite streams identified as a Significant Source of Bed Sediment should be avoided in the site design.

Check one of the following:

☐ The site design does avoid all onsite channels identified as a Significant Source of Bed Sediment *(The applicant may disregard subsequent steps of Section E.5 and directly advance directly to Section F.*)

- *Or* -

☐ The site design **does NOT avoid** all onsite channels identified as a Significant Source of Bed Sediment *(The applicant may proceed with the subsequent steps of Section E.5).*

Provide in Appendix 7 a site map that identifies all onsite channels and highlights those onsite channels that were identified as a Significant Source of Bed Sediment. The site map shall demonstrate, if feasible, that the site design avoids those onsite channels identified as a Significant Source of Bed Sediment. In addition, the applicant shall describe the characteristics of each onsite channel identified as a Significant Source of Bed Sediment. If the design plan cannot avoid the onsite channels, please provide a rationale for each channel individually.

Identified Channel #1 - Insert narrative description here

Identified Channel #2 - Insert narrative description here

Identified Channel #3 - Insert narrative description here

Step 3: By-Pass of Upstream Drainage(s) to Preserve the discharge of Bed Sediment Supply to the receiving channel(s)

Onsite channels identified as a Significant Source of Bed Sediment Supply should be by-passed the discharge of Bed Sediment Supply to the receiving channel(s).

Check one of the following:

☐ The site design does avoid and/or bypass all onsite channels identified as a source of Bed Sediment Supply *(The applicant may directly advance to Section F.*)

- *Or* -

☐ The site design **does NOT avoid or by-pass** all onsite channels identified as a source of Bed Sediment Supply *(The applicant may proceed to an Alternative Approach, as defined in Section F).*

Provide in Appendix 7 a site map that identifies all onsite channels and highlights those onsite channels that were identified as a Significant Source of Bed Sediment Supply. The site map shall demonstrate, if feasible, that the site design avoids or by-passes those onsite channels of significant Bed Sediment Supply to the receiving channel(s). In addition, the applicant shall describe the characteristics of each onsite channel identified as a Significant Source of Bed Sediment Supply. If the design plan cannot avoid or by-pass the onsite channels, please provide a rationale for each channel individually.

Identified Channel #1 - Insert narrative description here

Identified Channel #2 - Insert narrative description here

Identified Channel #3 - Insert narrative description here

Section F: Alternative Compliance

LID BMPs and Hydrologic Control BMPs are expected to be feasible on virtually all projects. Where LID BMPs and/or Hydrologic Control BMPs have been demonstrated to be infeasible as documented in Section D and/or Section E, respectively, other Treatment Control BMPs or alternative compliance approaches must be used (subject LID waiver and/or HMP alternative compliance approval by the Copermittee).

In addition, if supporting documentation demonstrates the infeasibility to implement Sediment Supply BMPs onsite (See Section E.5), the applicant may refer to Section F.5.

Check one of the following boxes:

☐ LID Principles, LID BMPs, Hydrologic Control BMPs, and Sediment Supply BMPs have been incorporated into the site design to fully address all Drainage Management Areas. No alternative compliance measures are required for this project and thus this Section is not required to be completed.

- *Or* -

☐ LID Principles and LID BMPs have NOT been incorporated into the site design to fully address the LID requirements for all Drainage Management Areas AND HMP Performance Standards are not fully addressed in the following Drainage Management Areas.

- The following Drainage Management Areas are unable to be addressed using LID BMPs. A site specific analysis demonstrating technical infeasibility of LID BMPs has been approved by the Copermittee and included in Appendix 5. The following alternative compliance measures on the following pages are being implemented to ensure that any pollutant loads expected to be discharged by not incorporating LID BMPs, are fully mitigated. The applicant should complete Section F.1, Section F.2, and Section F.3, as applicable.
- A site specific analysis demonstrating technical infeasibility of Hydrologic Control BMPs and Sediment Supply BMPs has been approved by the Copermittee and included in Appendix 7. Projects less than one acre have completed the Simplified Technical Feasibility Study. The applicant should complete Section F.5 and/or Section F.6, as applicable.

List DMAs Here.

- *Or* -

☐ LID Principles and LID BMPs have been incorporated into the site design to fully address the DCV for all Drainage Management Areas. However, HMP Performance Standards are not fully addressed in the following Drainage Management Areas. A site specific analysis demonstrating technical infeasibility of Hydrologic Control BMPs and Sediment Supply BMPs has been approved by the Copermittee and included in Appendix 7. Projects less than one acre have completed the Simplified Technical Feasibility. The applicant should complete Section F.5 and/or Section F.6, as applicable.

List DMAs Here.

F.1 Identify Pollutants of Concern

Utilizing Table A.1 from Section A above which noted your project's Receiving Waters and their associated USEPA approved 303(d) listed impairments, cross reference this information with that of your selected Priority Development Project Category in Table F.1 below. If the identified General Pollutant Categories are the same as those listed for your Receiving Waters, then these will be your Pollutants of Concern and the appropriate box or boxes will be checked on the last row. The purpose of this is to document compliance and to help you appropriately plan for mitigating your Pollutants of Concern in lieu of implementing LID BMPs.

Table F.1 Potential Pollutants by Land Use Type

Priority Development Project Categories and/or Project Features (check those that apply)	General Pollutant Categories							
	Bacterial Indicators	Metals	Nutrients	Pesticides	Toxic Organic Compounds	Sediments	Trash & Debris	Oil & Grease
☐ Detached Residential Development	P	N	P	P	N	P	P	P
☐ Attached Residential Development	P	N	P	P	N	P	P	P(2)
☐ Commercial/Industrial Development	P(3)	P	P(1)	P(1)	P(5)	P(1)	P	P
☐ Automotive Repair Shops	N	P	N	N	P(4, 5)	N	P	P
☐ Restaurants (>5,000 ft^2)	P	N	N	N	N	N	P	P
☐ Hillside Development (>5,000 ft^2)	P	N	P	P	N	P	P	P
☐ Parking Lots (>5,000 ft^2)	P(6)	P	P(1)	P(1)	P(4)	P(1)	P	P
☐ Retail Gasoline Outlets	N	P	N	N	P	N	P	P
Project Priority Pollutant(s) of Concern	☐	☐	☐	☐	☐	☐	☐	☐

P = Potential
N = Not Potential
(1) A potential Pollutant if non-native landscaping exists or is proposed onsite; otherwise not expected
(2) A potential Pollutant if the project includes uncovered parking areas; otherwise not expected
(3) A potential Pollutant is land use involving animal waste
(4) Specifically petroleum hydrocarbons
(5) Specifically solvents
(6) Bacterial indicators are routinely detected in pavement runoff

F.2 Stormwater Credits

Projects that cannot implement LID BMPs but nevertheless implement Smart Growth Principles are potentially eligible for Stormwater Credits. Utilize Table 3-7 within the WQMP Guidance Document to identify your Project Category and its associated Water Quality Credit. If not applicable, write N/A.

Table F.2 Stormwater Credits

Qualifying Project Categories	Credit Percentage[2]
Total Credit Percentage[1]	

[1] *Cannot Exceed 50%*
[2] *Obtain corresponding data from Table 3-7 in the WQMP Guidance Document*

F.3 Sizing Criteria

After you appropriately considered Stormwater Credits for your Project, utilize Table F.3 below to appropriately size them to the DCV, or Design Flow Rate, as applicable. Please reference Chapter 3.5.5 of the WQMP Guidance Document for further information.

Table F.3 Treatment Control BMP Sizing

DMA Type/ID	DMA (square feet)	Post-Project Surface Type	Effective Impervious Fraction, I_f	DMA Runoff Factor	DMA x Runoff Factor		*Enter BMP Name / Identifier Here*		
	[A]		[B]	[C]	[A] x [C]				
						Design Storm Depth (in)	*Minimum DCV or Design Flow Rate (cubic feet or cfs)*	*Total Storm Water Credit % Reduction*	*Proposed Volume or Flow on Plans (cubic feet or cfs)*
	A_T = Σ[A]				Σ= [D]	[E]	$[F] = \frac{[D]x[E]}{[G]}$	[F] X (1-[H])	[I]

[B], [C] is obtained as described in Section 2.5 from the WQMP Guidance Document
[E] is obtained from Exhibit A in the WQMP Guidance Document
[G] is for Flow-Based Treatment Control BMPs [G] = 43,560, for Volume-Based Control Treatment BMPs, [G] = 12
[H] is from the Total Stormwater Credit Percentage as Calculated from Table E.2 above
[I] as obtained from a design procedure sheet from the BMP manufacturer and should be included in Appendix 6

F.4 Treatment Control BMP Selection

Treatment Control BMPs typically provide proprietary treatment mechanisms to treat potential Pollutants in runoff, but do not sustain significant biological processes. Treatment Control BMPs must have a removal efficiency of a medium or high effectiveness as quantified below:

- **High**: equal to or greater than 80% removal efficiency
- **Medium**: between 40% and 80% removal efficiency

Such removal efficiency documentation (e.g., studies, reports, etc.) as further discussed in Chapter 3.5.2 of the WQMP Guidance Document, must be included in Appendix 6. In addition, ensure that proposed Treatment Control BMPs are properly identified on the WQMP Site Plan in Appendix 1.

Table F.4 Treatment Control BMP Selection

Selected Treatment Control BMP Name or ID[1]	Priority Pollutant(s) of Concern to Mitigate[2]	Removal Efficiency Percentage[3]

[1] Treatment Control BMPs must not be constructed within Receiving Waters. In addition, a proposed Treatment Control BMP may be listed more than once if they possess more than one qualifying pollutant removal efficiency.
[2] Cross Reference Table E.1 above to populate this column.
[3] As documented in a Copermittee Approved Study and provided in Appendix 6.

F.5 Hydrologic Performance Standard – Alternative Compliance Approach

Alternative compliance options are only available if the governing Copermittee has acknowledged the infeasibility of onsite Hydrologic Control BMPs and approved an alternative compliance approach. Attach to Appendix 7 the Technical Feasibility Study (Projects equal or greater than one acre) or Simplified Technical Feasibility Study (Projects less than one acre) along with a written approval from the Copermittee. The applicant may refer to Section 2.2.iv of the SMR HMP for extensive guidelines on the alternative compliance approach.

Select the pursued alternative and describe the specifics of the alternative:

☐ Offsite Hydrologic Control Management within the same channel system

Insert narrative description here

☐ In-Stream Restoration Project

Insert narrative description here

<u>For Offsite Hydrologic Control BMP Option</u>

Each Hydrologic Control BMP must be designed to ensure that the flow duration curve of the post-development DMA will not exceed that of the pre-existing, naturally occurring, DMA by more than ten percent over a one-year period. Using SMRHM, the applicant shall demonstrate that the performance of each designed Hydrologic Control BMP is equivalent with the Hydrologic Performance Standard for onsite conditions. Complete Table F.4 below and identify, for each Hydrologic Control BMP, the equivalent DMA the Hydrologic Control BMP mitigates, that the SMRHM model passed, the total volume capacity of the BMP, the BMP footprint at top floor elevation, and the drawdown time of the BMP. SMRHM summary reports for the alternative approach should be documented in Appendix 7. Refer to the SMRHM Guidance Document for additional information on SMRHM. You can add rows to the table as needed.

Table F.5 Offsite Hydrologic Control BMP Sizing

BMP Name / Type	Equivalent DMA (ac)	SMRHM Passed	BMP Volume (ac-ft)	BMP Footprint (ac)	Drawdown time (hr)
		☐			
		☐			
		☐			
		☐			

For Instream Restoration Option

Attach to Appendix 7 the technical report detailing the condition of the receiving channel subject to the proposed hydrologic and sediment regimes. Provide the full design plans for the in-stream restoration project that have been approved by the Copermittee.

F.6 Sediment Supply Performance Standard - Alternative Compliance

The alternative compliance option to the Sediment Supply Performance Standard is only available if the governing Copermittee has approved the investigation of alternative Bed Sediment Supply options. Attach to Appendix 7 the Technical Feasibility Study, along with the modeling analysis, the long-term monitoring program, and the potential corrective actions, that demonstrate the performance of the overall alternative compliance program. The applicant may refer to Section 2.3.ii of the SMR HMP for extensive guidelines on the alternative compliance approach.

Provide a narrative describing the alternative Bed Sediment Supply approach, including the long-term monitoring program and the findings of the numerical modeling.

Insert narrative description here

Section G: Source Control BMPs

Source Control BMPs include permanent, structural features that may be required in your Project plans — such as roofs over and berms around trash and recycling areas — and Operational BMPs, such as regular sweeping and "housekeeping", that must be implemented by the site's occupant or user. The Maximum Extent Practicable (MEP) standard typically requires both types of BMPs. In general, Operational BMPs cannot be substituted for a feasible and effective structural BMP. Using the Pollutant Sources/Source Control Checklist in Appendix 8, review the following procedure to specify Source Control BMPs for your site:

1. ***Identify Pollutant Sources*****:** Review Column 1 in the Pollutant Sources/Source Control Checklist. Check off the potential sources of Pollutants that apply to your site.

2. ***Note Locations on Project-Specific WQMP Exhibit*****:** Note the corresponding requirements listed in Column 2 of the Pollutant Sources/Source Control Checklist. Show the location of each Pollutant source and each permanent Source Control BMP in your Project-Specific WQMP Exhibit located in Appendix 1.

3. ***Prepare a Table and Narrative*****:** Check off the corresponding requirements listed in Column 3 in the Pollutant Sources/Source Control Checklist. In the left column of Table G.1 below, list each potential source of Pollutants on your site (from those that you checked in the Pollutant Sources/Source Control Checklist). In the middle column, list the corresponding permanent, Structural Source Control BMPs (from Columns 2 and 3 of the Pollutant Sources/Source Control Checklist) used to prevent Pollutants from entering runoff. **Add additional narrative** in this column that explains any special features, materials or methods of construction that will be used to implement these permanent, Structural Source Control BMPs.

4. ***Identify Operational Source Control BMPs:*** To complete your table, refer once again to the Pollutant Sources/Source Control Checklist. List in the right column of your table the Operational BMPs that should be implemented as long as the anticipated activities continue at the site. Copermittee stormwater ordinances require that applicable Source Control BMPs be implemented; the same BMPs may also be required as a condition of a use permit or other revocable Discretionary Approval for use of the site.

Table G.1 Structural and Operational Source Control BMP

Potential Sources of Runoff Pollutants	Structural Source Control BMPs	Operational Source Control BMPs

Section H: Construction Plan Checklist

Populate Table H.1 below to assist the plan checker in an expeditious review of your project. The first two columns will contain information that was prepared in previous steps, while the last column will be populated with the corresponding plan sheets. This table is to be completed with the submittal of your final Project-Specific WQMP.

Table H.1 Construction Plan Cross-reference

BMP No. or ID	BMP Identifier and Description	Corresponding Plan Sheet(s)

Note that the updated table — or Construction Plan WQMP Checklist — is **only a reference tool** to facilitate an easy comparison of the construction plans to your Project-Specific WQMP. The Copermittee with jurisdiction over the Project site can advise you regarding the process required to propose changes to the approved Project-Specific WQMP.

Section I: Operation, Maintenance and Funding

The Copermittee with jurisdiction over the Project site will periodically verify that BMPs on your Project are maintained and continue to operate as designed. To make this possible, the Copermittee will require that you include in Appendix 9 of this Project-Specific WQMP:

1. A means to finance and implement maintenance of BMPs in perpetuity, including replacement cost.
2. Acceptance of responsibility for maintenance from the time the BMPs are constructed until responsibility for operation and maintenance is legally transferred. A warranty covering a period following construction may also be required.
3. An outline of general maintenance requirements for the Stormwater BMPs you have selected.
4. Figures delineating and designating pervious and impervious areas, location, and type of Stormwater BMP, and tables of pervious and impervious areas served by each facility. Geo-locating the BMPs using a coordinate system of latitude and longitude is recommended to help facilitate a future statewide database system.
5. A separate list and location of self-retaining areas or areas addressed by LID Principles that do not require specialized Operations and Maintenance or inspections but will require typical landscape maintenance as noted in Chapter 5, in the WQMP Guidance. Include a brief description of typical landscape maintenance for these areas.

The Copermittee with jurisdiction over the Project site will also require that you prepare and submit a detailed BMP Operation and Maintenance Plan that sets forth a maintenance schedule for each of the BMPs built on your site. An agreement assigning responsibility for maintenance and providing for inspections and certification may also be required.

Details of these requirements and instructions for preparing a BMP Operation and Maintenance Plan are in Chapter 5 of the WQMP Guidance Document.

Maintenance Mechanism: Insert text here.

Will the proposed BMPs be maintained by a Homeowners' Association (HOA) or Property Owners Association (POA)?

☐ Y ☐ N

Include your Operation and Maintenance Plan and Maintenance Mechanism in Appendix 9. Additionally, include all pertinent forms of educational materials for those personnel that will be maintaining the proposed BMPs within this Project-Specific WQMP in Appendix 10.

Acronyms, Abbreviations and Definitions

2010 SMR MS4 Permit	Order No. R9-2010-0016, an NPDES Permit issued by the San Diego Regional Water Quality Control Board.
Applicant	Public or private entity seeking the discretionary approval of new or replaced improvements from the Copermittee with jurisdiction over the project site. The Applicant has overall responsibility for the implementation and the approval of a Priority Development Project. The WQMP uses consistently the term "user" to refer to the applicant such as developer or project proponent. The WQMP employs also the designation "user" to identify the Registered Professional Civil Engineer responsible for submitting the Project-Specific WQMP, and designing the required BMPs.
Best Management Practice (BMP)	Defined in 40 CFR 122.2 as schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. In the case of municipal storm water permits, BMPs are typically used in place of numeric effluent limits.
BMP Fact Sheets	BMP Fact Sheets are available in the LID BMP Design Handbook. Individual BMP Fact Sheets include sitting considerations, and design and sizing guidelines for seven types of structural BMPs (infiltration basin, infiltration trench, permeable pavement, harvest-and-use, bioretention, extended detention basin, and sand filter).
California Stormwater Quality Association (CASQA)	Publisher of the California Stormwater Best Management Practices Handbooks, available at www.cabmphandbooks.com.
Conventional Treatment Control BMP	A type of BMP that provides treatment of stormwater runoff. Conventional treatment control BMPs, while designed to treat particular Pollutants, typically do not provide the same level of volume reduction as LID BMPs, and commonly require more specialized maintenance than LID BMPs. As such, the 2010 SMR MS4 Permit and this WQMP require the use of LID BMPs wherever feasible, before Conventional Treatment BMPs can be considered or implemented.
Copermittees	The 2010 SMR MS4 Permit identifies the Cities of Murrieta, Temecula, and Wildomar, the County, and the District, as Copermittees for the SMR.
County	The abbreviation refers to the County of Riverside in this document.
CEQA	California Environmental Quality Act - a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

CIMIS	California Irrigation Management Information System - an integrated network of 118 automated active weather stations all over California managed by the California Department of Water Resources.
CWA	Clean Water Act - is the primary federal law governing water pollution. Passed in 1972, the CWA established the goals of eliminating releases of high amounts of toxic substances into water, eliminating additional water pollution by 1985, and ensuring that surface waters would meet standards necessary for human sports and recreation by 1983. CWA Section 402(p) is the federal statute requiring NPDES permits for discharges from MS4s.
CWA Section 303(d) Waterbody	Impaired water in which water quality does not meet applicable water quality standards and/or is not expected to meet water quality standards, even after the application of technology based pollution controls required by the CWA. The discharge of urban runoff to these water bodies by the Copermittees is significant because these discharges can cause or contribute to violations of applicable water quality standards.
Design Storm	The 2010 SMR MS4 Permit has established the 85th percentile, 24-hour storm event as the "Design Storm". The applicant may refer to Exhibit A to identify the applicable Design Storm Depth (D85) to the project.
DCV	Design Capture Volume (DCV) is the volume of runoff produced from the Design Storm to be mitigated through LID Retention BMPs, Other LID BMPs and Volume Based Conventional Treatment BMPs, as appropriate.
Design Flow Rate	The design flow rate represents the minimum flow rate capacity that flow-based conventional treatment control BMPs should treat to the MEP, when considered.
DCIA	Directly Connected Impervious Areas - those impervious areas that are hydraulically connected to the MS4 (i.e. street curbs, catch basins, storm drains, etc.) and thence to the structural BMP without flowing over pervious areas.
Discretionary Approval	A decision in which a Copermittee uses its judgment in deciding whether and how to carry out or approve a project.
District	Riverside County Flood Control and Water Conservation District.
DMA	A Drainage Management Area - a delineated portion of a project site that is hydraulically connected to a common structural BMP or conveyance point. The Applicant may refer to Section 3.3 for further guidelines on how to delineate DMAs.

Drawdown Time	Refers to the amount of time the design volume takes to pass through the BMP. The specified or incorporated drawdown times are to ensure that adequate contact or detention time has occurred for treatment, while not creating vector or other nuisance issues. It is important to abide by the drawdown time requirements stated in the fact sheet for each specific BMP.
Effective Area	Area which 1) is suitable for a BMP (for example, if infiltration is potentially feasible for the site based on infeasibility criteria, infiltration must be allowed over this area) and 2) receives runoff from impervious areas.
ESA	An Environmental Sensitive Area (ESA) designates an area "in which plants or animals life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which would be easily disturbed or degraded by human activities and developments". (Reference: California Public Resources Code § 30107.5).
ET	Evapotranspiration (ET) is the loss of water to the atmosphere by the combined processes of evaporation (from soil and plant surfaces) and transpiration (from plant tissues). It is also an indicator of how much water crops, lawn, garden, and trees need for healthy growth and productivity
FAR	The Floor Area Ratio (FAR) is the total square feet of a building divided by the total square feet of the lot the building is located on.
Flow-Based BMP	Flow-based BMPs are conventional treatment control BMPs that are sized to treat the design flow rate.
FPPP	Facility Pollution Prevention Plan
HCOC	Hydrologic Condition of Concern - Exists when the alteration of a site's hydrologic regime caused by development would cause significant impacts on downstream channels and aquatic habitats, alone or in conjunction with impacts of other projects.
HMP	Hydromodification Management Plan – Plan defining Performance Standards for PDPs to manage increases in runoff discharge rates and durations.
Hydrologic Control BMP	BMP to mitigate the increases in runoff discharge rates and durations and meet the Performance Standards set forth in the HMP.
HSG	Hydrologic Soil Groups – soil classification to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSGs are A (very low runoff potential/high infiltration rate), B, C, and D (high runoff potential/very low infiltration rate)
Hydromodification	The 2010 SMR MS4 Permit identifies that increased volume, velocity, frequency and discharge duration of storm water runoff from developed areas has the potential to greatly accelerate downstream erosion, impair stream habitat in natural drainages, and negatively impact beneficial uses.

JRMP	A separate Jurisdictional Runoff Management Plan (JRMP) has been developed by each Copermittee and identifies the local programs and activities that the Copermittee is implementing to meet the 2010 SMR MS4 Permit requirements.
LID	Low Impact Development (LID) is a site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques. LID site design BMPs help preserve and restore the natural hydrologic cycle of the site, allowing for filtration and infiltration which can greatly reduce the volume, peak flow rate, velocity, and pollutant loads of storm water runoff.
LID BMP	A type of stormwater BMP that is based upon Low Impact Development concepts. LID BMPs not only provide highly effective treatment of stormwater runoff, but also yield potentially significant reductions in runoff volume – helping to mimic the pre-project hydrologic regime, and also require less ongoing maintenance than Treatment Control BMPs. The applicant may refer to Chapter 2.
LID BMP Design Handbook	The LID BMP Design Handbook was developed by the Copermittees to provide guidance for the planning, design and maintenance of LID BMPs which may be used to mitigate the water quality impacts of PDPs within the County.
LID Bioretention BMP	LID Bioretention BMPs are bioretention areas are vegetated (i.e., landscaped) shallow depressions that provide storage, infiltration, and evapotranspiration, and provide for pollutant removal (e.g., filtration, adsorption, nutrient uptake) by filtering stormwater through the vegetation and soils. In bioretention areas, pore spaces and organic material in the soils help to retain water in the form of soil moisture and to promote the adsorption of pollutants (e.g., dissolved metals and petroleum hydrocarbons) into the soil matrix. Plants use soil moisture and promote the drying of the soil through transpiration. The 2010 SMR MS4 Permit defines "retain" as to keep or hold in a particular place, condition, or position without discharge to surface waters.
LID Biotreatment BMP	BMPs that reduce stormwater pollutant discharges by intercepting rainfall on vegetative canopy, and through incidental infiltration and/or evapotranspiration, and filtration, and other biological and chemical processes. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, biodegraded, and sequestered by the soil and plants, and collected through an underdrain.
LID Harvest and Reuse BMP	BMPs used to facilitate capturing Stormwater Runoff for later use without negatively impacting downstream water rights or other Beneficial Uses.

LID Infiltration BMP	BMPs to reduce stormwater runoff by capturing and infiltrating the runoff into in-situ soils or amended onsite soils. Typical LID Infiltration BMPs include infiltration basins, infiltration trenches and pervious pavements.
LID Retention BMP	BMPs to ensure full onsite retention without runoff of the DCV such as infiltration basins, bioretention, chambers, trenches, permeable pavement and pavers, harvest and reuse.
LID Principles	Site design concepts that prevent or minimize the causes (or drivers) of post-construction impacts, and help mimic the pre-development hydrologic regime.
MEP	Maximum Extent Practicable - standard established by the 1987 amendments to the CWA for the reduction of Pollutant discharges from MS4s. Refer to Attachment C of the 2010 SMR MS4 Permit for a complete definition of MEP.
MF	Multi-family – zoning classification for parcels having 2 or more living residential units.
MS4	Municipal Separate Storm Sewer System (MS4) is 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 CWA 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 (POTW) as defined at 40 CFR 122.26.
New Development Project	Defined by the 2010 MS4 permit as 'Priority Development Projects' if the project, or a component of the project meets the categories and thresholds described in Section 1.1.1.
NPDES	National Pollution Discharge Elimination System - Federal 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 CWA.
NRCS	Natural Resources Conservation Service
PDP	Priority Development Project - Includes New Development and Redevelopment project categories listed in Section F.1.d(2) of Order No. R9-2009-0002.

Priority Pollutants of Concern	Pollutants expected to be present on the project site and for which a downstream water body is also listed as Impaired under the CWA Section 303(d) list or by a TMDL.
Project-Specific WQMP	A plan specifying and documenting permanent LID Principles and Stormwater BMPs to control post-construction Pollutants and stormwater runoff for the life of the PDP, and the plans for operation and maintenance of those BMPs for the life of the project.
Receiving Waters	Waters of the United States.
Redevelopment Project	The creation, addition, and or replacement of impervious surface on an already developed site. Examples include the expansion of a building footprint, road widening, the addition to or replacement of a structure, and creation or addition of impervious surfaces. Replacement of impervious surfaces includes any activity that is not part of a routine maintenance activity where impervious material(s) are removed, exposing underlying soil during construction. Redevelopment does not include trenching and resurfacing associated with utility work; resurfacing existing roadways; new sidewalk construction, pedestrian ramps, or bike lane on existing roads; and routine replacement of damaged pavement, such as pothole repair. Project that meets the criteria described in Section 1.
Runoff Fund	Runoff Funds have not been established by the Copermittees and are not available to the Applicant. If established, a Runoff Fund will develop regional mitigation projects where PDPs will be able to buy mitigation credits if it is determined that implementing onsite controls is infeasible.
San Diego Regional Board	San Diego Regional Water Quality Control Board - The term "Regional Board", as defined in Water Code section 13050(b), is intended to refer to the California Regional Water Quality Control Board for the San Diego Region as specified in Water Code Section 13200. State agency responsible for managing and regulating water quality in the SMR.
SCCWRP	Southern California Coastal Water Research Project
Site Design BMP	Site design BMPs prevent or minimize the causes (or drivers) of post-construction impacts, and help mimic the pre-development hydrologic regime.
SF	Parcels with a zoning classification for a single residential unit.
SMC	Southern California Stormwater Monitoring Coalition
SMR	The Santa Margarita Region (SMR) represents the portion of the Santa Margarita Watershed that is included within the County of Riverside.

Source Control BMP	Source Control BMPs land use or site planning practices, or structural or nonstructural measures that aim to prevent runoff pollution by reducing the potential for contamination at the source of pollution. Source control BMPs minimize the contact between Pollutants and runoff.
Stormwater Credit	Stormwater Credit can be claimed by an Applicant if certain development practices that provide broad-scale environmental benefits to communities are incorporated into the project design. Refer to Section 3.5.4 for additional information on Stormwater Credits.
Structural BMP	Structures designed to remove pollutants from stormwater runoff and mitigate hydromodification impacts.
SWPPP	Storm Water Pollution Prevention Plan
Tentative Tract Map	Tentative Tract Maps are required for all subdivision creating five (5) or more parcels, five (5) or more condominiums as defined in Section 783 of the California Civil Code, a community apartment project containing five (5) or more parcels, or for the conversion of a dwelling to a stock cooperative containing five (5) or more dwelling units.
TMDL	Total Maximum Daily Load - the maximum amount of a Pollutant that can be discharged into a waterbody from all sources (point and non-point) and still maintain Water Quality Standards. Under CWA Section 303(d), TMDLs must be developed for all waterbodies that do not meet Water Quality Standards after application of technology-based controls.
USEPA	United States Environmental Protection Agency
Volume-Based BMP	Volume-Based BMPs applies to BMPs where the primary mode of pollutant removal depends upon the volumetric capacity such as detention, retention, and infiltration systems.
WQMP	Water Quality Management Plan
Wet Season	The 2010 SMR MS4 Permit defines the wet season from October 1 through April 30.

Appendix 1: Maps and Site Plans

Location Map, WQMP Site Plan and Receiving Waters Map

Appendix 2: Construction Plans

Grading and Drainage Plans

Appendix 3: Soils Information

Geotechnical Study and Other Infiltration Testing Data

Appendix 4: Historical Site Conditions

Phase I Environmental Site Assessment or Other Information on Past Site Use

Appendix 5: LID Infeasibility

LID Technical Infeasibility Analysis

Appendix 6: BMP Design Details

BMP Sizing, Design Details and other Supporting Documentation

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Pollutant Sources/Source Control Checklist

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Appendix 10: Educational Materials

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Appendix 8

STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

How to use this worksheet (also see instructions in Section G of the 2014 SMR WQMP Template):

1. Review Column 1 and identify which of these potential sources of stormwater pollutants apply to your site. Check each box that applies.
2. Review Column 2 and incorporate all of the corresponding applicable BMPs in your WQMP Exhibit.
3. Review Columns 3 and 4 and incorporate all of the corresponding applicable permanent controls and operational BMPs in your WQMP. Use the format shown in Table G.1on page 31 of this WQMP Template. Describe your specific BMPs in an accompanying narrative, and explain any special conditions or situations that required omitting BMPs or substituting alternative BMPs for those shown here.

IF THESE SOURCES WILL BE ON THE PROJECT SITE ...	... THEN YOUR WQMP SHOULD INCLUDE THESE SOURCE CONTROL BMPs, AS APPLICABLE		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ A. **On-site storm drain inlets**	❑ **Locations of inlets.**	❑ **Mark all inlets with the words "Only Rain Down the Storm Drain" or similar. Catch Basin Markers may be available from the Riverside County Flood Control and Water Conservation District, call 951.955.1200 to verify.**	❑ **Maintain and periodically repaint or replace inlet markings.** ❑ **Provide stormwater 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."**
❑ B. **Interior floor drains and elevator shaft sump pumps**		❑ **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.**
❑ C. **Interior parking garages**		❑ **State that parking garage floor drains will be plumbed to the sanitary sewer.**	❑ **Inspect and maintain drains to prevent blockages and overflow.**

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1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ D1. **Need for future indoor & structural pest control**		❑ **Note building design features that discourage entry of pests.**	❑ **Provide Integrated Pest Management information to owners, lessees, and operators.**
❑ D2. **Landscape/ Outdoor Pesticide Use**	❑ **Show locations of native trees or areas of shrubs and ground cover to be undisturbed and retained.** ❑ **Show self-retaining landscape areas, if any.** ❑ **Show stormwater treatment and hydrograph modification management BMPs. (See instructions in Chapter 3, Step 5 and guidance in Chapter 5.)**	**State that final landscape plans will accomplish all of the following.** ❑ **Preserve existing native 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 stormwater pollution.** ❑ **Where landscaped areas are used to retain or detain stormwater, specify plants that are tolerant of saturated soil conditions.** ❑ **Consider using pest-resistant plants, especially adjacent to hardscape. To insure 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 "What you should know for…..Landscape and Gardening"** at **http://www.rcflood.org/stormwater/Downloads/LandscapeGardenBrochure.pdf** ❑ **Provide IPM information to new owners, lessees and operators.**

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IF THESE SOURCES WILL BE ON THE PROJECT SITE …	… THEN YOUR WQMP SHOULD INCLUDE THESE SOURCE CONTROL BMPs, AS APPLICABLE		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ E. Pools, spas, ponds, decorative fountains, and other water features.	❑ Show location of water feature and a sanitary sewer cleanout in an accessible area within 10 feet. (Exception: Public pools must be plumbed according to County Department of Environmental Health Guidelines.)	If the Co-Permittee 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 "Guidelines for Maintaining Your Swimming Pool, Jacuzzi and Garden Fountain" at http://www.rcflood.org/stormwater/Downloads/poolsandspas.pdf
❑ F. Food service	❑ 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 insure that the largest items can be accommodated.	❑ See the brochure, "The Food Service Industry Best Management Practices for: Restaurants, Grocery Stores, Delicatessens and Bakeries" at http://www.rcflood.org/stormwater/downloads/FoodServ.pdf Provide this brochure to new site owners, lessees, and operators.
❑ G. Refuse areas	❑ 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. ❑ 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

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1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ H. **Industrial processes.**	❑ **Show process area.**	❑ **If industrial processes are to be located on site, 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** See the brochure "Industrial & Commercial Facilities Best Management Practices for: Industrial, Commercial Facilities" at http://www.rcflood.org/stormwater/Downloads/IndustrialCommercialFacilities.pdf
❑ I. **Outdoor storage of equipment or materials. (See rows J and K for source control measures for vehicle cleaning, repair, and maintenance.)**	❑ **Show any outdoor storage areas, including how materials will be covered. Show how areas will be graded and bermed to prevent run-on or run-off from area.** ❑ **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 Hazardous Materials Programs for:** ▪ **Hazardous Waste Generation** ▪ **Hazardous Materials Release Response and Inventory** ▪ **California Accidental Release (CalARP)** ▪ **Aboveground Storage Tank** ▪ **Uniform Fire Code Article 80 Section 103(b) & (c) 1991** ▪ **Underground Storage Tank** www.cchealth.org/groups/hazmat/	❑ **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**

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1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ J. Vehicle and Equipment Cleaning	❑ 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 on-site 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 any measures taken to discourage on-site 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. Refer to "Outdoor Cleaning Activities and Professional Mobile Service Providers" for many of the Potential Sources of Runoff Pollutants categories below. Brochure can be found at http://www.rcflood.org/stormwater/downloads/OutdoorCleaningActivities.pdf ❑ Car dealerships and similar may rinse cars with water only.

IF THESE SOURCES WILL BE ON THE PROJECT SITE ...	... THEN YOUR WQMP SHOULD INCLUDE THESE SOURCE CONTROL BMPs, AS APPLICABLE		
1 Potential Sources of Runoff Pollutants	2 Permanent Controls—Show on WQMP Drawings	3 Permanent Controls—List in WQMP Table and Narrative	4 Operational BMPs—Include in WQMP Table and Narrative
❑ K. **Vehicle/Equipment Repair and Maintenance**	❑ **Accommodate all vehicle equipment repair and maintenance indoors. Or designate an outdoor work area and design the area to prevent run-on and runoff of stormwater.** ❑ **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 Stormwater Control Plan, 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.** **Refer to "Automotive Maintenance & Car Care Best Management Practices for Auto Body Shops, Auto Repair Shops, Car Dealerships, Gas Stations and Fleet Service Operations". Brochure can be found at http://rcflood.org/stormwater/** **Refer to Outdoor Cleaning Activities and Professional Mobile Service Providers for many of the Potential Sources of Runoff Pollutants categories below. Brochure can be found at http://rcflood.org/stormwater/**

IF THESE SOURCES WILL BE ON THE PROJECT SITE …	… THEN YOUR WQMP SHOULD INCLUDE THESE SOURCE CONTROL BMPs, AS APPLICABLE		
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❑ L. **Fuel Dispensing Areas**	❑ **Fueling areas[6] shall have impermeable floors (i.e., portland cement concrete or equivalent smooth impervious surface) that are: a) graded at the minimum slope necessary to prevent ponding; and b) separated from the rest of the site by a grade break that prevents run-on of stormwater to the maximum extent practicable.** ❑ **Fueling areas shall be covered by a canopy that extends a minimum of ten feet in each direction from each pump. [Alternative: The fueling area must be covered and the cover's minimum dimensions must be equal to or greater than the area within the grade break or fuel dispensing area[1].] The canopy [or cover] shall not drain onto the fueling area.**		❑ **The property owner shall dry sweep the fueling area routinely.** ❑ **See the Fact Sheet SD-30 , "Fueling Areas" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com**

[6] **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.**

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❑ M. **Loading Docks**	❑ **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 stormwater away from the loading area. Water from loading dock areas shall be drained to the sanitary sewer, or diverted and collected for ultimate discharge to the sanitary sewer.** ❑ **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**

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❑ N. **Fire Sprinkler Test Water**		❑ **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**
O. **Miscellaneous Drain or Wash Water or Other Sources** ❑ **Boiler drain lines** ❑ **Condensate drain lines** ❑ **Rooftop equipment** ❑ **Drainage sumps** ❑ **Roofing, gutters, and trim.** ❑ **Other sources**		❑ **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 equipment with potential to produce pollutants shall be roofed and/or have secondary containment.** ❑ **Any drainage sumps on-site 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.** ❑ **Include controls for other sources as specified by local reviewer.**	

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❑ P. **Plazas, sidewalks, and parking lots.**			❑ **Sweep plazas, sidewalks, and parking lots regularly to prevent accumulation of litter and debris. Collect debris from pressure washing to prevent entry into the storm drain system. Collect washwater containing any cleaning agent or degreaser and discharge to the sanitary sewer not to a storm drain.**

Design Handbook

for

Low Impact Development

Best Management Practices

Prepared by:

9/2011

Riverside County Flood Control and Water Conservation District

1995 Market Street

Riverside, CA 92501

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APPENDICES

Riverside County Design Handbook for

Low Impact Development Best Management Practices

1.0 Introduction

What is Low Impact Development?

According to the State Water Resources Control Board, Low Impact Development (LID) is:

> *… a sustainable practice that benefits water supply and contributes to water quality protection. Unlike traditional storm water management, which collects and conveys storm water runoff through storm drains, pipes, or other conveyances to a centralized storm water facility, LID takes a different approach by using site design and storm water management to maintain the site's pre-development runoff rates and volumes. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to the source of rainfall.*[1]

When implemented correctly on a site, LID provides two primary benefits: 1) The post-construction site hydrology will more closely mimic the pre-development hydrology, thus reducing the downstream erosion that may occur due to increased runoff from impervious surfaces; and 2) Pollutants in runoff from the site will be significantly reduced.

Additionally, the California Stormwater Quality Association (CASQA) LID Manual[2] identifies that a properly and effectively designed site will incorporate two forms of LID: LID Principles and LID BMPs. Whereas LID Principles focus on planning and designing a site in a manner that minimizes the causes, or drivers, of project impacts (sometimes referred to as site design), this Handbook discusses LID BMPs which are implemented to help mitigate any impacts that are otherwise unavoidable.

[1] State Water Resources Control Board, *Low Impact Development – Sustainable Storm Water Management*, 2010; http://www.waterboards.ca.gov/water_issues/programs/low_impact_development/index.shtml

[2] California Stormwater Quality Association, *Low Impact Development Manual for Southern California: Technical Guidance and Site Planning Strategies*, April 2010

About this Handbook

This Handbook supplements the Riverside County Water Quality Management Plan (WQMP) by providing guidance for the planning, design and maintenance of Low Impact Development (LID) BMPs which may be used to mitigate the water quality impacts of developments within Riverside County.

This Handbook is the culmination of over five years of research, wherein manuals, studies, and experts from across the country were consulted to identify the most effective LID BMPs and designs. Although there are many types of BMPs that can be considered LID, this research found that the BMPs that are likely to be the most effective for the life of the project are those that are integrated into the design of the site and passively remove pollutants from runoff (without human intervention) through natural processes such as infiltration, biofiltration, and evapotranspiration. Further, it was found that BMPs are only effective as a function of how well they are maintained. Proprietary BMPs, underground BMPs or BMPs that require complicated maintenance equipment and procedures are all much less likely to be appropriately maintained, therefore, less reliable for the protection of water quality.

Based on that research, this Handbook contains detailed information and designs for seven (7) LID BMPs that are designed to encourage replication of the site's natural hydrologic processes. This includes maximizing direct or incidental infiltration and evapotranspiration, and using vegetation and other biological processes to filter and absorb pollutants. For each BMP, pertinent information is provided such as the maximum tributary drainage area, siting considerations, design procedures, and maintenance requirements. This Handbook also includes detailed guidance for infiltration testing, and basin considerations. By following these standardized designs and procedures, the citizens of Riverside County can be assured that water quality will be protected to the maximum extent practicable.

Selecting appropriate LID BMPs

LID BMPs are a highly effective and naturally-based form of Treatment Control BMPs. Before selecting any particular BMPs for a site, refer to the WQMP applicable to the project (based on the watershed the project is located in). The WQMP may specify particular types of LID or Treatment Control BMPs that can or must be considered for use on the project. Such considerations may include whether or not the LID BMP will maximize on-site retention of runoff, or be based on the types of pollutants that the site may generate, types of pollutants that are impairing the downstream receiving waters, and which BMPs are effective at addressing those pollutants. Generally infiltration BMPs have advantages over other types of BMPs, including reduction of the volume and rate of runoff, as well as full treatment of all potential pollutants potentially contained in the stormwater runoff. It is recognized however that infiltration may not be feasible on sites, such as those with high groundwater, low infiltration rates, or located on compacted engineered fill. In those situations, harvest and use, bioretention and/or biotreatment based BMPs that provide opportunity for evapotranspiration and incidental infiltration may be a more feasible option. The WQMP may specify criteria that can be used to determine when particular BMPs are considered feasible.

Who should be involved in the selection, siting and design of LID BMPs?

Everyone involved with the project site development, including owners, architects, engineers, and geologists, should be informed about the proposed/required BMPs as early as possible in the planning of a project. This reduces the chance of costly redesign, the need for additional testing and produces a better and more integrated site overall. For most basins and all infiltration BMPs, it is important that the responsible engineer/geologist be made aware of the location of BMPs, so they can make design recommendations including setbacks and perform the appropriate infiltration testing, if required. Landscape architects will need to know the locations and types of proposed BMPs as these might change the types of plants that can be used. Owners must be made aware of the long term maintenance and total cost of ownership for the BMPs in order to make informed decisions during the BMP selection process.

Many of the BMP fact sheets reference the 'Engineering Authority' (EA). Who is the EA for my project?

The engineering authority for a project is the public agency responsible for reviewing and approving the proposed project. Usually the EA is the City/County wherein the project is located.

Do I need to do additional studies?

Most infiltration BMPs and basins will require a geotechnical report prepared by either a licensed geotechnical engineer, civil engineer or certified engineering geologist. The report must provide characterization of site specific soil conditions, recommendations of any required testing, and site specific recommendations for setbacks as well as commentary on slope stability and potential offsite impacts. See Infiltration Testing Requirements and Basin Guidelines in Appendices A and C, respectively, for more information.

Designing the BMPs

The BMPs in this Handbook are designed based on volume. Volume based BMPs are designed to capture a particular volume of stormwater runoff (referred to as V_{BMP}), and either infiltrate that volume, re-use the water, or slowly and naturally filter pollutants from that stormwater, and discharge the volume within a specified drawdown time.

This Handbook contains worksheets to assist the designer in determining the required V_{BMP} based on the location of the site. While there are likely significant direct or indirect volume reduction benefits associated with each of the included LID BMPs, these sizing worksheets are not intended to meet the requirements listed in the Hydraulic Conditions of Concern (HCOC) section of the WQMP.

Can I make my BMP smaller?

The worksheets in this Handbook calculate the minimum required size for each LID BMP based on the amount of runoff reaching the BMP. However, early and aggressive implementation of LID Principles (site design) during the planning stages of a project will translate directly to less runoff, and in turn will help minimize the required size of the BMPs. To further reduce the required size, consider looking for additional ways to increase the percentage of landscaped areas and porous surfaces on the site, and opportunities to drain impervious areas into pervious areas.

Can I place my BMP underground?

Under most circumstances, in areas of new development or significant redevelopment, the use of underground treatment control BMPs in lieu of the LID BMPs in this Handbook is not justifiable.

What are Drawdown Times?

Volume based BMPs are usually associated with a required drawdown time. The drawdown time refers to the amount of time the design volume takes to pass through the BMP. The specified or incorporated drawdown times are to ensure that adequate contact or detention time has occurred for treatment, while not creating vector or other nuisance issues. It is important to abide by the drawdown time requirements stated in the fact sheet for each specific BMP.

What is the tributary drainage area?

The tributary drainage area is the entire area that drains to the proposed onsite BMP. While small sites could be tributary to a single BMP, usually the site is broken up into several drainage management areas (DMAs), each draining to a discrete BMP. Although it is usually desirable to address offsite flows separately, if flows from offsite areas commingle with onsite flows they shall also be included in the sizing calculation. At the beginning of each fact sheet, the maximum (or minimum) tributary drainage area for each BMP is listed. The tributary areas for each BMP will be required to be clearly shown on one or more drainage exhibits. Such exhibits shall be clearly labeled to show which areas drain to which BMP.

What are pervious and impervious areas?

Project sites are made up of both pervious and impervious surfaces. The pervious portion of a site is where stormwater has the opportunity to infiltrate into the ground, such as but not limited to landscaped or natural areas. Impervious areas are where water has no opportunity to infiltrate and immediately becomes surface runoff. When a site is developed, the percentage of impervious area typically increases from the natural state. This higher impervious percentage increases the volume and flow rate of stormwater runoff.

2.0 Sizing Calculations

The following section includes sizing calculations for three regions: Santa Ana, Santa Margarita and Whitewater. These calculations are based on approved methodologies within the currently active Municipal Separate Storm Sewer System (MS4) permits for each of these three watershed regions of Riverside County. In this manual, all BMP designs are sized based on the design capture volume, V_{BMP}. However, there may be circumstances when flow based Treatment Control BMPs are utilized and therefore this section also includes guidelines for calculating the design flow rate, Q_{BMP}.

2.1 Calculating V_{BMP}

Volume based BMPs, including all of the BMPs in this manual, are sized to capture and treat the design capture volume, V_{BMP}. As the method for calculating and documenting the design capture volume varies by watershed, the designer must first know which watershed the proposed project is within, and then follow the corresponding guidelines below.
The watershed a particular project is within can be determined from the 'Locate my Watershed' tool available at:

www.rcflood.org/npdes/

2.1.1 Santa Ana Watershed (including the San Jacinto sub-watershed)

In order to meet Regional Water Quality Control Board (RWQCB) requirements, in the Santa Ana Watershed the design capture volume (V_{BMP}) is based on capturing the volume of runoff generated from an 85th percentile, 24-hour storm event. Follow the steps below to calculate V_{BMP} in the Santa Ana Watershed. For convenience, these steps have also been integrated into an excel worksheet that has been provided in Appendix F of this Handbook.

1) Delineate Drainage Management Areas (DMAs) draining to the BMP as described in the WQMP. Wherever possible, use separate DMAs for each surface type (e.g., landscaping, pervious paving, or roofs). Assign each DMA a unique ID code and determine its area in square feet. Multiple DMAs can be combined to individual downstream BMPs.

2) Compile a list of DMAs draining to each volume based BMP using the V_{BMP} calculation worksheet provided in Appendix F to this Handbook. An example of the table from that worksheet is provided below. Account for all areas that will contribute runoff to the proposed BMP, including runoff from off-site areas that commingle with on-site runoff. Enter the unique DMA ID, area, and post-project surface type for each DMA, into the first three columns of the table. The remaining steps describe the process for filling in the remaining parts of the table.

DMA Type/ ID	*DMA Area (square feet)*	*Post-Project Surface Type*	*Effective Imper-vious Fraction, I_F*	*DMA Runoff Factor, C*	*DMA Area × Runoff Factor*	*LID BMP Name/Identifier*		
						Design Storm Depth (in)	*Design Capture Volume (cubic feet)*	*Proposed Volume on Plans (cubic feet)*
	Σ= A_T	***Total***			***Σ= [A]***	**[B]**	***[C]***	

3) Determine the effective impervious fraction (I_f) for each DMA, and fill in the fourth column of the table described in Step 2.

For DMAs comprised of a single post-project surface type (as described in the WQMP, most DMAs should be designed in this manner), the effective Impervious Fraction should be derived from the following table:

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

If a single DMA contains mixed post-project surface types, a composite or area-weighted average effective impervious fraction should be used. The following equation can be used for determining an area-weighted average:

$$\frac{\left[(I_f)_1 \cdot A_1\right] + \left[(I_f)_2 \cdot A_2\right] + [\ldots]}{A_T}$$

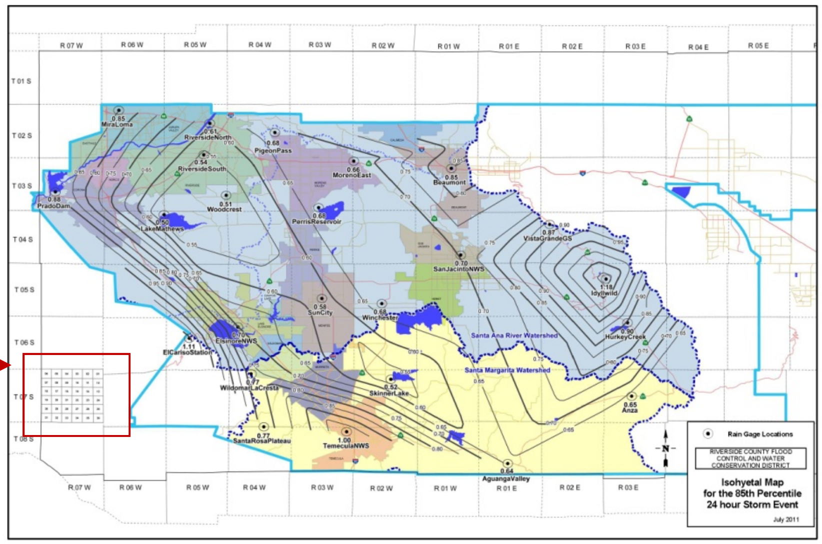
4) Calculate a runoff factor, 'C', using the following equation, and enter this value into the fifth column of the table described in Step 2:

$$C = 0.858 \cdot I_f^{\,3} - 0.78 \cdot I_f^{\,2} + 0.774 * I_f + 0.04$$

5) For each tabulated DMA, multiply the area by the runoff factor, and enter the resulting value in the sixth column of the table described in Step 2. Enter the sum of the sixth column in the field identified with "[A]" in the table.

6) Determine the Design Storm Depth (D_{85}) by locating the project site on the full sized Isohyetal Map for the 85th Percentile 24-hour Storm Event, contained in Appendix D of this Handbook. These values were determined throughout Riverside County using rain gauges with the greatest periods of record. Use township, range and section information to locate the project site, and interpolate the closest value for the site. Enter this value (inches) in the field identified with "[B]" in the table from Step 2.

Tip: Make a clear acetate copy of the township, range and section grid to use as an overlay on other sections of the map.



7) Determine the Design Capture Volume or 'VBMP' using the equation below:

$$V_{BMP}(ft^3) = \frac{[A] \times [B]}{12\ (in/ft)}$$

Enter this value in the field identified with "[C]" in the table from Step 2. This is the volume to be used in the design of BMPs presented in this Handbook.

2.1.2 Santa Margarita Watershed

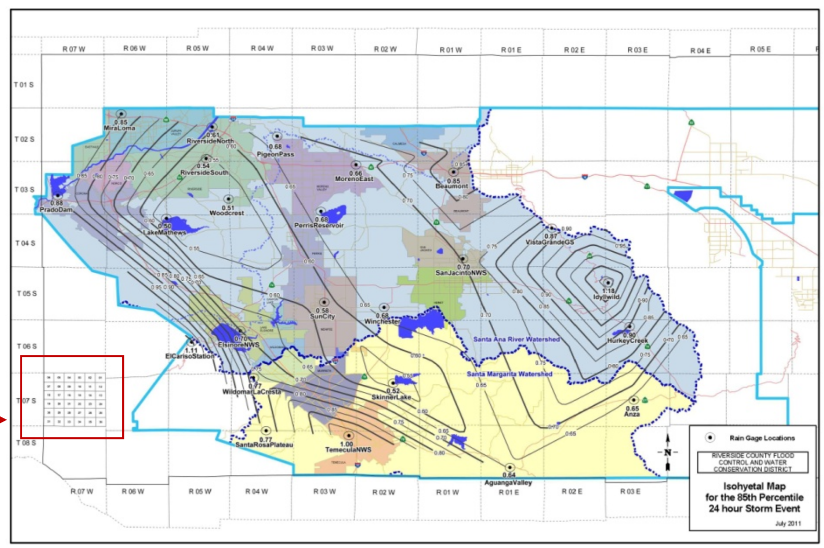
In order to meet RWQCB requirements, in the Santa Margarita Watershed, the design capture volume (V_{BMP}) is based on capturing the volume of runoff generated from an 85th percentile, 24-hour storm event. Follow the steps below to calculate V_{BMP} in the Santa Margarita Watershed. For convenience, these steps have also been integrated into an excel worksheet that has been provided in Appendix F of this Handbook.

1) Determine the tributary drainage area to the BMP, A_T. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, and runoff from off-site areas that commingle with on-site runoff. Calculate this area in acres.

2) Locate the project site on the full sized Isohyetal Map for the 85th Percentile 24-hour Storm Event contained in Appendix D of this Handbook. These values were determined throughout Riverside County using rain gauges with the greatest periods of record. Use township, range and section information to locate the project site, and interpolate the closest value, D85, for the site.

   <u>NOTE:</u> *The use of the Isohyetal Map in Appendix D of this Handbook requires the use of BMPs identified in this LID BMP Design Handbook. This Isohyetal Map cannot be used with older BMP designs.*

Tip: Make a clear acetate copy of the township, range and section grid to use as an overlay on other sections of the map.



3) Determine the effective impervious fraction (I_f) for the area tributary to the BMP, using the following table:

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

If the area tributary to the BMP contains mixed post-project surface types, a composite or area-weighted average effective impervious fraction should be used. The following equation can be used for determining an area-weighted average:

$$\frac{\left[\left(I_f\right)_1 \cdot A_1\right] + \left[\left(I_f\right)_2 \cdot A_2\right] + [\ldots]}{A_T}$$

4) Calculate a runoff factor, 'C', using the following equation:

$$C = 0.858 \cdot {I_f}^3 - 0.78 \cdot {I_f}^2 + 0.774 * I_f + 0.04$$

5) Determine unit storage volume, V_U. This is found by multiplying the Design Storm Depth found in Step 2 by the runoff coefficient found in Step 4.

$$\mathrm{V_U} = \mathrm{D_{85}} \times \mathrm{C}$$

6) Determine V_{BMP} using the equation below or the worksheet provided in Appendix F of this Handbook. This is the volume to be used in the design of selected BMPs presented in this Handbook. Multiply the BMP tributary drainage area, A_T, by the unit storage volume, V_U, to give the BMP design storage volume.

$$\mathrm{V_{BMP}}(\mathrm{ft}^3) = \frac{\mathrm{V_U}(\mathrm{in-ac/ac}) \times \mathrm{A_T}(\mathrm{ac}) \times 43{,}560(\mathrm{ft}^2/\mathrm{ac})}{12\ (\mathrm{in/ft})}$$

2.1.3 Whitewater Watershed

In order to meet RWQCB requirements, in the Whitewater Watershed the design capture volume (V_{BMP}) is based on the CASQA methodology referenced in Section F.1.c.v.4.a.ii of the MS4 permit. The Palms Springs Thermal Airport rain gauge was used as the reference gauge. Follow the steps below to calculate V_{BMP} in the Whitewater Watershed. For convenience, these steps have also been integrated into an excel worksheet that has been provided in Appendix F of this Handbook.

7) Determine the tributary drainage area, A_T. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, and runoff from offsite areas that commingle with site runoff. Calculate this area in acres.

8) Determine the effective impervious fraction (I_f) for the area tributary to the BMP, using the following table:

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

If the area tributary to the BMP contains mixed post-project surface types, a composite or area-weighted average effective impervious fraction should be used. The following equation can be used for determining an area-weighted average:

$$\frac{\left[(I_f)_1 \cdot A_1\right] + \left[(I_f)_2 \cdot A_2\right] + [\ldots]}{A_T}$$

9) Calculate a runoff factor, 'C', using the following equation:

$$C = 0.858 \cdot {I_f}^3 - 0.78 \cdot {I_f}^2 + 0.774 * I_f + 0.04$$

10) Determine 85th percentile unit storage volume, V_U. This is found by multiplying the runoff coefficient found in Step 3 by 0.40.

$$V_U = 0.4 \times C$$

11) Determine the design capture volume, V_{BMP} using the equation below or the worksheet provided in Appendix F of this Handbook. This is the volume to be used in the design of selected BMPs presented in this Handbook.

$$V_{BMP}(ft^3) = \frac{V_U(in-ac/ac) \times A_T(ac) \times 43{,}560(ft^2/ac)}{12\ (in/ft)}$$

2.2 Calculating Q_{BMP}

While the BMPs in this Handbook are designed based on V_{BMP} as discussed in 2.1 above, in some circumstances flow based BMPs may be used. Flow-based BMPs are sized to treat the design flow rate. As the method for calculating and documenting the design flow rate varies by watershed, the designer must first know which watershed the proposed project is within, and then follow the corresponding guidelines below.

The watershed a particular project is within can be determined from the 'Locate my Watershed' tool available at:

www.rcflood.org/npdes/

2.2.1 Santa Ana Watershed (including the San Jacinto sub-watershed)

In the Santa Ana Watershed, Q_{BMP} is the runoff flow rate resulting from a design rainfall intensity of 0.2 inches per hour. Follow the steps below to calculate and document Q_{BMP} in the Santa Ana Watershed. For convenience, these steps have also been integrated into a worksheet that has been provided in Appendix F of this Handbook.

1) Delineate Drainage Management Areas (DMAs) draining to the BMP, as described in the WQMP. Wherever possible, use separate DMAs for each surface type (e.g., landscaping, pervious paving, or roofs). Assign each DMA a unique code and determine its size in square feet. Multiple DMAs can be combined to individual downstream BMPs.

2) Compile a list of DMAs draining to each flow based BMP using the Q_{BMP} calculation worksheet provided in Appendix F to this Handbook. An example of the table from that worksheet is provided below. Account for all areas that will contribute runoff to the proposed BMP, including runoff from off-site areas that commingle with on-site runoff. Enter the unique DMA ID, area, and post-project surface type for each DMA, into the first three columns of the table. The remaining steps describe the process for filling in the remaining parts of the table.

DMA Type /ID	*DMA Area (square feet)*	*Post-Project Surface Type*	*Effective Imper-vious Fraction, I_F*	*DMA Runoff Factor, C*	*DMA Area × Runoff Factor*	*LID BMP Name/Identifier*		
						Design Rainfall Intensity	*Minimum Flow (cfs)*	*Proposed Flow (cfs)*
	$\Sigma = A_T$	**Total**			**$\Sigma = [A]$**	**0.2**	**[B]**	

3) Determine the effective impervious fraction (I_f) for each DMA, and fill in the fourth column of the table described in Step 2.

For DMAs comprised of a single post-project surface type (as described in the WQMP, most DMAs should be designed in this manner), the effective Impervious Fraction should be derived from the following table:

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

If a single DMA contains mixed post-project surface types, a composite or area-weighted average effective impervious fraction should be used. The following equation can be used for determining an area-weighted average:

$$\frac{\left[(I_f)_1 \cdot A_1\right] + \left[(I_f)_2 \cdot A_2\right] + [\ldots]}{A_T}$$

4) Calculate a runoff factor, 'C', using the following equation, and enter this value into the fifth column of the table described in step 2:

$$C = 0.858 \cdot {I_f}^3 - 0.78 \cdot {I_f}^2 + 0.774 * I_f + 0.04$$

5) For each tabulated DMA, multiply the area by the runoff factor. Enter the resulting value in the sixth column of the table described in Step 2. Enter the sum of the sixth column in the field identified with "[A]" in the table.

6) Determine the BMP Design Flow Rate (Q_{BMP}) using the equation:

$$\text{QBMP} = \frac{(0.2\ x\ \text{"}[A]\text{"})}{43{,}560}$$

Enter Q_{BMP} in the field identified with "[B]" in the table.

2.2.2 *Santa Margarita and Whitewater Watersheds*

In the Santa Margarita and Whitewater Watershed regions of Riverside County, Q_{BMP} is the runoff flow rate resulting from a design rainfall intensity of 0.2 inches per hour. Follow the steps below to calculate Q_{BMP} for both the Santa Margarita and Whitewater watersheds.

1) Determine the tributary drainage area, A_T, that drains to the proposed BMP. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, impervious areas, and runoff from offsite areas that commingle with site runoff, whether or not they are directly or indirectly connected to the BMP. Calculate this area in units of acres.

2) Determine the effective impervious fraction (I_f) for the area tributary to the BMP, using the following table:

Surface Type	Effective Impervious Fraction, I_f
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40

If the area tributary to the BMP contains mixed post-project surface types, a composite or area-weighted average effective impervious fraction should be used. The following equation can be used for determining an area-weighted average:

$$\frac{\left[\left(I_f\right)_1 \cdot A_1\right] + \left[\left(I_f\right)_2 \cdot A_2\right] + [\dots]}{A_T}$$

3) Calculate a runoff factor, 'C', using the following equation:

$$C = 0.858 \cdot {I_f}^3 - 0.78 \cdot {I_f}^2 + 0.774 * I_f + 0.04$$

4) Determine the BMP Design Flow Rate using the equation:

$$Q_{BMP} = C \times I \times A_T$$

Where,

A_T = Tributary Area to the BMP, in acres

I = Design Rainfall Intensity, 0.2 inch/hour is used for this Handbook

C = Runoff Factor, found in Step 3

3.0 BMP Fact Sheets

This section provides fact sheets for the following seven types of BMPs:

3.1 - Infiltration Basins

3.2 - Infiltration Trenches

3.3 - Permeable Pavement

3.4 - Harvest and Use

3.5 - Bioretention Facilities

3.6 - Extended Detention Basins

3.7 - Sand Filter Basins

►For portability, the fact sheets for each BMP, as well as Calculation worksheets for sizing and documenting the design of these BMPs, are provided as separate downloadable files on the LID Handbook page at www.rcflood.org/NPDES/developers.aspx

BEFORE selecting any particular BMP for use on your project, review the requirements of the applicable WQMP, and the discussions in sections 1 and 2 of this Handbook. These provide important context and instructions that may dictate that particular BMPs be used.

3.1 Infiltration Basin

Type of BMP	LID - Infiltration
Treatment Mechanisms	Infiltration, Evapotranspiration (when vegetated), Evaporation, and Sedimentation
Maximum Treatment Area	50 acres
Other Names	Bioinfiltration Basin

Description

An Infiltration Basin is a flat earthen basin designed to capture the design capture volume, V_{BMP}. The stormwater infiltrates through the bottom of the basin into the underlying soil over a 72 hour drawdown period. Flows exceeding V_{BMP} must discharge to a downstream conveyance system. Trash and sediment accumulate within the forebay as stormwater passes into the basin. Infiltration basins are highly effective in removing all targeted pollutants from stormwater runoff.

Figure 1 – Infiltration Basin

See Appendix A, and Appendix C, Section 1 of *Basin Guidelines*, for additional requirements.

Siting Considerations

The use of infiltration basins may be restricted by concerns over ground water contamination, soil permeability, and clogging at the site. See the applicable WQMP for any specific feasibility considerations for using infiltration BMPs. Where this BMP is being used, the soil beneath the basin must be thoroughly evaluated in a geotechnical report since the underlying soils are critical to the basin's long term performance. To protect the basin from erosion, the sides and bottom of the basin must be vegetated, preferably with native or low water use plant species.

In addition, these basins may not be appropriate for the following site conditions:

- Industrial sites or locations where spills of toxic materials may occur
- Sites with very low soil infiltration rates
- Sites with high groundwater tables or excessively high soil infiltration rates, where pollutants can affect ground water quality
- Sites with unstabilized soil or construction activity upstream
- On steeply sloping terrain
- Infiltration basins located in a fill condition should refer to Appendix A of this Handbook for details on special requirements/restrictions

Setbacks

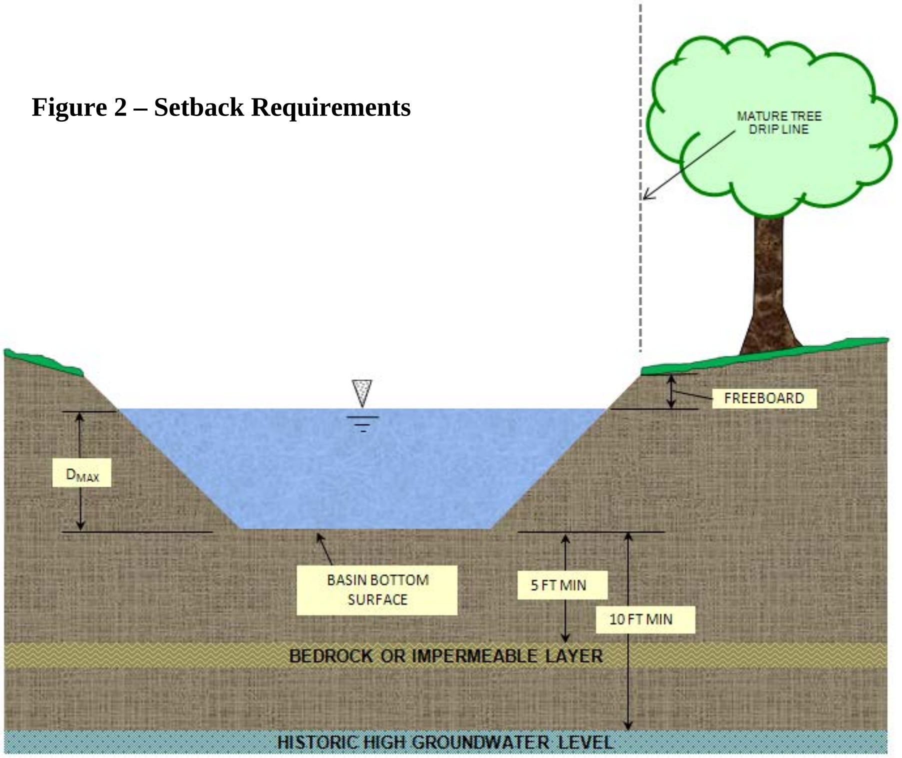
Always consult your geotechnical engineer for site specific recommendations regarding setbacks for infiltration trenches. Recommended setbacks are needed to protect buildings, existing trees, walls, onsite or nearby wells, streams, and tanks. Setbacks should be considered early in the design process since they can affect where infiltration facilities may be placed and how deep they are allowed to be. For instance, depth setbacks can dictate fairly shallow facilities that will have a larger footprint and, in some cases, may make an infiltration basin infeasible. In that instance, another BMP must be selected.

Infiltration basins typically must be set back:

- 10 feet from the historic high groundwater (measured vertically from the bottom of the basin, as shown in Figure 2)
- 5 feet from bedrock or impermeable surface layer (measured vertically from the bottom of the basin, as shown in Figure 2)
- From all existing mature tree drip lines as indicated in Figure 2 (to protect their root structure)
- 100 feet horizontally from wells, tanks or springs

Setbacks to walls and foundations must be included as part of the Geotechnical Report. All other setbacks shall be in accordance with applicable standards of the District's *Basin Guidelines* (Appendix C).

Figure 2 – Setback Requirements



Forebay

A concrete forebay shall be provided to reduce sediment clogging and to reduce erosion. The forebay shall have a design volume of at least 0.5% V_{BMP} and a minimum 1 foot high concrete splashwall / berm. Full height notch-type weir(s), offset from the line of flow from the basin inlet to prevent short circuiting, shall be used to outlet the forebay. It is recommended that two weirs be used and that they be located on opposite sides of the forebay (see Figure 2).

Overflow

Flows exceeding V_{BMP} must discharge to an acceptable downstream conveyance system. Where an adequate outlet is present, an overflow structure may be used. Where an embankment is present, an emergency spillway may be used instead. Overflows must be placed just above the design water surface for V_{BMP} and be near the outlet of the system. The overflow structure shall be similar to the District's Standard Drawing CB 110. Additional details may be found in the District's *Basin Guidelines* (Appendix C).

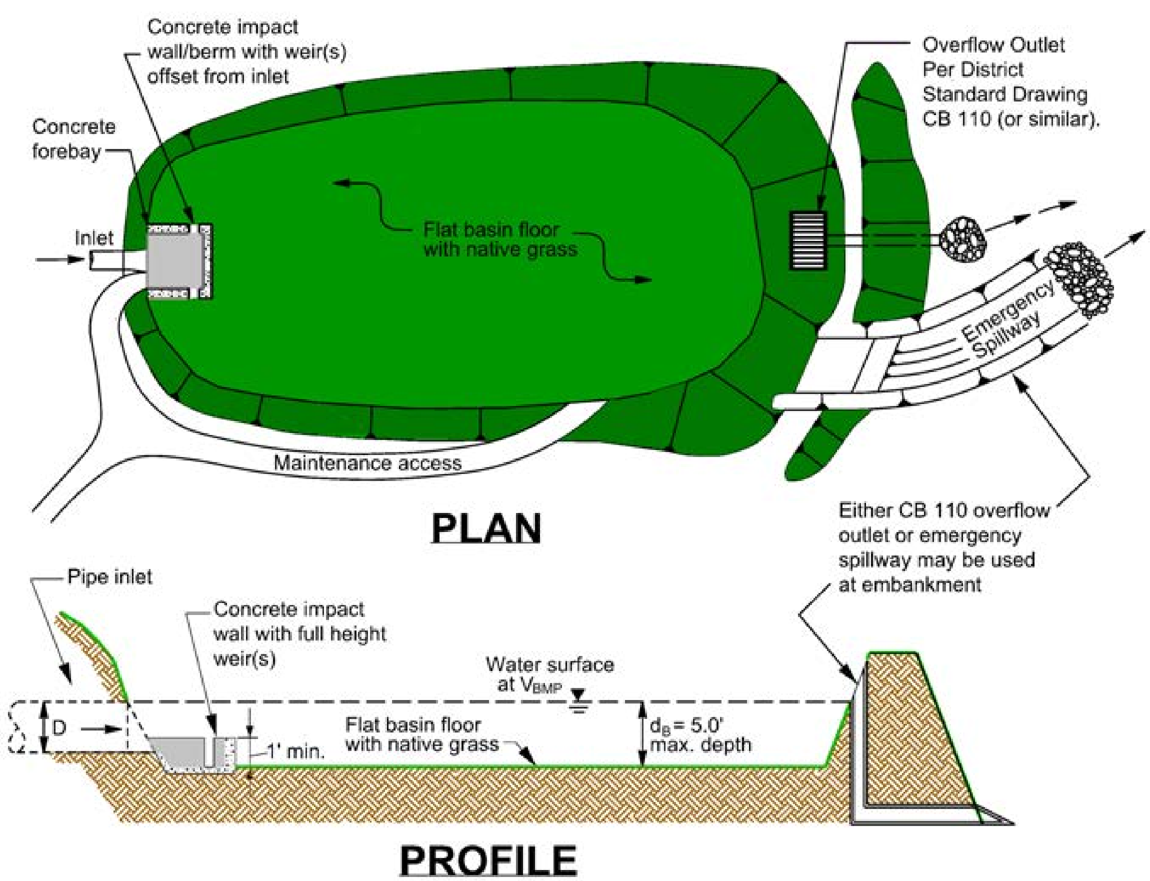


Figure 3 – Infiltration Basin

Landscaping Requirements

Basin vegetation provides erosion protection, improves sediment removal and assists in allowing infiltration to occur. The basin surface and side slopes shall be planted with native grasses. Proper landscape management is also required to ensure that the vegetation does not contribute to water pollution through pesticides, herbicides, or fertilizers. Landscaping shall be in accordance with County of Riverside Ordinance 859 and the District's *Basin Guidelines* (Appendix C), or other guidelines issued by the Engineering Authority.

Maintenance

Normal maintenance of an infiltration basin includes the maintenance of landscaping, debris and trash removal from the surface of the basin, and tending to problems associated with standing water (vectors, odors, etc.). Significant ponding, especially more than 72 hours after an event, may indicate that the basin surface is no longer providing sufficient infiltration and requires aeration. See the District's *Basin Guidelines* (Appendix C) for additional requirements (i.e., fencing, maintenance access, etc.).

Table 1 - Inspection and Maintenance

Schedule	Inspection and Maintenance Activity
Ongoing including just before annual storm seasons and following rainfall events.	• Maintain vegetation as needed. Use of fertilizers, pesticides and herbicides should be strenuously avoided to ensure they don't contribute to water pollution. If appropriate native plant selections and other IPM methods are used, such products shouldn't be needed. If such projects are used, o Products shall be applied in accordance with their labeling, especially in relation to application to water, and in areas subjected to flooding. o Fertilizers should not be applied within 15 days before, after, or during the rain season. • Remove debris and litter from the entire basin to minimize clogging and improve aesthetics. • Check for obvious problems and repair as needed. Address odor, insects, and overgrowth issues associated with stagnant or standing water in the basin bottom. There should be no long-term ponding water. • Check for erosion and sediment laden areas in the basin. Repair as needed. Clean forebay if needed. • Revegetate side slopes where needed.
Annually. If possible, schedule these inspections within 72 hours after a significant rainfall.	• Inspection of hydraulic and structural facilities. Examine the inlet for blockage, the embankment and spillway integrity, as well as damage to any structural element. • Check for erosion, slumping and overgrowth. Repair as needed. • Check basin depth for sediment build up and reduced total capacity. Scrape bottom as needed and remove sediment. Restore to original cross-section and infiltration rate. Replant basin vegetation. • Verify the basin bottom is allowing acceptable infiltration. Use a disc or other method to aerate basin bottom only if there is actual significant loss of infiltrative capacity, rather than on a routine basis[1]. • No water should be present 72 hours after an event. No long term standing water should be present at all. No algae formation should be visible. Correct problem as needed.
1. CA Stormwater BMP Handbook for New Development and Significant Redevelopment	

Table 2 - Design and Sizing Criteria for Infiltration Basins

Design Parameter	Infiltration Basin
Design Volume	V_{BMP}
Forebay Volume	0.5% V_{BMP}
Drawdown time (maximum)	72 hours
Maximum tributary area	50 acres [2]
Minimum infiltration rate	Must be sufficient to drain the basin within the required Drawdown time over the life of the BMP. The WQMP may include specific requirements for minimum tested infiltration rates.
Maximum Depth	5 feet
Spillway erosion control	Energy dissipators to reduce velocities[1]
Basin Slope	0%
Freeboard (minimum)	1 foot [1]
Historic High Groundwater Setback (max)	10 feet
Bedrock/impermeable layer setback (max)	5 feet
Tree setbacks	Mature tree drip line must not overhang the basin
Set back from wells, tanks or springs	100 feet
Set back from foundations	As recommended in Geotechnical Report

1. **Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures**
2. **CA Stormwater BMP Handbook for New Development and Significant Redevelopment**

Note: The information contained in this BMP Factsheet is intended to be a summary of design considerations and requirements. Additional information which applies to all detention basins may be found in the District's Basin Guidelines (Appendix C). In addition, information herein may be superseded by other guidelines issued by the co-permittee.

INFILTRATION BASIN SIZING PROCEDURE

1. Find the Design Volume, V_{BMP}.
   a) Enter the Tributary Area, A_{T}.
   b) Enter the Design Volume, V_{BMP}, determined from Section 2.1 of this Handbook.
2. Determine the Maximum Depth.
   a) Enter the infiltration rate. The infiltration rate shall be established as described in Appendix A: "Infiltration Testing".
   b) Enter the design Factor of Safety from Table 1 in Appendix A: "Infiltration Testing".
   c) The spreadsheet will determine D_1, the maximum allowable depth of the basin based on the infiltration rate along with the maximum drawdown time (72 hours) and the Factor of Safety.

$$D_1 = [(t) \times (I)] / 12s$$

Where I = site infiltration rate (in/hr)
s = safety factor
t = drawdown time (maximum 72 hours)

d) Enter the depth of freeboard.

e) Enter the depth to the historic high groundwater level measured from the top of the basin.

f) Enter the depth to the top of bedrock or other impermeable layer measured from the finished grade.

g) The spreadsheet will determine D_2, the total basin depth (including freeboard, if used) of the basin, based on restrictions to the depth by groundwater and an impermeable layer.

$$D_2 = \text{Depth to groundwater} - (10 + \text{freeboard}) \text{ (ft)};$$

or

$$D_2 = \text{Depth to impermeable layer} - (5 + \text{freeboard}) \text{ (ft)}$$

Whichever is least.

h) The spreadsheet will determine the maximum allowable effective depth of basin, D_{MAX}, based on the smallest value between D_1 and D_2. D_{MAX} is the maximum depth of water only and does not include freeboard. D_{MAX} shall not exceed 5 feet.

3. Basin Geometry

a) Enter the basin side slopes, z (no steeper than 4:1).

b) Enter the proposed basin depth, d_B excluding freeboard.

c) The spreadsheet will determine the minimum required surface area of the basin:

$$A_s = V_{BMP} / d_B$$

Where A_s = minimum area required (ft^2)
V_{BMP} = volume of the infiltration basin (ft^3)
d_B= proposed depth not to exceed maximum allowable depth, D_{MAX} (ft)

d) Enter the proposed bottom surface area. This area shall not be less than the minimum required surface area.

4. Forebay

A concrete forebay with a design volume of at least 0.5% V_{BMP} and a minimum 1 foot high concrete splashwall shall be provided. Full-height rectangular weir(s) shall be used to outlet the forebay. The weir(s) must be offset from the line of flow from the basin inlet. It is recommended that two weirs be used and that they be located on opposite sides of the forebay (see Figure 2).

a) The spreadsheet will determine the minimum required forebay volume based on 0.5% V_{BMP}.

b) Enter the proposed depth of the forebay berm/splashwall (1foot minimum).

c) The spreadsheet will determine the minimum required forebay surface area.

d) Enter the width of rectangular weir to be used (minimum 1.5 inches). Weir width should be established based on a 5 minute drawdown time.

Infiltration Basin - Design Procedure (Rev. 03-2012)	BMP ID	Legend:	Required Entries Calculated Cells

Company Name: | Date:
Designed by: | County/City Case No.:

Design Volume

a) Tributary area (BMP subarea) — A_T = acres

b) Enter V_{BMP} determined from Section 2.1 of this Handbook — V_{BMP} = ft^3

Maximum Depth

a) Infiltration rate — I = in/hr

b) Factor of Safety (See Table 1, Appendix A: "Infiltration Testing" from this BMP Handbook) — FS =

c) Calculate D_1

$$D_1 = \frac{I\ (in/hr) \times 72\ hrs}{12\ (in/ft) \times FS}$$

D_1 = ft

d) Enter the depth of freeboard (at least 1 ft) — ft

e) Enter depth to historic high ground water (measured from **top** of basin) — ft

f) Enter depth to top of bedrock or impermeable layer (measured from **top** of basin) — ft

g) D_2 is the smaller of:

Depth to groundwater - (10 ft + freeboard) and
Depth to impermeable layer - (5 ft + freeboard)

D_2 = ft

h) D_{MAX} is the smaller value of D_1 and D_2 but shall not exceed 5 feet — D_{MAX} = ft

Basin Geometry

a) Basin side slopes (no steeper than 4:1) — z = :1

b) Proposed basin depth (excluding freeboard) — d_B = ft

c) Minimum bottom surface area of basin ($A_S = V_{BMP}/d_B$) — A_S = ft^2

d) Proposed Design Surface Area — A_D = ft^2

Forebay

a) Forebay volume (minimum 0.5% V_{BMP}) — Volume = ft^3

b) Forebay depth (height of berm/splashwall. 1 foot min.) — Depth = ft

c) Forebay surface area (minimum) — Area = ft^2

d) Full height notch-type weir — Width (W) = in

Notes:

3.2 INFILTRATION TRENCH

Type of BMP	LID - Infiltration
Treatment Mechanisms	Infiltration, Evapotranspiration (when vegetated), Evaporation
Maximum Drainage Area	10-acres
Other Names	None

Description

Infiltration trenches are shallow excavated areas that are filled with rock material to create a subsurface reservoir layer. The trench is sized to store the design capture volume, V_{BMP}, in the void space between the rocks. Over a period of 72 hours, the stormwater infiltrates through the bottom of the trench into the surrounding soil. Infiltration basins are highly effective in removing all targeted pollutants from stormwater runoff.

Figure 1 shows the components of an infiltration trench. The section shows the reservoir layer and observation well, which is used to monitor water depth. An overflow pipe that is used to bypass flows once the trench fills with stormwater is also shown.

Site Considerations

Location

The use of infiltration trenches may be restricted by concerns over groundwater contamination, soil permeability, and clogging at the site. See the applicable WQMP for any specific feasibility considerations for using infiltration BMPs. Where this BMP is being used, the soil beneath the basin must be thoroughly evaluated in a geotechnical report since the underlying soils are critical to the basin's long term performance. These basins may not be appropriate for the following site conditions:

- Industrial sites or locations where spills of toxic materials may occur.
- Sites with very low soil infiltration rates.
- Sites with high groundwater tables or excessively high soil infiltration rates, where pollutants can affect groundwater quality.
- Sites with unstabilized soil or construction activity upstream.
- On steeply sloping terrain.
- Infiltration trenches located in a fill condition should refer to Appendix A of this Handbook for details on special requirements/restrictions.

This BMP has a flat surface area, so it may be challenging to incorporate into steeply sloping terrain.

INFILTRATION TRENCH BMP FACT SHEET

Setbacks

Always consult your geotechnical engineer for site specific recommendations regarding setbacks for infiltration trenches. Recommended setbacks are needed to protect buildings, walls, onsite or nearby wells, streams, and tanks. Setbacks should be considered early in the design process as they affect where infiltration facilities may be placed and how deep they are allowed to be. For instance, depth setbacks can dictate fairly shallow facilities that will have a larger footprint and, in some cases, may make an infiltration trench infeasible. In that instance, another BMP must be selected.

In addition to setbacks recommended by the geotechnical engineer, infiltration trenches must be set back:

- 10 feet from the historic high groundwater mark (measured vertically from the bottom of the trench, as shown in Figure 1)
- 5 feet from bedrock or impermeable surface layer (measured vertically from the bottom of the trench, as shown in Figure 1)
- From all mature tree drip lines as indicated in Figure 1
- 100 feet horizontally from wells, tanks or springs

Setbacks to walls and foundations must be included as part of the Geotechnical Report.

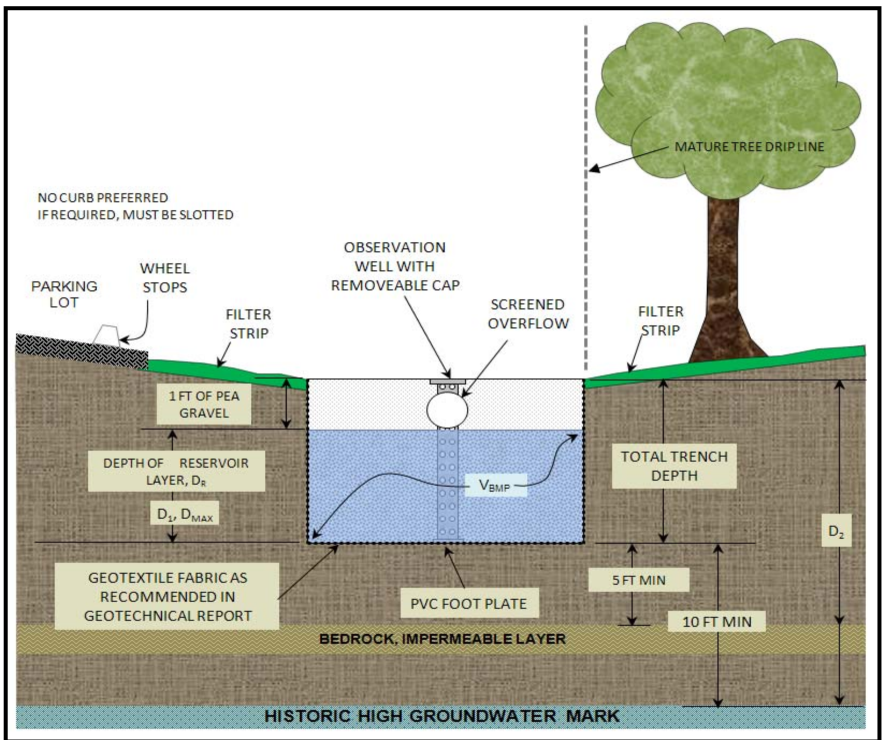


Figure 1 Section View of an Infiltration Trench

Sediment Control

Infiltration BMPs have the risk of becoming plugged over time. To prevent this, sediment must be removed before stormwater enters the trench. Both sheet and concentrated flow types have requirements that should be considered in the design of an infiltration trench.

When sheet type flows approach the trench along its length (as illustrated in Figure 2), a vegetated filter strip should be placed between the trench and the upstream drainage area. The filter strip must be a minimum of 5 feet wide and planted with grasses (preferably native) or covered with mulch.

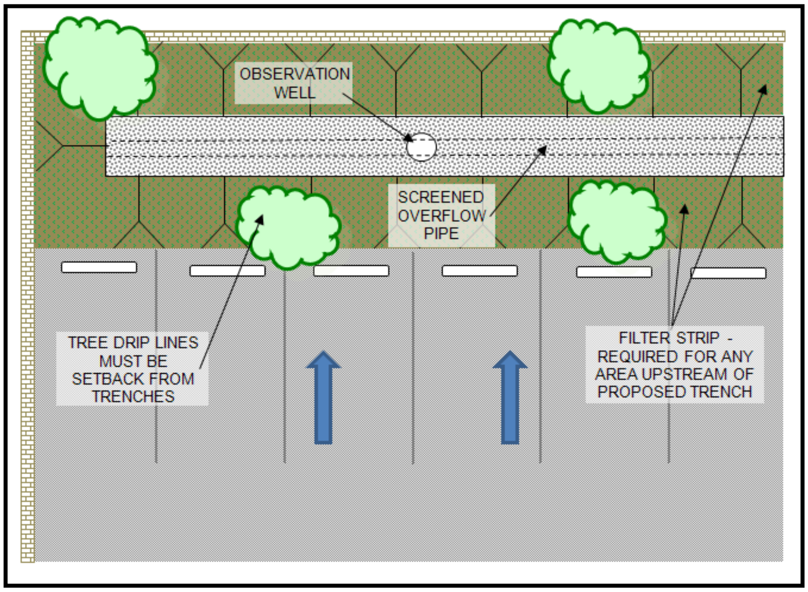


Figure 2 Plan View, Sheet Type Flows

Concentrated flows require a different approach. A 2004 Caltrans BMP Retrofit Report found that flow spreaders recommended in many water quality manuals are ineffective in distributing concentrated flows. As such, concentrated flows should either be directed toward a traditional vegetated swale (as shown on the right side of Figure 3) or to catch basin filters that can remove litter and sediment. Catch basins must discharge runoff as surface flow above the trench; they cannot outlet directly into the reservoir layer of the infiltration trench. If catch basins are used, the short and long term costs of the catch basin filters should be considered.

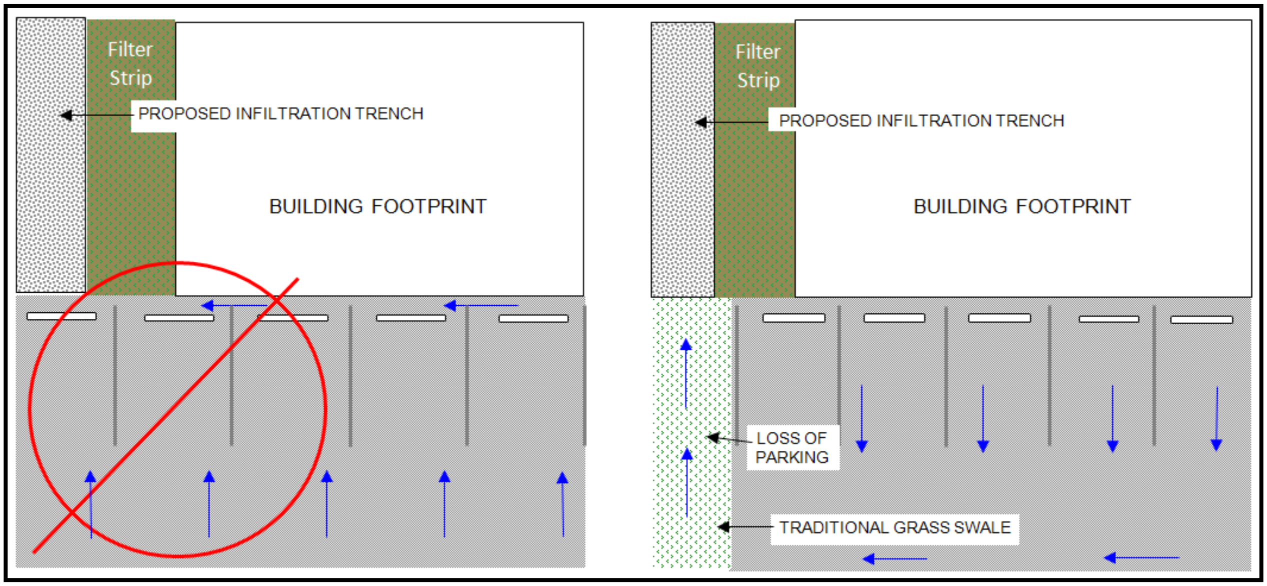


Figure 3 Plan View, Concentrated Flows

Additional Considerations

Class V Status

In certain circumstances, for example, if an infiltration trench is "deeper than its widest surface dimension," or includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground, it would probably be considered by the EPA to be a Class V injection well. Class V injection wells are subject to regulations and reporting requirements via the Underground Injection Control (UIC) Program. To ensure that infiltration trenches are not considered Class V wells, the design procedure in this manual requires that the trench not be deeper than it is wide.

Geotechnical Report

A geotechnical report must be included for all infiltration trenches. Appendix A of this Handbook entitled "Infiltration Testing Guidelines", details which types of infiltration tests are acceptable and how many tests or boring logs must be performed. A Geotechnical Report must be submitted in support of all infiltration trenches. Setbacks to walls and foundations must be included in the Geotechnical Report.

Observation Wells

One or more observation wells should be provided. The observation well consists of a vertical section of perforated pipe, 4 to 6 inches in diameter, installed flush with top of trench on a foot plate and have a locking, removable cap.

Overflow

An overflow route is needed to bypass storm flows larger than the V_{BMP} or in the event of clogging. Overflow systems must connect to an acceptable discharge point such as a downstream conveyance system.

Maintenance Access

Normal maintenance of an infiltration trench includes maintenance of the filter strip as well as debris and trash removal from the surface of the trench and filter strip. More substantial maintenance requiring vehicle access may be required every 5 to 10 years. Vehicular access along the length of the swale should be provided to all infiltration trenches. It is preferred that trenches be placed longitudinally along a street or adjacent to a parking lot area. These conditions have high visibility which makes it more likely that the trench will be maintained on a regular basis.

INFILTRATION TRENCH BMP FACT SHEET

Inspection and Maintenance

Schedule	Inspection and Maintenance Activity
Every two weeks, or as often as necessary to maintain a pleasant appearance	- Maintain adjacent landscaped areas. Remove clippings from landscape maintenance activities. - Remove trash & debris
3 days after Major Storm Events	- Check for surface ponding. If ponding is only above the trench, remove, wash and replace pea gravel. May be needed every 5-10 years. - Check observation well for ponding. If the trench becomes plugged, remove rock materials. Provide a fresh infiltration surface by excavating an additional 2-4 inches of soil. Replace the rock materials.

Design and Sizing Criteria

Design Parameter	Design Criteria
Design Volume	V_{BMP}
Design Drawdown time	72 hrs
Maximum Tributary Drainage Area	10 acres
Maximum Trench Depth	8.0 ft
Width to Depth Ratio	Width must be greater than depth
Reservoir Rock Material	AASHTO #3 or 57 material or a clean, washed aggregate 1 to 3-in diameter equivalent
Filter Strip Width	Minimum of 5 feet in the direction of flow for all areas draining to trench
Filter Strip Slope	Max slope = 1%
Filter Strip Materials	Mulch or grasses (non-mowed variety preferred)
Historic High Groundwater Mark	10 ft or more below bottom of trench
Bedrock/Impermeable Layer Setback	5 ft or more below bottom of trench
Tree Setbacks	Mature tree drip line must not overhang the trench
Trench Lining Material	As recommended in Geotechnical Report

Infiltration Trench Design Procedure

1. Enter the area tributary to the trench, maximum drainage area is 10 acres.

2. Enter the Design Volume, $V_{BMP,}$ determined from Section 2.1 of this Handbook.

3. Enter the site infiltration rate, found in the geotechnical report.

4. Enter the factor of safety from Table 1 of Appendix A, Infiltration Testing.

5. Determine the maximum reservoir layer depth, $D_{MAX.}$ The value is obtained by taking the smaller of two depth equations but may never exceed 8 feet. The first depth, D_1 is related to the infiltration rate of the soil. The second depth, $D_{2,}$ is related to required setbacks to groundwater, bedrock/impermeable layer. These parameters are shown in Figure 1.

   Calculate D_1.

$$D_1 = \frac{I\left({}^{in}/_{hr}\right) \times 72\ (hrs)}{12\left({}^{in}/_{ft}\right) \times {}^{n}/_{100} \times FS}$$

   Where:

   I = site infiltration rate (in/hr), found in the geotechnical report
   FS = factor of safety, refer to Appendix A - Infiltration Testing
   n = porosity of the trench material, 40%

   Calculate D_2. Enter the depth to the seasonal high groundwater and bedrock/impermeable layer measured from the finished grade. The spreadsheet checks the minimum setbacks shown in Figure 1 and selects the smallest value. The equations are listed below for those doing hand calculations.

   Minimum Setbacks (includes 1 foot for pea gravel):
   = Depth to historic high groundwater mark - 11 feet
   = Depth to impermeable layer - 6 feet

   D_2 is the smaller of the two values.

   D_{MAX} is the smaller value of D_1 and $D_{2,}$ and must be less than or equal to 8 feet.

6. Enter the proposed reservoir layer depth, D_R. The value must be no greater than D_{MAX}.

7. Find the required surface area of the trench, A_S. Once D_R is entered, the spreadsheet will calculate the corresponding depth of water and the minimum surface area of the trench.

$$Design\ d_W = D_R \times \left({}^{n}/_{100}\right) \qquad A_S = \frac{V_{BMP}}{Design\ d_W}$$

Where:

A_S = minimum area required (ft^2)
V_{BMP} = BMP storage volume (ft^3)
Design d_W = Depth of water in reservoir layer (ft)

8. Enter the proposed design surface area; it must be greater than the minimum surface area.

9. Calculate the minimum trench width. This is to ensure that EPA's Class V Injection well status is not triggered. The total trench depth (shown in Figure 1) includes the upper foot where the overflow pipe is located. The minimum surface dimension is D_R + 1 foot.

Additional Items

The following items detailed in the preceding sections should also be addressed in the design.

- Sediment Control
- Geotechnical Report
- Observation well(s)
- Overflow

Reference Material

California Stormwater Quality Association. California Stormwater BMP Handbook New Development and Redevelopment. 2003.

County of Los Angeles Department of Public Works. Stormwater BMP Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems. Los Angeles, CA, 2009.

LandSaver Stormwater Management System. Tech Sheet - Porosity of Structural Backfill. 2006.

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United States Environmental Protection Agency. Office of Water. Memorandum on Clarification on Which Stormwater Infiltration Practices/technologies Have the Potential to Be Regulated as "Class V" Wells by Underground Injection Control Program. By Linda Boornazian and Steve Heare. Washington D.C., 2008.

Ventura Countywide Stormwater Quality Management Program. Land Development Guidelines Biofilter Fact Sheet. Ventura, CA, 2001.

Ventura Countywide Stormwater Quality Management Program. Technical Guidance Manual for Stormwater Quality Control Measures. Ventura, CA, 2002.

Infiltration Trench - Design Procedure	BMP ID	Legend:	Required Entries
			Calculated Cells

Company Name: | Date:

Designed by: | County/City Case No.:

Design Volume

Enter the area tributary to this feature, Max = 10 acres — A_t= acres

Enter V_{BMP} determined from Section 2.1 of this Handbook — V_{BMP}= ft^3

Calculate Maximium Depth of the Reservoir Layer

Enter Infiltration rate — I = in/hr

Enter Factor of Safety, FS (unitless) — FS =

Obtain from Table 1, Appendix A: "Infiltration Testing" of this BMP Handbook

n = 40 %

Calculate D_1.

$$D_1 = \frac{I\ (in/hr) \times 72\ hrs}{12\ (in/ft) \times (n/100) \times FS}$$

D_1 = ft

Enter depth to historic high groundwater mark (measured from finished grade) — ft

Enter depth to top of bedrock or impermeable layer (measured from finished grade) — ft

D_2 is the smaller of:

Depth to groundwater - 11 ft; & Depth to impermeable layer - 6 ft — D_2 = ft

D_{MAX} is the smaller value of D_1 and D_2, must be less than or equal to 8 feet. — D_{MAX}= ft

Trench Sizing

Enter proposed reservoir layer depth D_R, must be $\leq D_{MAX}$ — D_R = ft

Calculate the design depth of water, d_W

$$\text{Design } d_W = (D_R) \times (n/100)$$

Design d_W= ft

Minimum Surface Area, A_S

$$A_S = \frac{V_{BMP}}{d_W}$$

A_S = ft^2

Proposed Design Surface Area — A_D = ft^2

Minimum Width = D_R + 1 foot pea gravel — ft

Sediment Control Provided? (Use pulldown)

Geotechnical report attached? (Use pulldown)

If the trench has been designed correctly, there should be no error messages on the spreadsheet.

3.3 Permeable Pavement

Type of BMP	LID - Infiltration
Treatment Mechanisms	Infiltration, Evaporation
Maximum Drainage Area	10 acres
Other Names	porous pavement, pervious concrete, pervious asphalt, pervious gravel pavement, cobblestone block, modular block, modular pavement

Description

Permeable pavements can be either pervious asphalt and concrete surfaces, or permeable modular block. Unlike traditional pavements that are impermeable, permeable pavements reduce the volume and peak of stormwater runoff as well as mitigate pollutants from stormwater runoff, provided that the underlying soils can accept infiltration. Permeable pavement surfaces work best when they are designed to be flat or with gentle slopes. This factsheet discusses criteria that apply to infiltration designs.

The permeable surface is placed on top of a reservoir layer that holds the water quality stormwater volume, $V_{BMP.}$ The water infiltrates from the reservoir layer into the native subsoil. Tests must be performed according to the Infiltration Testing Section in Appendix A to be able to use this design procedure.

In some circumstances, permeable pavement may be implemented on a project as a source control feature. Where implemented as a source control feature (sometimes referred to as a 'self-retaining' area), the pavement is not considered a 'BMP' that would be required to be designed and sized per this manual. Where permeable pavement receives runoff from adjacent tributary areas, the permeable pavement *may* be considered a BMP that must be sized according to this manual. Consult the Engineering Authority and the WQMP for any applicable requirements for designing and sizing permeable pavement installations.

Siting Considerations

The WQMP applicable to the project location should be consulted, as it may include criteria for determining the applicability of this and other Infiltration-based BMPs to the project.

Permeable pavements can be used in the same manner as concrete or asphalt in low traffic parking lots, playgrounds, walkways, bike trails, and sports courts. Most types of permeable pavement can be designed to meet Americans with Disabilities Act (ADA) requirements. Permeable pavements **should not** be used in the following conditions:

- ⃠ Downstream of erodible areas
- ⃠ Downstream of areas with a high likelihood of pollutant spills
- ⃠ Industrial or high vehicular traffic areas (25,000 or greater average daily traffic)
- ⃠ Areas where geotechnical concerns, such as soils with low infiltration rates, would preclude the use of this BMP.

Sites with Impermeable Fire Lanes

Oftentimes, Fire Departments do not allow alternative pavement types including permeable pavement. They require traditional impermeable surfaces for fire lanes. In this situation, it is acceptable to use an impermeable surface for the fire lane drive aisles and permeable pavement for the remainder of the parking lot.

Where impermeable fire lanes are used in the design, the impermeable surface must slope towards the permeable pavement, and the base layers shall remain continuous underneath the two pavement types, as shown in Figure 1. This continuous reservoir layer helps to maintain infiltration throughout the pervious pavement site, and can still be considered as part of the total required storage area.

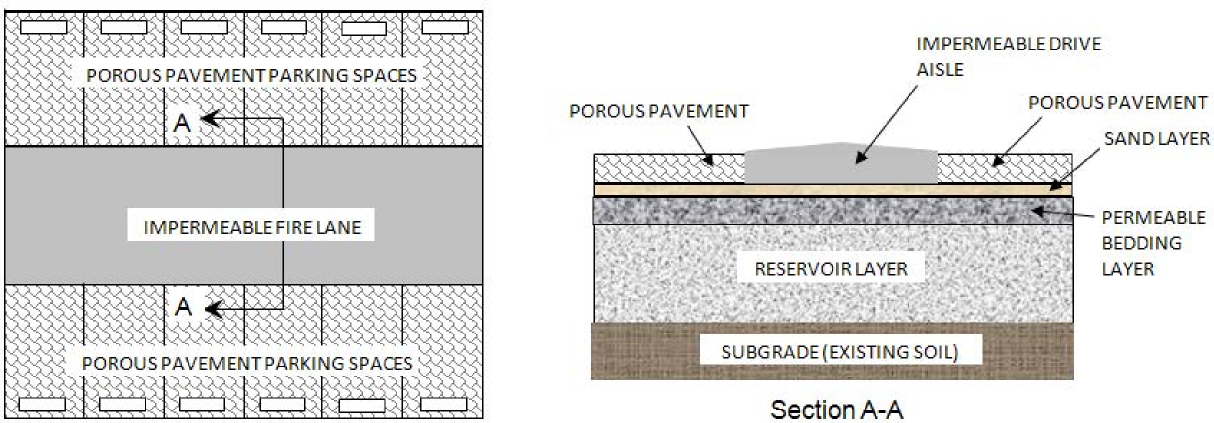

Figure 1: Impermeable Fire Lanes

Also, while a seal coat treatment may be used on the impermeable fire land, traditional seal coat treatments **shall not** be used on permeable pavement.

Setbacks

Always consult your geotechnical engineer for site specific recommendations regarding setbacks for permeable pavement. Recommended setbacks are needed to protect buildings, walls, onsite wells, streams and tanks.

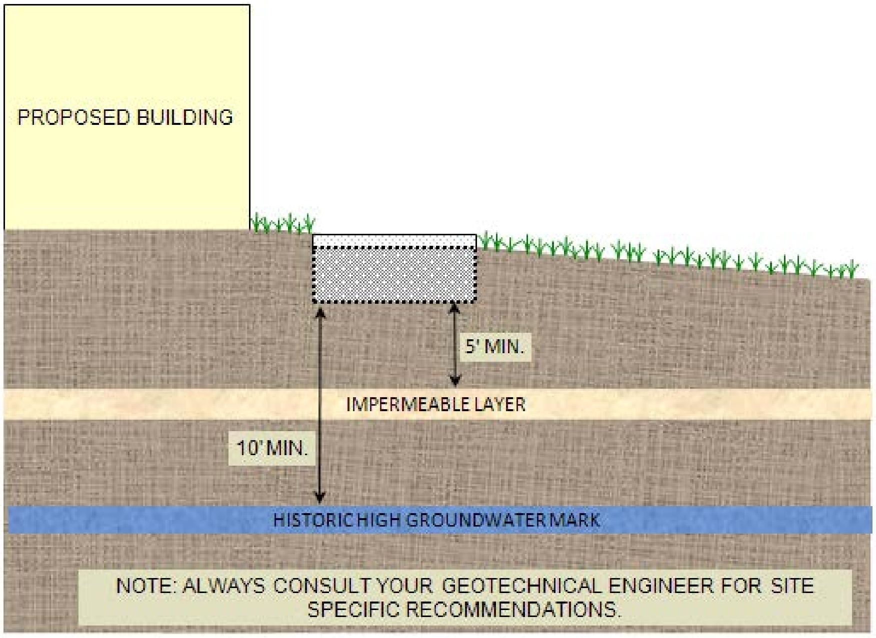

Figure 2: Permeable Pavement Setback Requirements

A minimum vertical separation of 10 feet is required from the bottom of the reservoir layer to the historic high groundwater mark, see Figure 2. A minimum vertical separation of 5 feet is required from the bottom of the reservoir layer to any impermeable layer in the soil. If the historic high groundwater mark is less than 10 feet below the reservoir layer section, or less than 5 feet from an impermeable layer, the infiltration design is not feasible.

Design and Sizing Criteria

To ensure that the pavement structural section is not compromised, a 24-hour drawdown time is utilized for this BMP instead of the longer drawdown time used for most volume based BMPs.

Reservoir Layer Considerations

Even with proper maintenance, sediment will begin to clog the soil below the permeable pavement. Since the soil cannot be scarified or replaced, this will result in slower infiltration rates over the life of the permeable pavement. Therefore, the reservoir layer is limited to a maximum of 12 inches in depth to ensure that over the life of the BMP, the reservoir layer will drain in an adequate time.

***Note**: All permeable pavement BMP installations (not including Permeable Pavement as a source control BMP i.e. a self-retaining area) must be tested by the geotechnical engineer to ensure that the soils drain at a minimum allowable rate to ensure drainage.. See the Infiltration Testing Section of this manual for specific details for the required testing and applied factors of safety.*

Sloping Permeable Pavement

Ideally permeable pavement would be level, however most sites will have a mild slope. If the tributary drainage area is too steep, the water may be flowing too fast when it approaches the permeable pavement, which may cause water to pass over the pavement instead of percolating and entering the reservoir layer. If the maximum slopes shown in Table 1 are complied with, it should address these concerns.

Table 1: Design Parameters for Permeable Pavement

Design Parameter	Permeable Pavement
Maximum slope of permeable pavement	3%
Maximum contributing area slope	5%

Regardless of the slope of the pavement surface design, the bottom of the reservoir layers **shall be flat and level** as shown in Figure 3. The design shown ensures that the water quality volume will be contained in the reservoir layer. A terraced design utilizing non-permeable check dams may be a useful option when the depth of gravel becomes too great as shown in Figure 3.

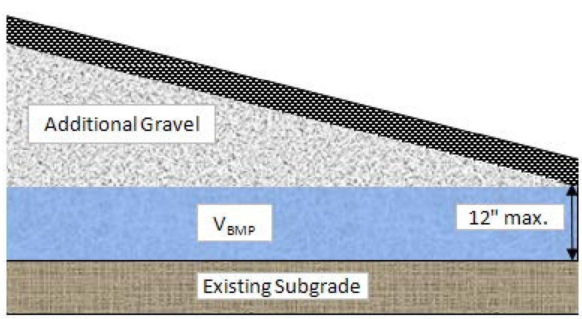

Figure 3: Sloped Cross Sections for Permeable Pavement

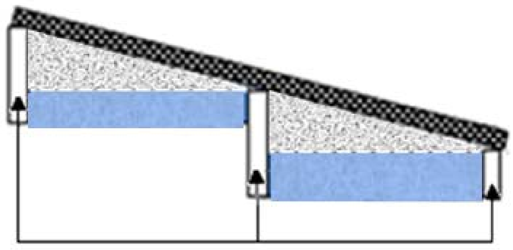

Figure 4: Permeable Pavement with Non-permeable Check Dams

In Figure 4, the bottom of the gravel reservoir layer is incorrectly sloped parallel to the pavement surface. Water would only be allowed to pond up to the lowest point of the BMP. Additional flows would simply discharge from the pavement. Since only a portion of the gravel layer can store water, this design would result in insufficient capacity. This is not acceptable.

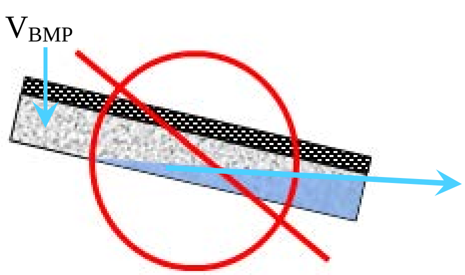

Figure 5: Incorrect Sloping of Permeable Pavement

To assure that the subgrade will empty within the 24 hour drawdown time, it is important that the maximum depth of 12 inches for the reservoir layer discussed in the design procedure is not exceeded. The value should be measured from the lowest elevation of the slope (Figure 4).

Minimum Surface Area

The minimum surface area required, A_S, is calculated by dividing the water quality volume, V_{BMP}, by the depth of water stored in the reservoir layer. The depth of water is found by multiplying the void ratio of the reservoir aggregate by the depth of the layer, b_{TH}. The void ratio of the reservoir aggregate is typically 40%; the maximum reservoir layer depth is 12".

Sediment Control

A pretreatment BMP should be used for sediment control. This pretreatment BMP will reduce the amount of sediment that enters the system and reduce clogging. The pretreatment BMP will also help to spread runoff flows, which allows the system to infiltrate more evenly. The pretreatment BMP must discharge to the surface of the pavement and not the subgrade. Grass swales may also be used as part of a treatment train with permeable pavements.

Liners and Filter Fabric

Always consult your geotechnical engineer for site specific recommendations regarding liners and filter fabrics. Filter fabric may be used around the edges of the permeable pavement; this will help keep fine sediments from entering the system. Unless recommended for the site, impermeable liners are not to be used below the subdrain gravel layer.

Overflow

An overflow route is needed in the permeable pavement design to bypass storm flows larger than the V_{BMP} or in the event of clogging. Overflow systems must connect to an acceptable discharge point such as a downstream conveyance system.

Roof Runoff

Permeable pavement can be used to treat roof runoff. However, the runoff cannot be discharged beneath the surface of the pavement directly into the subgrade, as shown in Figure 6. Instead the pipe should empty on the surface of the permeable pavement as shown in Figure 7. A filter on the drainpipe should be used to help reduce the amount of sediment that enters the permeable pavement.

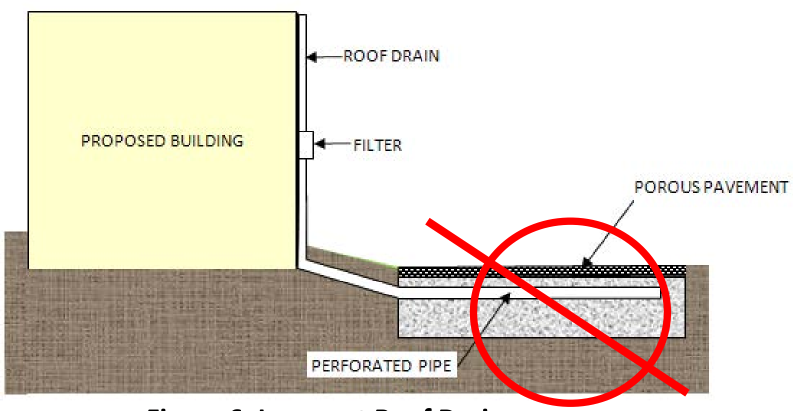

Figure 6: Incorrect Roof Drainage

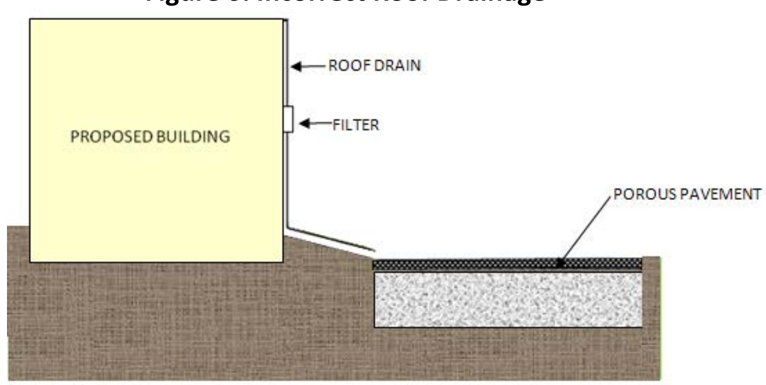

Figure 7: Correct Roof Runoff Drainage

Infiltration
Refer to the Infiltration Testing Section (Appendix A) in this manual for recommendations on testing for this BMP.

Pavement Section
The cross section necessary for infiltration design of permeable pavement includes:

- The thickness of the layers of permeable pavement, sand and bedding layers depends on whether it is permeable modular block or pervious pavement. A licensed geotechnical or civil engineer is required to determine the thickness of these upper layers appropriate for the pavement type and expected traffic loads.
- A 12" maximum reservoir layer consisting of AASHTO #57 gravel vibrated in place or equivalent with a minimum of 40% void ratio.

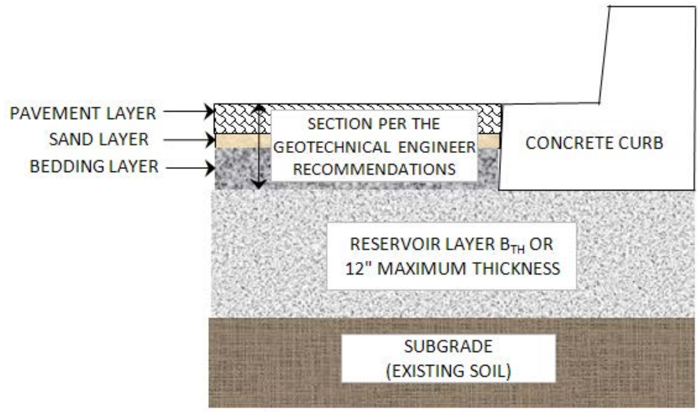

Figure 8: Infiltration Cross Section

Inspection and Maintenance Schedule –Modular Block

Schedule	Activity
Ongoing	• Keep adjacent landscape areas maintained. Remove clippings from landscape maintenance activities. • Remove trash and debris
Utility Trenching and other pavement repairs	• Remove and reset modular blocks, structural section and reservoir layer as needed. Replace damaged blocks in-kind. • Do not pave repaired areas with impermeable surfaces.
After storm events	• Inspect areas for ponding
2-3 times per year	• Sweep to reduce the chance of clogging
As needed	• Sand between pavers may need to be replaced if infiltration capacity is lost

PERMEABLE PAVEMENT BMP FACT SHEET

Inspection and Maintenance Schedule –Pervious Concrete/Asphalt

Schedule	Activity
Ongoing	• Keep adjacent landscape areas maintained. Remove clippings from landscape maintenance activities. • Remove trash and debris
Utility Trenching other pavement repairs	• Replace structural section and reservoir layer in kind. • Re-pave using pervious concrete/asphalt. Do not pave repaired areas with impermeable surfaces.
After storm events	• Inspect areas for ponding
2-3 times per year	• Vacuum the permeable pavement to reduce the chance of clogging
As needed	• Remove and replace damaged or destroyed permeable pavement

Design Procedure Permeable Pavement

1. Enter the Tributary Area, A_T.

2. Enter the Design Volume, $V_{BMP,}$ determined from Section 2.1 of this Handbook.

3. Enter the reservoir layer depth, b_{TH} for the proposed permeable pavement. The reservoir layer maximum depth is 12 inches.

4. Calculate the Minimum Surface Area, A_S, required.

$$A_S(\text{ft}) = \frac{V_{BMP}\ (\text{ft}^3)}{(0.4\ \times\ b_{TH}\ (\text{in}))/12(\text{in/ft})}$$

   Where, the porosity of the gravel in the reservoir layer is assumed to be 40%.

5. Enter the proposed surface area and ensure that this is equal to or greater than the minimum surface area required.

6. Enter the dimensions, per the geotechnical engineer's recommendations, for the pavement cross section. The cross section includes a pavement layer, usually a sand layer and a permeable bedding layer. Then add this to the maximum thickness of the reservoir layer to find the total thickness of the BMP.

7. Enter the slope of the top of the permeable pavement. The maximum slope is 3%.

8. Enter whether sediment control was provided.

9. Enter whether the geotechnical approach is attached.

10. Describe the surfaces surrounding the permeable pavement. It is preferred that a vegetation buffer is used around the permeable pavement.
11. Check to ensure that vertical setbacks are met. There should be a minimum of 10 feet between the bottom of the BMP and the top of the high groundwater table, and a minimum of 5 feet between the reservoir layer the top of the impermeable layer.

Reference Materials Used to Develop this Fact Sheet:

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Bean, E. Z., et al. "Study on the Surface Infiltration Rate of Permeable Pavements." Water and Environment Specialty Conference of the Canadian Society for Civil Engineering. Saskatoon, 2004. 1-10.

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Tennis, Paul D., Michael L. Leming and David J. Akers. Pervious Concrete Pavements. Silver Spring: Portland Cement Association and National Ready Mixed Concrete Association, 2004.

Urban Drainage and Flood Control District. Urban Storm Drainage Criteria Manual Volume 3 - Best Management Practices. Vol. 3. Denver, 2008. 3 vols.

Urbonas, Ben R. Stormwater Sand Filter Sizing and Design: A Unit Operations Approach. Denver: Urban Drainage and Flood Control District, 2002.

Permeable Pavement - Design Procedure	BMP ID	Legend:	Required Entries
			Calculated Cells

Company Name: | Date:

Designed by: | County/City Case No.:

Design Volume

Enter the area tributary to this feature $A_T=$ acres

Enter V_{BMP} determines from Section 2.1 of this Handbook $V_{BMP}=$ ft^3

Permeable Pavement Surface Area

Reservoir Layer Depth, b_{TH} $b_{TH}=$ inches

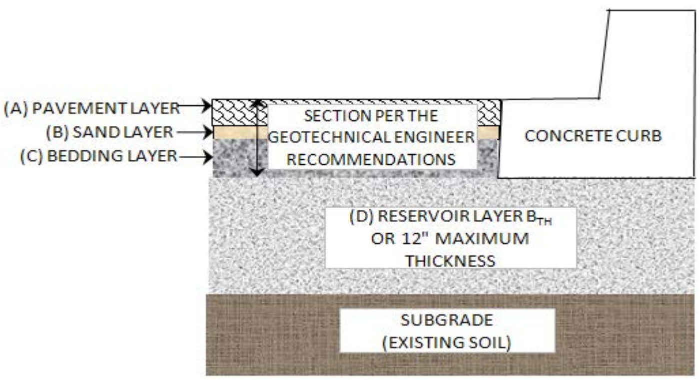
Minimum Surface Area Required, A_S

$$A_{S\ (ft)} = \frac{V_{BMP}\ (ft^3)}{(0.4 \times b_{TH}\ (in)) / 12(in/ft)}$$

$A_S=$ ft^2

Proposed Surface Area = ft^2

Permeable Pavement Cross Section



Per the Geotechnical Engineer's Recommendations	(A)		in
	(B)		in
	(C)		in

Reservoir Layer (D) in

Total Permeable Pavement Section in

Slope of Permeable Pavement %

Sediment Control Provided? (Use pulldown)

Geotechnical report attached? (Use pulldown)

Describe Surrounding Vegetation:

Notes:

If the permeable pavement has been designed correctly, there should be no error messages on the spreadsheet.

3.4 Harvest and Use BMPs

Type of BMP	LID – Harvest and Use
Treatment Mechanisms	Volume Reduction
Minimum Tributary Drainage Area	This BMP is generally limited by the cistern / detention storage size.
Other Names	Cistern, Above-Ground Cistern, Underground Detention

Description

Harvest and use BMPs include both above-ground and underground cisterns / vaults. Such BMPs collect and temporarily store runoff for later non-potable uses including the following:

- Irrigation
- Toilet flushing
- Other non-potable uses, such as industrial processes

Above-ground cisterns collect and temporarily store runoff from rooftops or other above-ground impervious surfaces. Underground cisterns include subsurface tanks, vaults and oversized pipes that temporarily store runoff for later use. These systems can include pipes that divert runoff to the cistern, an overflow system for when the cistern is full, a pump, and a distribution system to supply the intended uses.

Siting Considerations

- The primary feasibility consideration for harvest and use BMPs is the presence of a consistent and reliable demand that is sufficient to drain the BMPs between storms. When designing harvest and use systems for stormwater management, a reliable method of quickly regenerating storage capacity (through the use of the captured stormwater) must exist to ensure that there will be adequate storage capacity for subsequent storms in the wet season.
- Other feasibility considerations include potential conflicts with health and plumbing codes. Applicable health codes focus mainly on the potential impacts of long-term standing water in the BMP facility.
- For above-ground cisterns, the facilities should be installed on a level surface, either on consolidated and stable native soil, or on a concrete pad. A geotechnical analysis is required to ensure stability.
- For underground detention facilities, **pretreatment** must be provided where necessary or as directed by the Engineering Authority, to prevent accumulation of sediments within the BMP. These facilities should be installed on consolidated and stable native soil. A geotechnical analysis is required to ensure stability.

Key Design Elements

- All cisterns must:
  - Have provisions for mosquito prevention and abatement.
  - Have mechanisms to keep debris and animals from entering the cistern, and have a mechanism to easily clean any/all screens.
  - Have provisions for safe overflow of runoff when the cistern is full. Overflow shall be directed to an appropriate area as approved by the Engineering Authority. Dispersion within vegetated areas is preferred.
  - Have adequate access to maintain and/or replace the cistern and all associated equipment such as pumps. For underground cisterns / vaults, this includes access adequate to remove any/all accumulated sediment.
  - Be designed in a manner that allows for supplemental potable water to be used when there is insufficient harvested water to fully meet required demands.
  - Include measures acceptable to the local water supplier to prevent harvested storm water from being introduced into the potable water supply.

See the following figures for *examples* of common elements of above-ground and underground cisterns. The proposed design elements and configurations must be approved by the Engineering Authority.

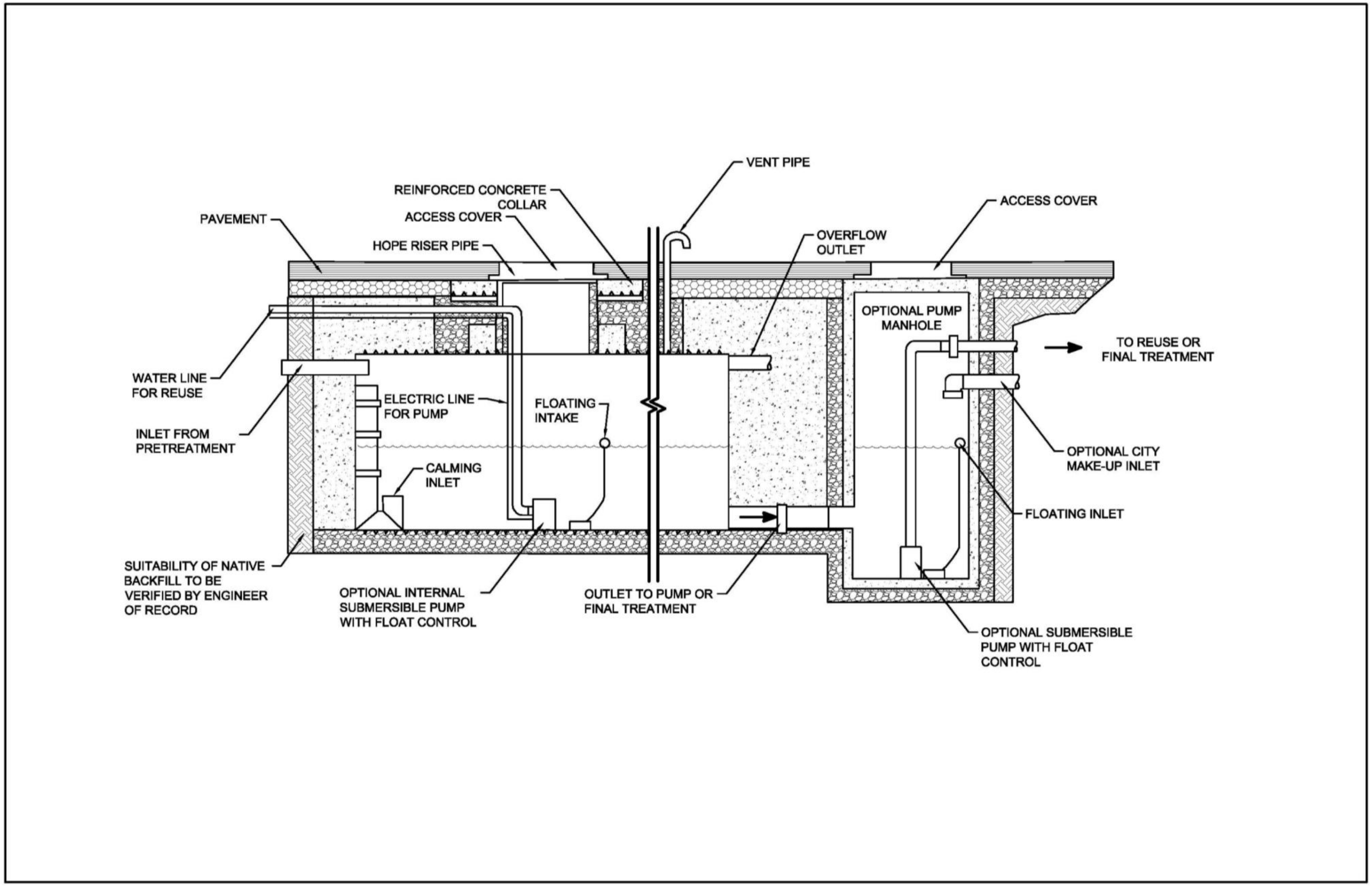


Figure 1 – Common Design Elements of Underground Cistern

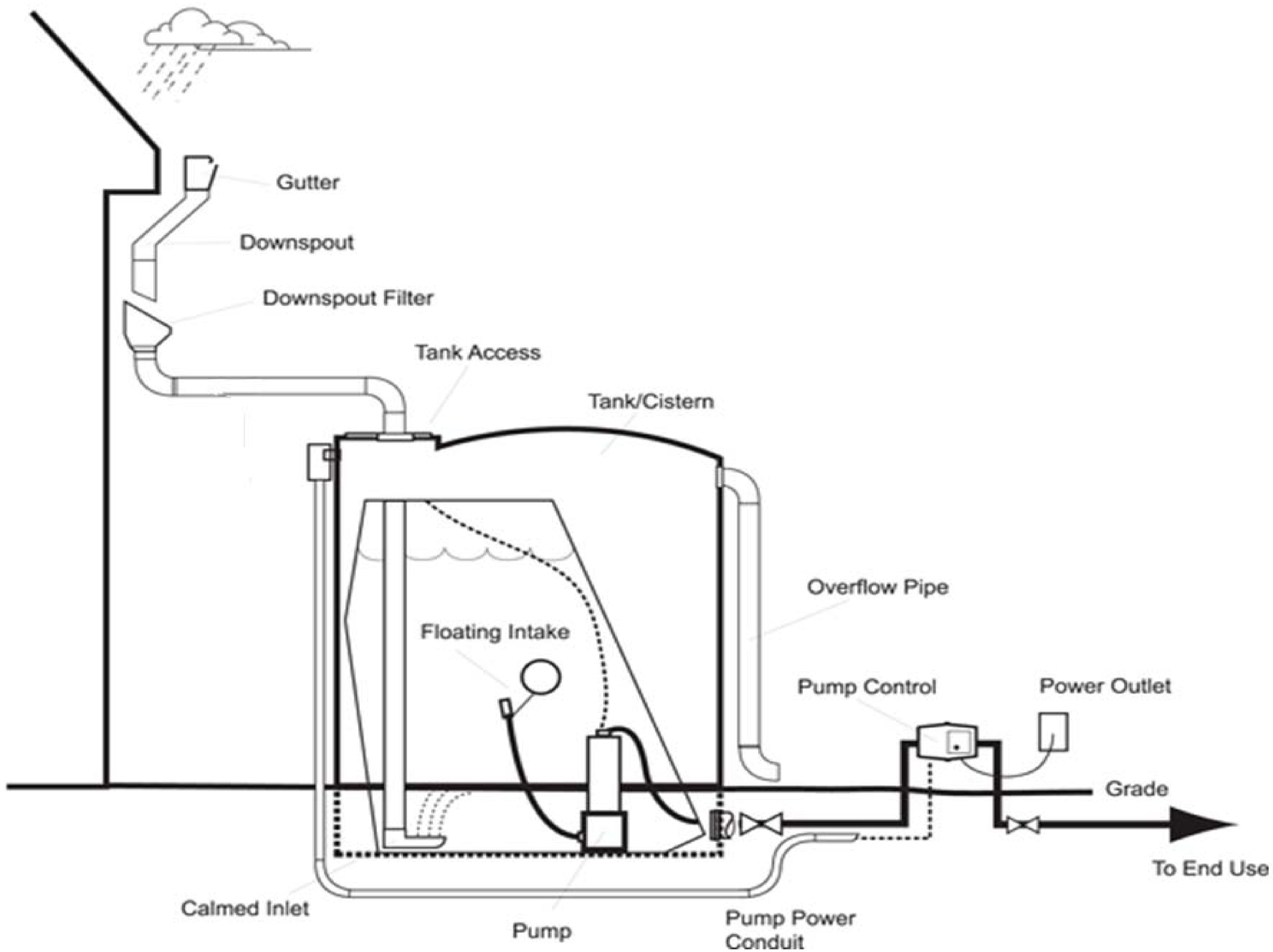


Figure 2 – Common Design Elements of Above-ground Cistern
Graphic courtesy of BRAE

Design and Sizing Criteria

1. Assess whether there is sufficient and reliable (year-round) demand for non-potable use of the runoff from the area tributary to the BMP. Consider seasonal variations in demand for harvested water, such as irrigation needs during the wet season, periodic facility closures (such as for schools), etc. Verify with the Engineering Authority (EA) and the applicable WQMP for applicability requirements / restrictions for this BMP. The following potential on-site uses for harvested rainwater are typically assessed:

   a. Irrigation use
   b. Toilet use
   c. Other non-potable uses (i.e. industrial use)

2. If there is a sufficient on-site demand for harvested rainwater acceptable to the Engineering Authority, determine the Design Capture Volume, V_{BMP}, determined from Section 2.1 of this Handbook.

3. Size the cistern to hold and allow for the use of the Design Capture Volume, in accordance with any manufacturer specifications.

Inspection and Maintenance Schedule

Schedule	Activity
Annually before the wet season	• Check for debris and sediment on screens and overflow facilities and remove where observed. • Verify proper operation of all pumps. • Check integrity of downspout connections to harvest and use BMPs • Check locking mechanisms on facility entry covers • Check integrity of mosquito screens
After storm events	• Check for long-term standing water in the facility. If standing water is observed more than 72 hours after the last storm event, monitor water levels, and verify that the water is being drawn down through the intended use of the water. If water is not properly being drawn down ensure that all pumps distribution systems are functioning correctly. Under no circumstances shall water retained within a cistern be pumped or otherwise drained in a manner that could allow a discharge to a street or storm drain. • Remove debris and sediment from screens and overflow facilities

3.5 Bioretention Facility

Type of BMP	LID – Bioretention
Treatment Mechanisms	Infiltration, Evapotranspiration, Evaporation, Biofiltration
Maximum Drainage Area	This BMP is intended to be integrated into a project's landscaped area in a distributed manner. Typically, contributing drainage areas to Bioretention Facilities range from less than 1 acre to a maximum of around 10 acres.
Other Names	Rain Garden, Bioretention Cell, Bioretention Basin, Biofiltration Basin, Landscaped Filter Basin, Porous Landscape Detention

Description

Bioretention Facilities are shallow, vegetated basins underlain by an engineered soil media. Healthy plant and biological activity in the root zone maintain and renew the macro-pore space in the soil and maximize plant uptake of pollutants and runoff. This keeps the Best Management Practice (BMP) from becoming clogged and allows more of the soil column to function as both a sponge (retaining water) and a highly effective and self-maintaining biofilter. In most cases, the bottom of a Bioretention Facility is unlined, which also provides an opportunity for infiltration to the extent the underlying onsite soil can accommodate. When the infiltration rate of the underlying soil is exceeded, fully biotreated flows are discharged via underdrains. Bioretention Facilities therefore will inherently achieve the maximum feasible level of infiltration and evapotranspiration and achieve the minimum feasible (but highly biotreated) discharge to the storm drain system.

Siting Considerations

These facilities work best when they are designed in a relatively level area. Unlike other BMPs, Bioretention Facilities can be used in smaller landscaped spaces on the site, such as:

- ✓ Parking islands
- ✓ Medians
- ✓ Site entrances

Landscaped areas on the site (such as may otherwise be required through minimum landscaping ordinances), can often be designed as Bioretention Facilities. This can be accomplished by:

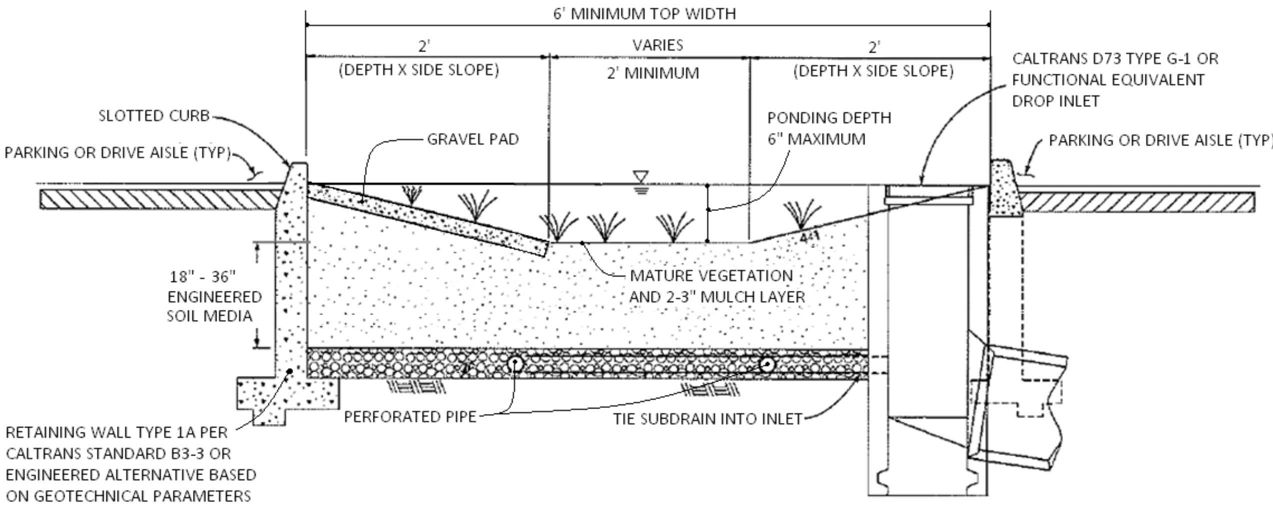
- *Depressing* landscaped areas below adjacent impervious surfaces, rather than elevating those areas
- Grading the site to direct runoff from those impervious surfaces *into* the Bioretention Facility, rather than away from the landscaping
- Sizing and designing the depressed landscaped area as a Bioretention Facility as described in this Fact Sheet

Bioretention Facilities should however not be used downstream of areas where large amounts of sediment can clog the system. Placing a Bioretention Facility at the toe of a steep slope should also be avoided due to the potential for clogging the engineered soil media with erosion from the slope, as well as the potential for damaging the vegetation.

Design and Sizing Criteria

The recommended cross section necessary for a Bioretention Facility includes:

- Vegetated area
- 18' minimum depth of engineered soil media
- 12' minimum gravel layer depth with 6' perforated pipes (added flow control features such as orifice plates may be required to mitigate for HCOC conditions)



While the 18-inch minimum engineered soil media depth can be used in some cases, it is recommended to use 24 inches or a preferred 36 inches to provide an adequate root zone for the chosen plant palate. Such a design also provides for improved removal effectiveness for nutrients. The recommended ponding depth inside of a Bioretention Facility is 6 inches; measured from the flat bottom surface to the top of the water surface as shown in Figure 1.

Because this BMP is filled with an engineered soil media, pore space in the soil and gravel layer is assumed to provide storage volume. However, several considerations must be noted:

- Surcharge storage above the soil surface (6 inches) is important to assure that design flows do not bypass the BMP when runoff exceeds the soil’s absorption rate.
- In cases where the Bioretention Facility contains engineered soil media deeper than 36 inches, the pore space within the engineered soil media can only be counted to the 36-inch depth.
- A maximum of 30 percent pore space can be used for the soil media whereas a maximum of 40 percent pore space can be use for the gravel layer.

Figure 1: Standard Layout for a Bioretention Facility

Bioretention Facility BMP Fact Sheet

Engineered Soil Media Requirements

The engineered soil media shall be comprised of 85 percent mineral component and 15 percent organic component, by volume, drum mixed prior to placement. The mineral component shall be a Class A sandy loam topsoil that meets the range specified in Table 1 below. The organic component shall be nitrogen stabilized compost[1], such that nitrogen does not leach from the media.

Table 1: Mineral Component Range Requirements

Percent Range	Component
70-80	Sand
15-20	Silt
5-10	Clay

The trip ticket, or certificate of compliance, shall be made available to the inspector to prove the engineered mix meets this specification.

Vegetation Requirements

Vegetative cover is important to minimize erosion and ensure that treatment occurs in the Bioretention Facility. The area should be designed for at least 70 percent mature coverage throughout the Bioretention Facility. To prevent the BMP from being used as walkways, Bioretention Facilities shall be planted with a combination of small trees, densely planted shrubs, and natural grasses. Grasses shall be native or ornamental; preferably ones that do not need to be mowed. The application of fertilizers and pesticides should be minimal. To maintain oxygen levels for the vegetation and promote biodegradation, it is important that vegetation not be completely submerged for any extended period of time. Therefore, a maximum of 6 inches of ponded water shall be used in the design to ensure that plants within the Bioretention Facility remain healthy.

A 2 to 3-inch layer of standard shredded aged hardwood mulch shall be placed as the top layer inside the Bioretention Facility. The 6-inch ponding depth shown in Figure 1 above shall be measured from the top surface of the 2 to 3-inch mulch layer.

Curb Cuts

To allow water to flow into the Bioretention Facility, 1-foot-wide (minimum) curb cuts should be placed approximately every 10 feet around the perimeter of the Bioretention Facility. Figure 2 shows a curb cut in a Bioretention Facility. Curb cut flow lines must be at or above the V_{BMP} water surface level.

[1] For more information on compost, visit the US Composting Council website at: http://compostingcouncil.org/

BIORETENTION FACILITY BMP FACT SHEET

Figure 2: Curb Cut located in a Bioretention Facility

To reduce erosion, a gravel pad shall be placed at each inlet point to the Bioretention Facility. The gravel should be 1- to 1.5-inch diameter in size. The gravel should overlap the curb cut opening a minimum of 6 inches. The gravel pad inside the Bioretention Facility should be flush with the finished surface at the curb cut and extend to the bottom of the slope.

In addition, place an apron of stone or concrete, a foot square or larger, inside each inlet to prevent vegetation from growing up and blocking the inlet. See Figure 3.

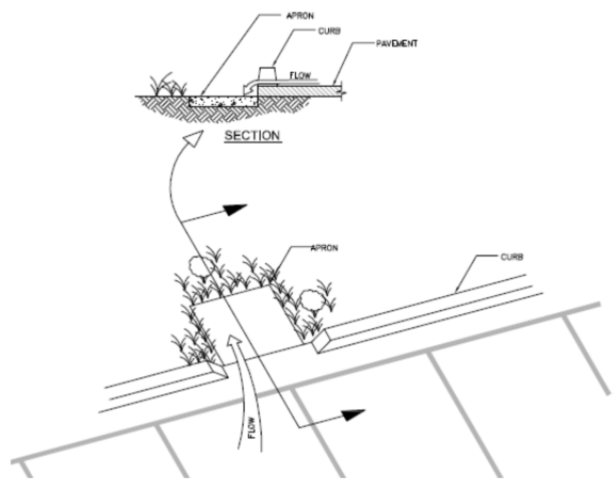


Figure 3: Apron located in a Bioretention Facility

Terracing the Landscaped Filter Basin

It is recommended that Bioretention Facilities be level. In the event the facility site slopes and lacks proper design, water would fill the lowest point of the BMP and then discharge from the basin without being treated. To ensure that the water will be held within the Bioretention Facility on sloped sites, the BMP must be terraced with nonporous check dams to provide the required storage and treatment capacity.

The terraced version of this BMP shall be used on non-flat sites with no more than a 3 percent slope. The surcharge depth cannot exceed 0.5 feet, and side slopes shall not exceed 4:1. Table 2 below shows the spacing of the check dams, and slopes shall be rounded up (i.e., 2.5 percent slope shall use 10' spacing for check dams).

Table 2: Check Dam Spacing

6" Check Dam Spacing	
Slope	**Spacing**
1%	*25'*
2%	*15'*
3%	*10'*

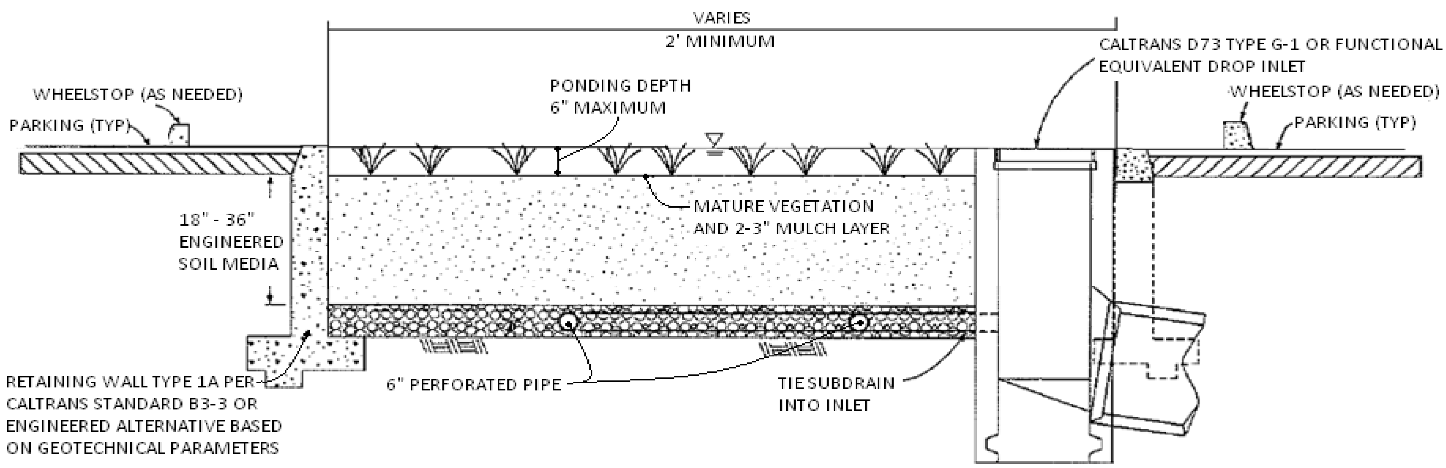
BIORETENTION FACILITY BMP FACT SHEET

Roof Runoff
Roof downspouts may be directed towards Bioretention Facilities. However, the downspouts must discharge onto a concrete splash block to protect the Bioretention Facility from erosion.
Retaining Walls
It is recommended that Retaining Wall Type 1A, per Caltrans Standard B3-3 or equivalent, be constructed around the entire perimeter of the Bioretention Facility. This practice will protect the sides of the Bioretention Facility from collapsing during construction and maintenance or from high service loads adjacent to the BMP. Where such service loads would not exist adjacent to the BMP, an engineered alternative may be used if signed by a licensed civil engineer.

Side Slope Requirements

Bioretention Facilities Requiring Side Slopes
The design should assure that the Bioretention Facility does not present a tripping hazard. Bioretention Facilities proposed near pedestrian areas, such as areas parallel to parking spaces or along a walkway, must have a gentle slope to the bottom of the facility. Side slopes inside of a Bioretention Facility shall be 4:1. A typical cross section for the Bioretention Facility is shown in Figure 1.

Bioretention Facilities Not Requiring Side Slopes
Where cars park perpendicular to the Bioretention Facility, side slopes are not required. A 6-inch maximum drop may be used, and the Bioretention Facility must be planted with trees and shrubs to prevent pedestrian access. In this case, a curb is not placed around the Bioretention Facility,
but wheel stops shall be used to prevent vehicles from entering the Bioretention Facility, as shown in Figure 4.



Planter Boxes

Bioretention Facilities can also be placed above ground as planter boxes. Planter boxes must have a minimum width of 2 feet, a maximum surcharge depth of 6 inches, and no side slopes are necessary. Planter boxes must be constructed so as to ensure that the top surface of the engineered soil media will remain level. This option may be constructed of concrete, brick, stone or other stable materials that will not warp or bend. Chemically treated wood or galvanized steel, which has the ability to contaminate stormwater, should not be used. Planter boxes must be lined with an impermeable liner on all sides, including the bottom. Due to the impermeable liner, the inside bottom of the planter box shall be designed and constructed with a cross fall, directing treated flows within the subdrain layer toward the point where subdrain exits the planter box, and subdrains shall be oriented with drain holes oriented down. These provisions will help avoid excessive stagnant water within the gravel underdrain layer. Similar to the in-ground Bioretention Facility versions, this BMP benefits from healthy plants and biological activity in the root zone. Planter boxes should be planted with appropriately selected vegetation.

Figure 5: Planter Box

Source: LA Team Effort

Overflow

An overflow route is needed in the Bioretention Facility design to bypass stored runoff from storm events larger than V_{BMP} or in the event of facility or subdrain clogging. Overflow systems must connect to an acceptable discharge point, such as a downstream conveyance system as shown in Figure 1 and Figure 4. The inlet to the overflow structure shall be elevated inside the Bioretention Facility to be flush with the ponding surface for the design capture volume (V_{BMP}) as shown in Figure 4. This will allow the design capture volume to be fully treated by the Bioretention Facility, and for larger events to safely be conveyed to downstream systems. The overflow inlet shall **not** be located in the entrance of a Bioretention Facility, as shown in Figure 6.

Underdrain Gravel and Pipes

An underdrain gravel layer and pipes shall be provided in accordance with Appendix B – Underdrains.

Figure 6: Incorrect Placement of an Overflow Inlet.

Inspection and Maintenance Schedule

The Bioretention Facility area shall be inspected for erosion, dead vegetation, soggy soils, or standing water. The use of fertilizers and pesticides on the plants inside the Bioretention Facility should be minimized.

Schedule	Activity
Ongoing	• Keep adjacent landscape areas maintained. Remove clippings from landscape maintenance activities. • Remove trash and debris • Replace damaged grass and/or plants • Replace surface mulch layer as needed to maintain a 2-3 inch soil cover.
After storm events	• Inspect areas for ponding
Annually	• Inspect/clean inlets and outlets

Bioretention Facility Design Procedure

1) Enter the area tributary, A_T, to the Bioretention Facility.

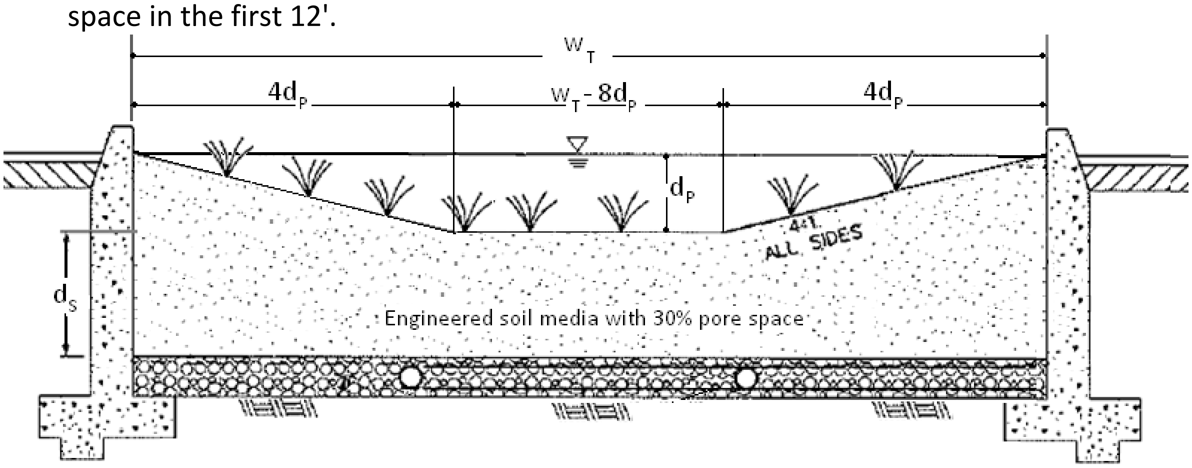
2) Enter the Design Volume, $V_{BMP,}$ determined from Section 2.1 of this Handbook.

3) Select the type of design used. There are two types of Bioretention Facility designs: the standard design used for most project sites that include side slopes, and the modified design used when the BMP is located perpendicular to the parking spaces or with planter boxes that do not use side slopes.

4) Enter the depth of the engineered soil media, d_S. The minimum depth for the engineered soil media can be 18' in limited cases, but it is recommended to use 24' or a preferred 36' to provide an adequate root zone for the chosen plant palette. Engineered soil media deeper than 36' will only get credit for the pore space in the first 36'.

5) Enter the top width of the Bioretention Facility.

6) Calculate the total effective depth, d_E, within the Bioretention Facility. The maximum allowable pore space of the soil media is 30% while the maximum allowable pore space for the gravel layer is 40%. Gravel layer deeper than 12' will only get credit for the pore space in the first 12'.



a. For the design with side slopes the following equation shall be used to determine the total effective depth. Where, d_P is the depth of ponding within the basin.

$$d_E(\text{ft}) = \frac{0.3 \times \left[\left(w_T(\text{ft}) \times d_S(\text{ft})\right) + 4\left(d_P(\text{ft})\right)^2\right] + 0.4 \times 1(\text{ft}) + d_P(\text{ft})\left[4d_P(\text{ft}) + \left(w_T(\text{ft}) - 8d_P(\text{ft})\right)\right]}{w_T(\text{ft})}$$

This above equation can be simplified if the maximum ponding depth of 0.5' is used. The equation below is used on the worksheet to find the minimum area required for the Bioretention Facility:

$$d_E(\text{ft}) = (0.3 \times d_S(\text{ft}) + 0.4 \text{ x } 1(\text{ft})) - \left(\frac{0.7\ (\text{ft}^2)}{w_T(\text{ft})}\right) + 0.5(\text{ft})$$

b. For the design without side slopes the following equation shall be used to determine the total effective depth:

$$d_E(ft) = d_P(ft) + [(0.3) \times d_S(ft) + (0.4) \times 1(ft)]$$

The equation below, using the maximum ponding depth of 0.5', is used on the worksheet to find the minimum area required for the Bioretention Facility:

$$d_E(ft) = 0.5\ (ft) + [(0.3) \times d_S(ft) + (0.4) \times 1(ft)]$$

7) Calculate the minimum surface area, A_M, required for the Bioretention Facility. This does not include the curb surrounding the Bioretention Facility or side slopes.

$$A_M(ft^2) = \frac{V_{BMP}(ft^3)}{d_E\ (ft)}$$

8) Enter the proposed surface area. This area shall not be less than the minimum required surface area.

9) Verify that side slopes are no steeper than 4:1 in the standard design, and are not required in the modified design.

10) Provide the diameter, minimum 6 inches, of the perforated underdrain used in the Bioretention Facility. See Appendix B for specific information regarding perforated pipes.

11) Provide the slope of the site around the Bioretention Facility, if used. The maximum slope is 3 percent for a standard design.

12) Provide the check dam spacing, if the site around the Bioretention Facility is sloped.

13) Describe the vegetation used within the Bioretention Facility.

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Urbonas, Ben R. Stormwater Sand Filter Sizing and Design: A Unit Operations Approach. Denver: Urban Drainage and Flood Control District, 2002.

Bioretention Facility - Design Procedure	BMP ID	Legend:	Required Entries
			Calculated Cells

Company Name: | Date:

Designed by: | County/City Case No.:

Design Volume

Enter the area tributary to this feature — A_T= ____ acres

Enter V_{BMP} determined from Section 2.1 of this Handbook — V_{BMP}= ____ ft^3

Type of Bioretention Facility Design

◉ Side slopes required (parallel to parking spaces or adjacent to walkways)

○ No side slopes required (perpendicular to parking space or Planter Boxes)

Bioretention Facility Surface Area

Depth of Soil Filter Media Layer — d_S = ____ ft

Top Width of Bioretention Facility, excluding curb — w_T = ____ ft

Total Effective Depth, d_E

$$d_E = (0.3) \times d_S + (0.4) \times 1 - (0.7/w_T) + 0.5$$

d_E = ____ ft

Minimum Surface Area, A_m

$$A_M\ (ft^2) = \frac{V_{BMP}\ (ft^3)}{d_E\ (ft)}$$

A_M = ____ ft^2

Proposed Surface Area — A= ____ ft^2

Bioretention Facility Properties

Side Slopes in Bioretention Facility — z = ____ :1

Diameter of Underdrain — ____ inches

Longitudinal Slope of Site (3% maximum) — ____ %

6" Check Dam Spacing — ____ feet

Describe Vegetation:

Notes:

3.6 Extended Detention Basin

Type of BMP	LID - Biotreatment
Treatment Mechanisms	Sedimentation, Infiltration, Biofiltration, Evapotranspiration, and Evaporation
Minimum Tributary Drainage Area	5 acres
Other Names	Enhanced Water Quality Basin

Overview

The Extended Detention Basin (EDB) is designed to detain the design volume of stormwater, V_{BMP}, and maximize opportunities for volume losses through infiltration, evaporation, evapotranspiration and surface wetting. Additional pollutant removal is provided through sedimentation, in which pollutants can attach to sediment accumulated in the basin through the process of settling. Stormwater enters the EDB through a *forebay* where any trash, debris, and sediment accumulate for easy removal. Flows from the forebay enter the basin which is vegetated with native grasses that enhance infiltration and evapotranspiration, and which is interspersed with gravel-filled trenches that help further enhance infiltration. Water that does not get infiltrated or evapotranspired is conveyed to the *bottom stage* of the basin. At the bottom stage of the basin, low or incidental dry weather flows will be treated through a sand filter and collected in a subdrain structure. Any additional flows will be detained in the basin for an extended period by incorporating an outlet structure that is more restrictive than a traditional detention basin outlet. The restrictive outlet structure extends the drawdown time of the basin which further allows particles and associated pollutants to settle out before exiting the basin, while maximizing opportunities for additional incidental volume losses.

EXTENDED DETENTION BASIN BMP FACT SHEET

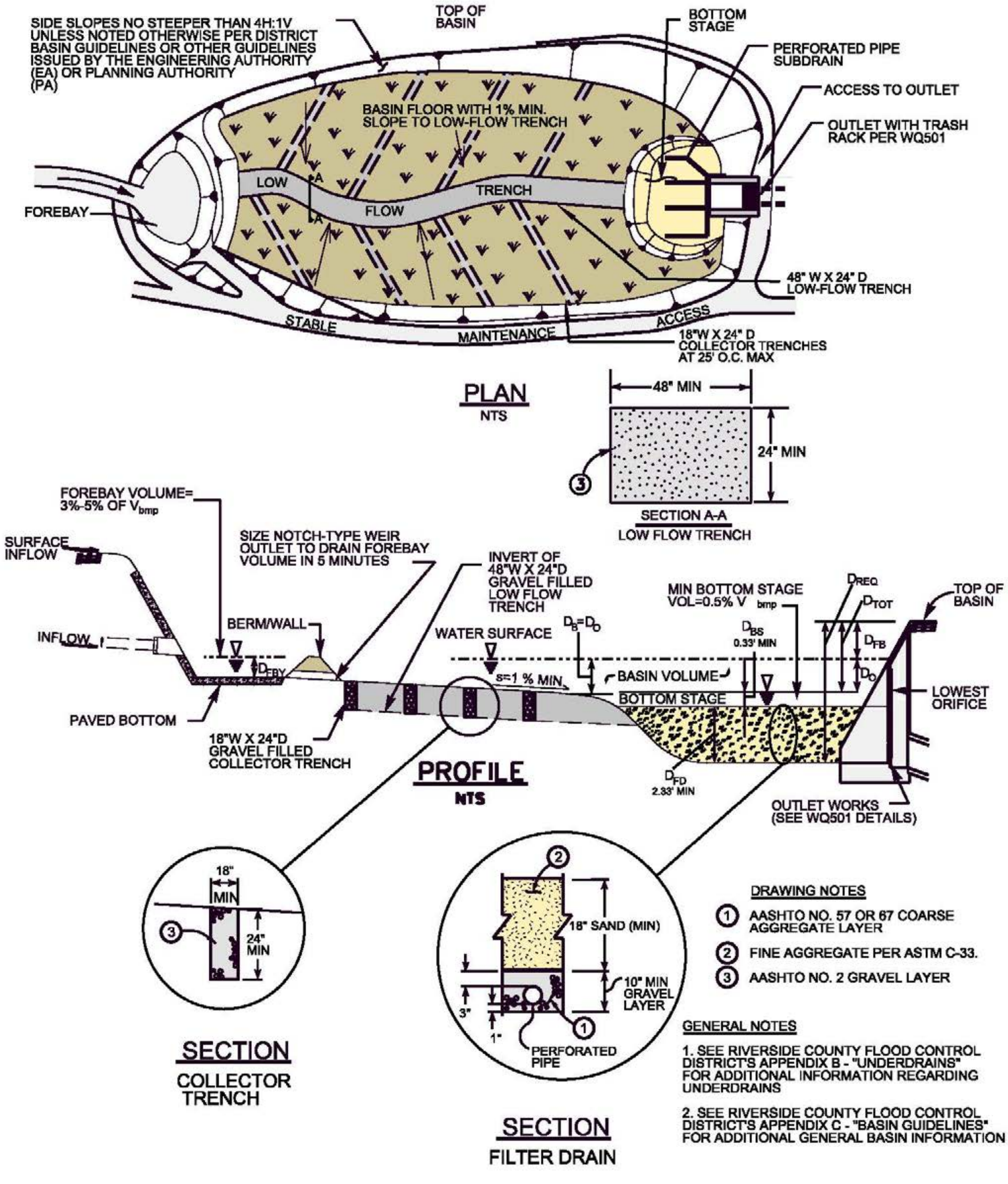


Figure 1 – Extended Detention Basin

Siting Considerations

Soils: EDBs can be used with almost all soils and geology. However, pollutant removal effectiveness is greatly improved when the underlying soil permits at least some infiltration.

Tributary Area: EDBs should only be used where the tributary drainage area is at least 5 acres, since meeting the draw-down requirements (discussed below) for smaller areas would result in very small outlet orifice diameters which would be prone to clogging.

Proximity to Receiving Waters: All site runoff must be treated to the MEP with appropriate BMPs *before* being discharged into Receiving Waters; as such the EDB cannot be constructed in-line within Receiving Waters.

Setbacks: Due to the infiltration characteristics incorporated into the EDB design, the lowest pervious point (beneath the filter drain) of the extended detention facility should be a minimum of 10' above the seasonal high groundwater table. All other setbacks shall be in accordance with applicable standards of the “Basin Guidelines” (Appendix C) or other guidelines issued by the Engineering Authority (EA).

Basin Guidelines: See Section 1 of the “Basin Guidelines” (Appendix C) for additional requirements (i.e., fencing, maintenance access, etc.) that may be required by the Engineering Authority (EA).

Landscaping Requirements

Basin vegetation provides erosion protection, enhances evapotranspiration and infiltration, and improves pollutant removal. The upper stage basin surface, berms and side slopes shall be planted with native grasses. Proper landscape management is also required to ensure that the vegetation does not contribute to water pollution through the use of pesticides, herbicides, or fertilizers. Landscaping shall be in accordance with applicable standards of the “Basin Guidelines” (Appendix C) or other guidelines issued by the EA.

Maintenance Guidelines

Schedule	Inspection and Maintenance Activity
During every scheduled maintenance check (per below), and *as needed* at other times	• Maintain vegetation as needed. Use of fertilizers, pesticides and herbicides should be strongly avoided to ensure they don't contribute to water pollution. If appropriate native plant selections and other IPM methods are used, such products shouldn't be needed. If such projects are used: o Care should be taken to avoid contact with the low-flow or other trenches, and the media filter in the bottom stage. o Products shall be applied in accordance with their labeling, especially in relation to application to water, and in areas subjected to flooding. o Fertilizers should not be applied within 15 days before, after, or during the rainy season. • No ponded water should be present for more than 72 hours to avoid nuisance or vector problems. No algae formation should be visible. Correct problems as needed.
Annually. If possible, schedule these inspections before the beginning of the rain season to allow for any repairs to occur before rains occur.	• Remove debris and litter from the entire basin • Inspect hydraulic and structural facilities. Examine the outlet for clogging, the embankment and spillway integrity, as well as damage to any structural element. • Check for erosion, slumping and overgrowth. Repair as needed. • Inspect sand media at the filter drain to verify it is allowing acceptable infiltration. **Scarify top <u>3 inches</u> by raking the filter drain's sand surface annually.** • Check the media filter underdrains (via the cleanout) for damage or clogging. Repair as needed. • Remove accumulated sediment and debris from the forebay, and ensure that the notch weir is clear and will allow proper drainage. • Check gravel filled low flow and collector trenches for sediment buildup and repair as needed.
Every 5 years or sooner (depending on whether observed drain times to empty the basin are less than 72 hours).	• Remove the top 3 inches of sand from the filter drain and backfill with 3 inches of new sand to return the sand layer to its original depth. When scarification or removal of the top 3 inches of sand is no longer effective, remove and replace sand filter layer.
Whenever substantial sediment accumulation has occurred.	• Remove accumulated sediment from the bottom of the basin. Removal should extend to original basin depth.

Extended Detention Basin BMP Fact Sheet

Design Summary

Design Parameter	Extended Detention Basin
Drawdown time (total)	72 hours [2,3]
Minimum drawdown time for 50% V_{BMP}	24 hours [2]
Minimum tributary area	5 acres [2]
Outlet erosion control	Energy dissipaters to reduce velocities[1]
Forebay volume	3 to 5 % of V_{BMP} [3]
Basin Invert Longitudinal Slope (min.)	1%
Basin Invert Transverse (cross) Slope (min)	1%
Low-flow trench width (min.)	48 inches
Low-flow trench depth (min.)	24 inches
Slope of low-flow trench along bottom excavated Surface (max.)	1%
Slope of gravel collector trenches along bottom excavated surface (max.)	1 %
Length to width ratio (min.)	1.5:1
Basin depth (min.)	1 foot [3]
Bottom stage volume	0.5 % of V_{BMP} [3]
Bottom stage depth (min)	0.33 feet [3]
Filter drain depth (min)	2.33 feet [3]

1. **Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures**
2. **CA Stormwater BMP Handbook for New Development and Significant Redevelopment**
3. **Denver, Colorado's UDFCD Drainage Criteria Manual, Volume 3**

Note: The information contained in this BMP Factsheet is intended to be a summary of design considerations and requirements. Additional information which applies to all detention basins may be found in the "Basin Guidelines" (Appendix C). In addition, information herein may be superseded by other guidelines issued by the Engineering Authority.

Design Procedure

These steps correspond to and provide a description of the information required in the EDB Design Worksheet.

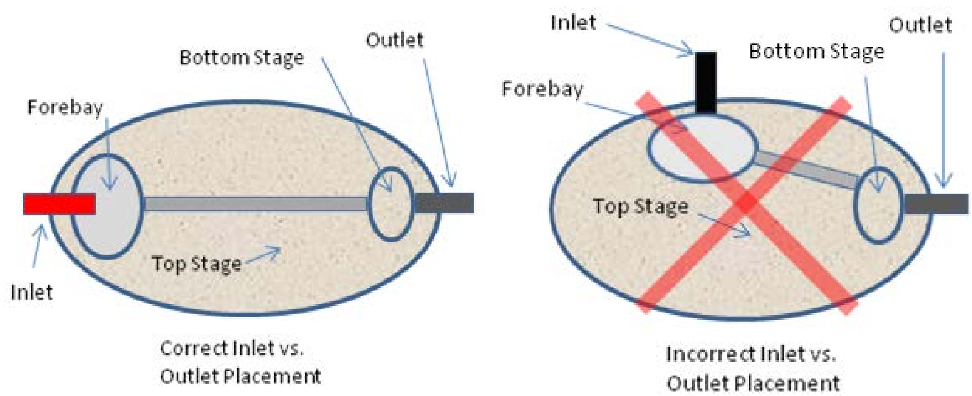
1. Find the Design Volume, V_{BMP}.

a) Enter the tributary area, A_T to the BMP. The minimum tributary area is 5 acres.

b) Enter the Design Volume, V_{BMP}, determined from Section 2.1 of this Handbook.

2. Basin Footprint

a) Enter the length and width of the EDB. The length shall be measured between the inlet to the basin and the outlet structure; and the width shall be measured at the widest point of the basin invert. The length to width ratio should be 1.5:1 or longer to prevent short-circuiting and increase the overall effectiveness of the BMP.



b) Enter the internal basin side slopes. See the "Basin Guidelines" (Appendix C) for side slope requirements. If variable internal side-slopes are used, enter the steepest slope that will be used.

c) Using Figure 1 as a guide, enter the proposed basin depth, D_B, and the freeboard depth, D_{FB}. Based on the information provided, the spreadsheet will calculate the minimum total depth required, D_{REQ}, for this BMP. D_{REQ} is the depth from the bottom of the underdrain layer in the bottom stage (see step 5c), to the top of the freeboard. This calculated minimum required depth can be used to determine if enough elevation difference is available within the design topography to allow for use of this BMP.

d) Additionally, the basin depth D_B is equal to $D_{O,}$ which is the depth from the design pond water surface elevation to the lowest orifice in the outlet structure. D_O is confirmed by the spreadsheet and is used in the Basin Outlet Design described in step 6 below. It should be noted that this lowest orifice is a critical elevation in the design of this BMP. The Volume of the Basin V_{Basin} described in step 3d) is the volume of water above this lowest orifice. This lowest-orifice also represents the dry weather ponded water surface discussed in step 5c below. Below this elevation there must be a minimum of a 4-inch drop down to the surface of the Sand Filter in the bottom stage.

EXTENDED DETENTION BASIN BMP FACT SHEET

3. Basin Design

a) The Total Basin Depth, D_{TOT}, is calculated automatically, and is the sum of the basin depth D_B plus the freeboard depth D_{FB}.

b) Enter the longitudinal slope of the basin invert. This slope must be at least 1% and is measured along the low flow trench between the forebay and the bottom stage. Note that the surface of the sand layer in the bottom stage must be level (see Figure 1).

c) Enter the transverse slope of the basin invert. This transverse (cross sectional) slope must be at least 1% sloped toward the low flow trench.

d) Enter the Volume of the Basin, V_{Basin}. This volume must be the actual volume of water held within the basin as substantiated by modeling or appropriate volumetric calculations, and must be equal to or greater than V_{BMP}. This volume must be held above the lowest orifice in the Basin Outlet Design described in step 6 below.

4. Forebay Design

All flows must enter the basin through the forebay. The forebay provides a location for the settlement and collection of larger particles, and any other trash or debris. A relatively smooth and level concrete bottom surface should be provided to facilitate mechanical removal of any accumulated sediment, trash and debris.

Figure 2: Forebay filled with storm water

a) Enter the Forebay Volume VFB. This volume must be from 3 to 5 percent of V_{BMP}.

b) A rock or concrete berm must be constructed to detain water before it drains into the basin. The top of the berm shall be set no higher than the invert of the inlet conveyance. Enter the Forebay Depth, D_{FBY}.

c) The spreadsheet will calculate the minimum surface area of the forebay, A_{FB}, based on the provided Forebay Volume and Depth. Ensure that the plans provide for a forbay area at least this large.

d) Although the forebay will be well submerged in the design event, a full height rectangular notch-type weir shall be constructed through the berm to prevent permanent ponding in the forebay, and allow water to slowly and fully drain to the main body of the basin. This notch should be offset from the inflow streamline to prevent low-flows from short circuiting. Enter the width, W, of this rectangular notch weir. The width shall not be less than 1.5 inches to prevent clogging. Additionally, immediately outside the notch construct a minimum 1-foot by 1-foot gravel pad to prevent vegetative growth within the basin invert from blocking the notch.

5. Dry Weather and Low-Flow Management

The basin shall have both a low-flow gravel trench and a network of gravel collector trenches across the invert of the basin, as well as a bottom stage sand filter to treat low flows and dry weather flows (see Figure 1).

a) Low Flow Trench: The low-flow gravel trench conveys flow from the forebay to the bottom stage, while allowing for maximum incidental infiltration and volume loss. The trench shall be a minimum of 48 inches wide by 24 inches deep. This trench shall be unlined and backfilled with AASHTO No. 2 gravel (or similar) to the finished surface of the basin invert, and shall not use underdrains. The bottom excavated surface of the low-flow trench shall be 1 percent or flatter to promote infiltration.

Figure 3: Gravel filled low-flow trench

b) Collector Trenches: Gravel collector trenches beneath the top stage shall be arranged as illustrated in Figure 1 of Appendix C with minimal slope (1% maximum) along their bottom excavated surface to promote infiltration, and must extend from the low-flow trench to the toe of the basin side slopes. They shall be a minimum of 18-inches wide by 24-inches deep, unlined and backfilled with AASHTO No. 2 gravel (or similar) to the finished basin invert surface. The gravel collector trenches shall not use underdrains and shall be constructed with a maximum spacing of 25 feet, center to center. See Figure 1 of Appendix C.

c) Bottom Stage: A depressed sand filter drain area, referred to as the bottom stage, must be constructed adjacent to the outlet structure to treat any dry weather flows. To ensure that dry weather flows are treated through the sand filter and not discharged through the orifice plate, the top surface of the sand filter must be depressed at least 4 inches below the lowest orifice in the outlet structure. This depressed area will create a micro pool of water that is then filtered down through the sand filter and out through underdrains. Based on the minimum dimensions described below, the minimum depth of excavation below the lowest orifice in the outlet structure is 2.33 feet.

   i. Enter the Depth of the bottom stage, D_{BS}. As mentioned above, this depth must be at least 4 inches, and extend down below the lowest orifice in the outlet structure.

   ii. Enter the area of the bottom stage, A_{BS}.

iii. Based on the D_{BS} and A_{BS} entered, the spreadsheet will calculate V_{BS}. This volume is the volume of ponded water that will be held below the lowest orifice in the outlet structure, and above the surface of the sand filter. This volume must be at least 0.5% of V_{BMP}.

iv. Enter the thickness of the ASTM C-33 sand layer that will be provided, D_S. A minimum thickness of 18 inches is required.

v. Below the sand layer, a minimum 10-inch thick layer of gravel shall be installed with underdrains to drain the water that has been treated through the sand filter. The underdrains shall connect into the outlet structure. See Appendix B for standard underdrain construction. Enter the diameter of the underdrain pipe (minimum 6" dia.), and the spacing of the underdrains. The maximum spacing of the underdrains is 20 feet on center, however where the area of the bottom stage is particularly small (less than 500 square feet), the underdrain pipes shall be placed at no more than a 10-foot separation on center.

6. Basin Outlet Design

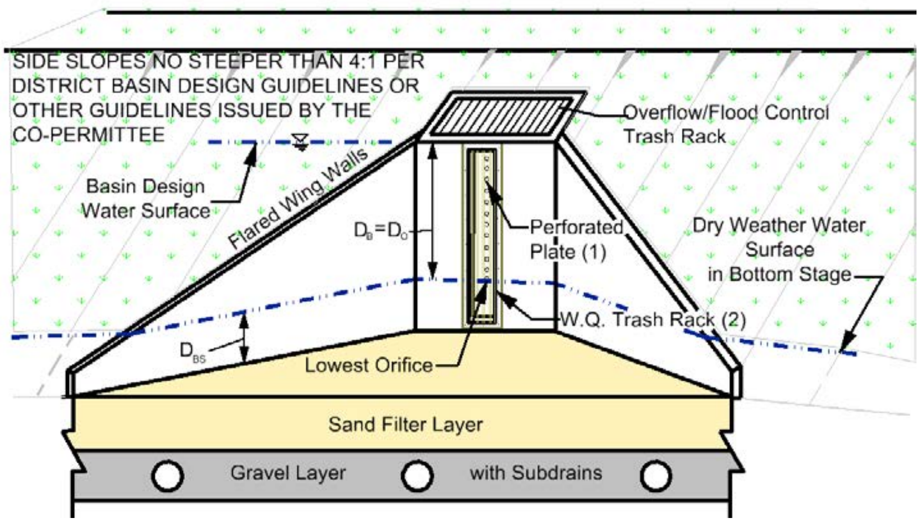


Figure 4: Basin Outlet Structure with Bottom Stage Shown

Outlet structures for publicly maintained basins shall conform to District Standard Drawings WQ501 unless approved in advance by the local Engineering Authority (EA). This standardization is to provide for efficient maintenance. The basin outlet should be sized to release the design volume, VBMP, within a 72-hour period but 50 percent of VBMP within 24 hours. This is an iterative design process where an appropriate control orifice can be selected using the following steps:

a. Develop a Stage vs. Discharge Curve for the Outlet Structure

Estimate the orifice size and outlet plate configuration (number per row, etc.). Based on D_O provided in the Basin Footprint section, the spreadsheet will automatically generate the stage vs. discharge relationship for this outlet:

$$Q = C*A*[2*g*(H-H_o)]^{0.5}$$

Where:

Q = discharge (ft^3/s)

C = orifice coefficient

A = area of the orifice (ft)

g = gravitational constant (32.2 ft2/s)

H = water surface elevation (ft)

H_o = orifice elevation (ft)

The lowest orifice shall be located with its centerline at the top of the bottom stage; at least 4 inches above the surface of the sand filter drain. To help avoid clogging, the minimum orifice diameter is limited to 3/8 inch. Since the 1/4 inch thickness of the orifice plate will be less than the orifice diameter, a value for C of 0.66 may be used. If another value for C is used, justification may be required.

b. Develop a Discharge/Volume vs. Stage Table for the Basin

Based on the shape and size of the basin, develop a relationship between the stage and the volume of water in the basin. Since the orifice spacing is 4 inches on center for the standard orifice plate, the stage intervals must also be 4 inches. Enter the basin volume at each interval starting at the centerline of the lowest orifice.

c. Route the Design Volume through the Basin

The spreadsheet assumes that the Design Volume, $V_{BMP,}$ enters the basin instantaneously and as such, no inflow/outflow hydrograph is necessary. The drawdown time for each stage becomes:

$$\Delta t = V_i/Q$$

Where:

Δt = drawdown time for each stage

V_i = the volume at each stage

Q = the flow rate corresponding to the headwater elevation at each stage.

The spreadsheet automatically determines the drawdown time from the sum of the Δt values for each stage. If the orifice size and plate configuration estimate meets the hydraulic retention time requirements (50% of the volume empties in not less than 24 hours, 100% of the volume empties in no more than 72 hours), the outlet is correctly sized. If these requirements are not met, select a new orifice size or configuration and repeat the process starting at Step 6a.

7. Outlet Protection

To prevent the orifices from clogging, trash racks are required where perforated vertical outlet control plates are used. This allows for easier access to outlet orifices for inspection and cleaning. Trash racks shall be sized to prevent clogging of the primary water quality outlet without restricting the hydraulic capacity of the outlet control orifices. The orifice plate shall be protected with a trash rack conforming to Standard Drawing WQ501 (at end of this section) with at least six square feet of open surface area or 25 times the total orifice area, whichever is greater. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.

Overflow Structure Similar to Standard Drawing Number WQ 501
(Photo courtesy of Colorado Association of Stormwater Floodplain Managers)

Trash rack with screen

8. Overflow Outlet

Overflow outlets for publicly maintained basins shall conform to Standard Drawing WQ501 (at end of this section) unless approved in advance by the Engineering Authority (EA).

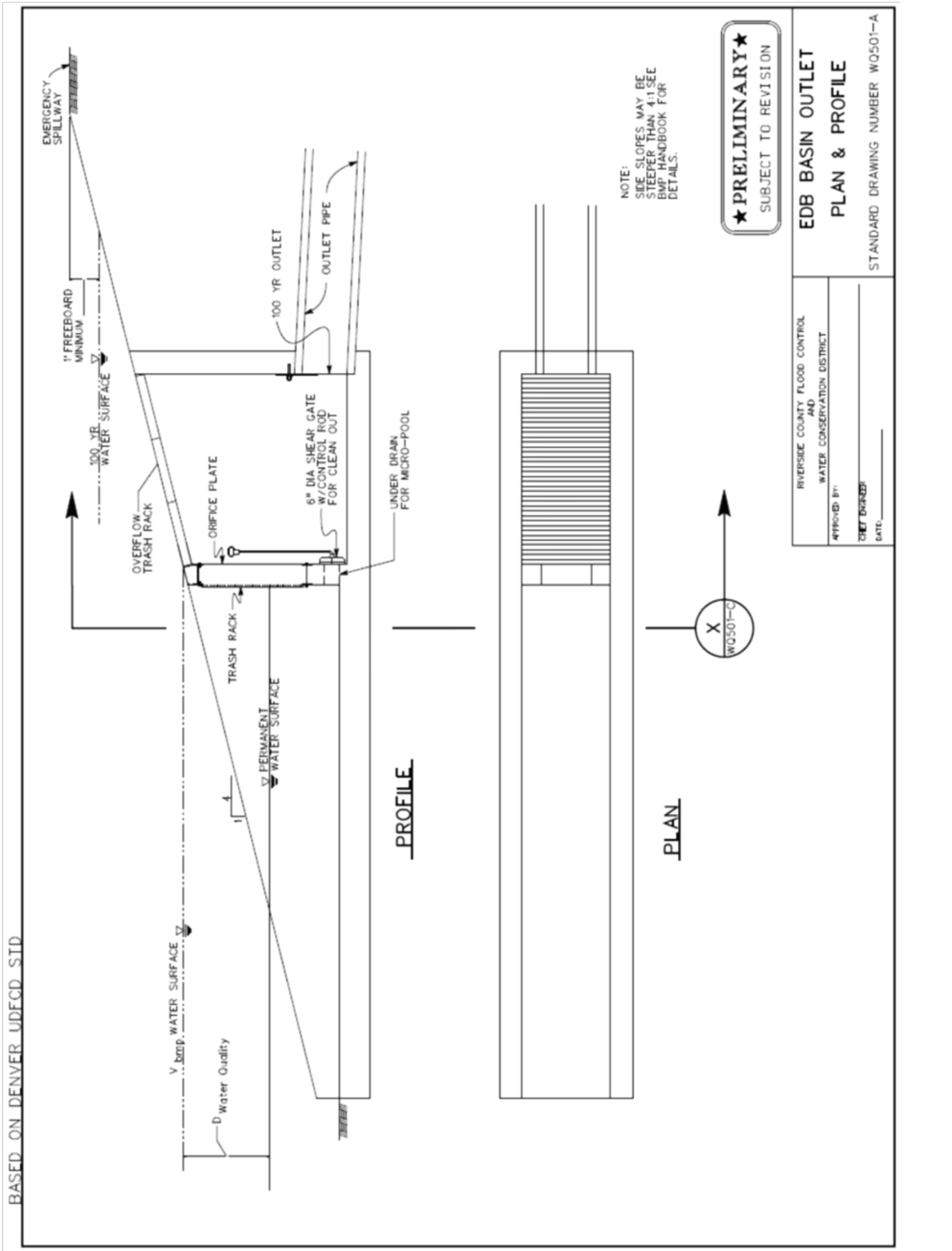
9. Embankment

Embankments shall be designed in accordance with applicable standards of Riverside County Flood Control District's "Basin Guidelines" (Appendix C) or other guidelines issued by the Engineering Authority (EA). Where applicable, embankment designs must additionally conform to the requirements of the State of California Division of Safety of Dams.

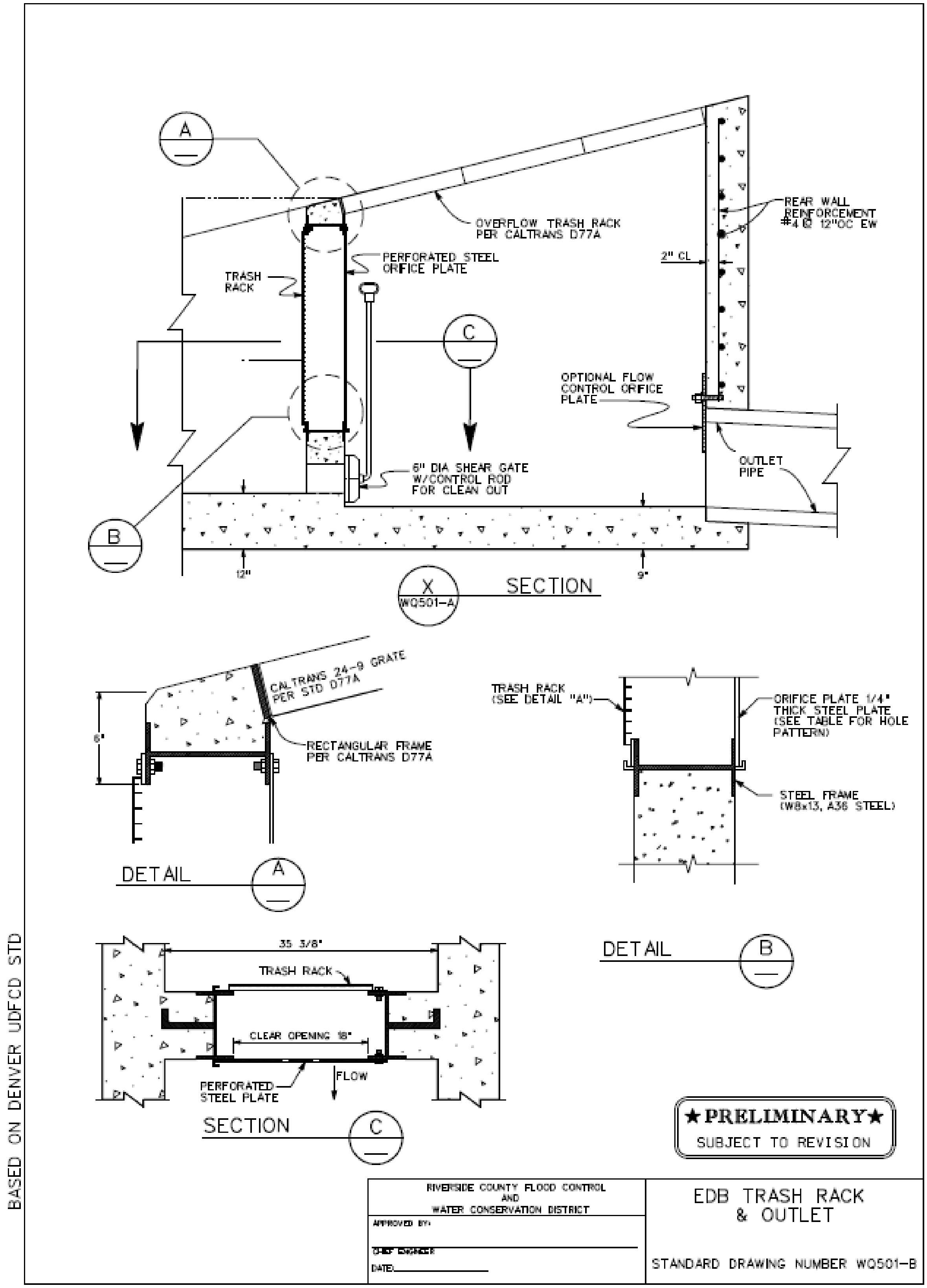
10. Spillway and Overflow Structures

Spillway and overflow structures should be designed in accordance with applicable standards of the "Basin Guidelines" (Appendix C) or other guidelines issued by the Engineering Authority (EA).

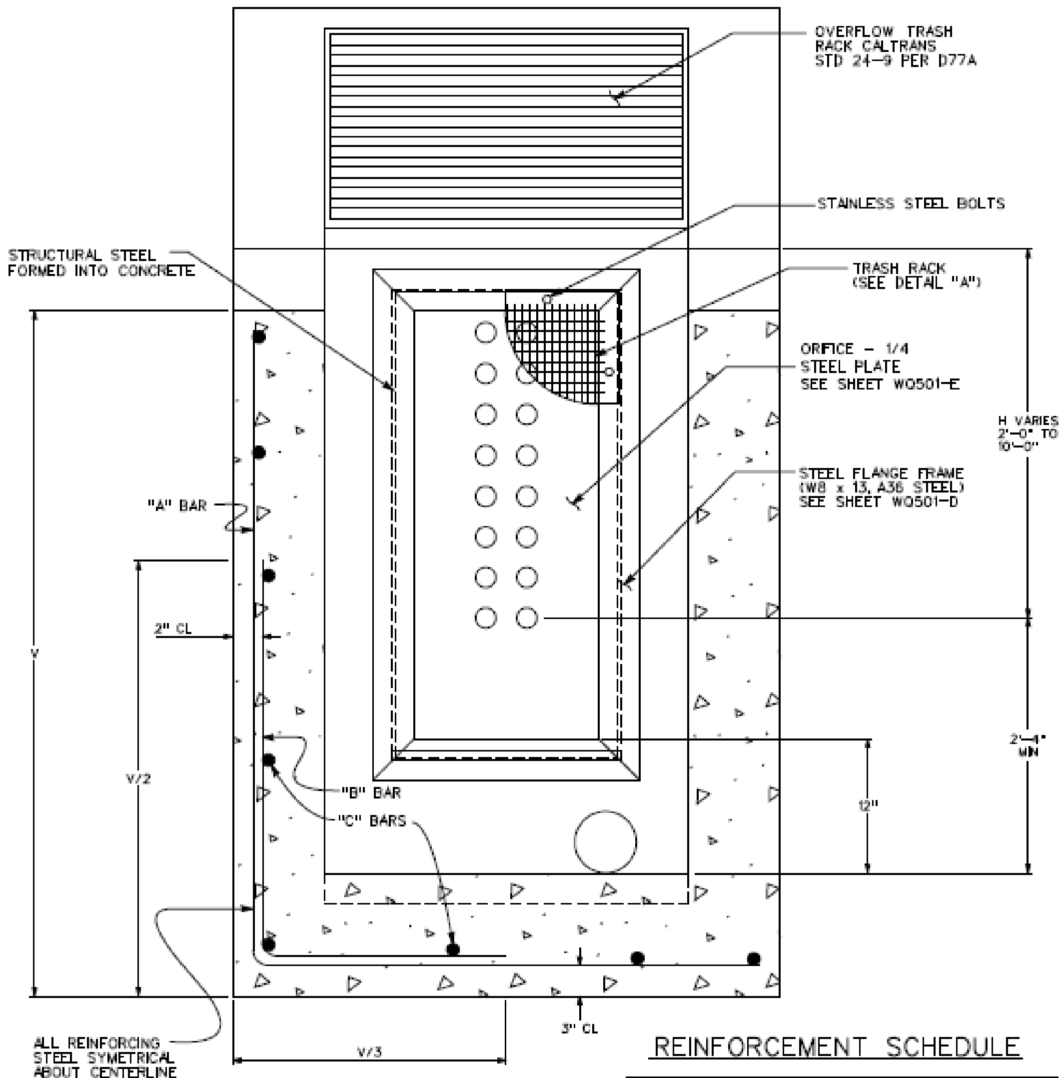
EXTENDED DETENTION BASIN BMP FACT SHEET



EXTENDED DETENTION BASIN BMP FACT SHEET



EXTENDED DETENTION BASIN BMP FACT SHEET



REINFORCEMENT SCHEDULE

MAX V	T WALL	A&B BARS	C BARS
6'	9"	#4 @ 18"	#4 @ 18"
10'	10"	#4 @ 12"	#4 @ 18"
12'	10"	#5 @ 12"	#4 @ 18"
REAR WALL REINFORCEMENT #4 @ 12" OC EW SEE DWG WQ501-B			

ELEVATION X WQ501-A

★PRELIMINARY★
SUBJECT TO REVISION

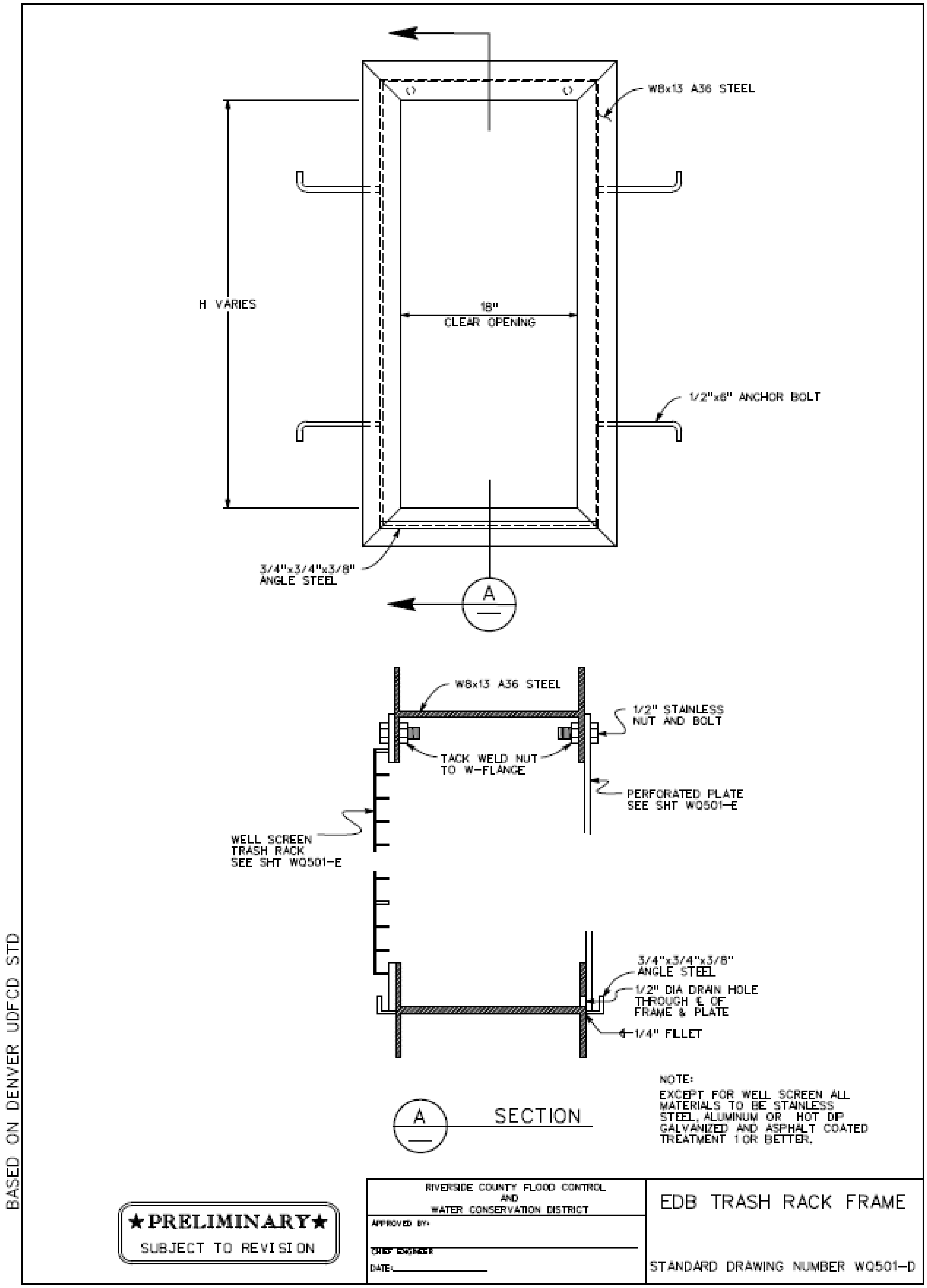
BASED ON DENVER UDFCD STD

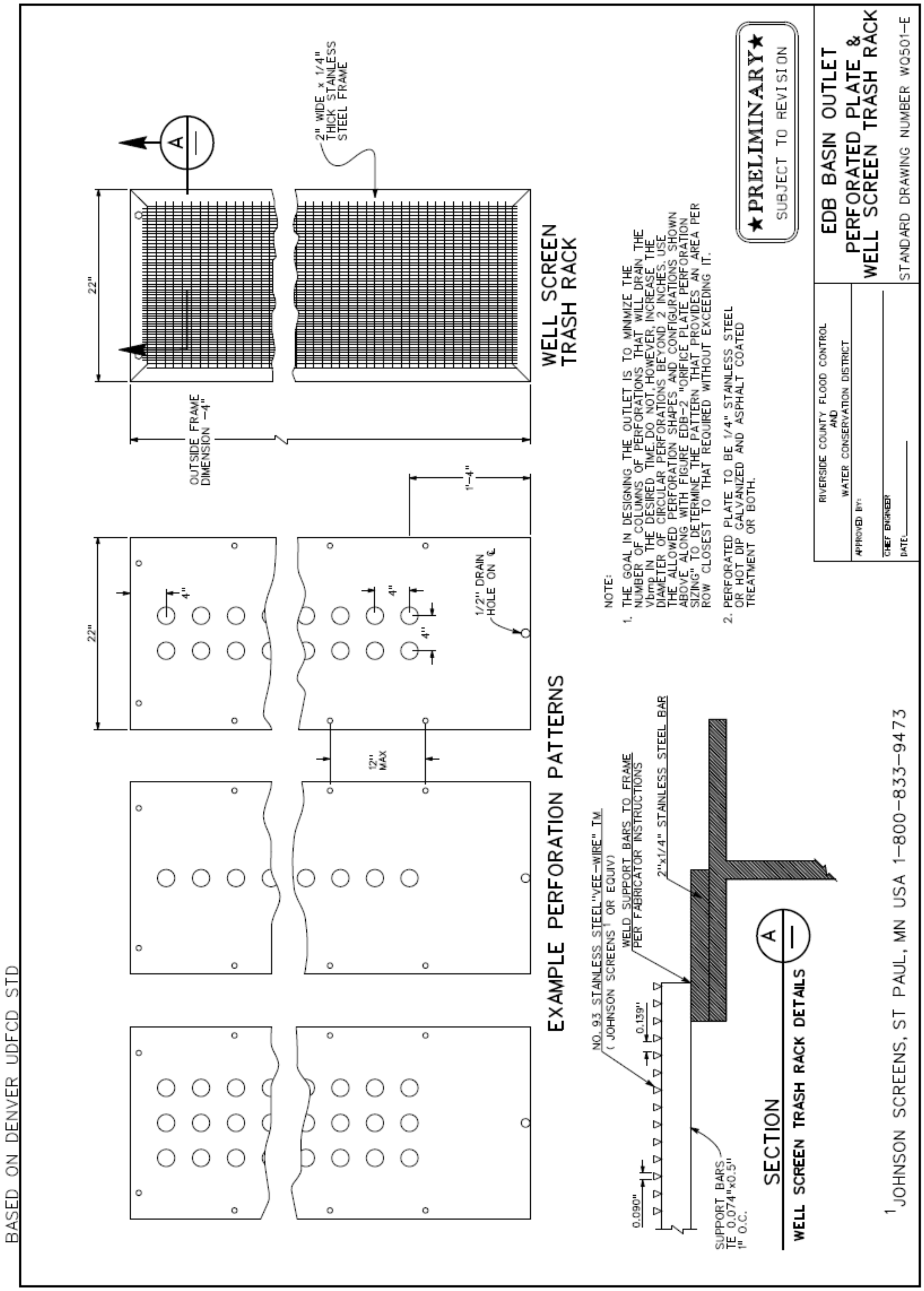
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
APPROVED BY:
CHIEF ENGINEER
DATE:

EDB BASIN OUTLET

STANDARD DRAWING NUMBER WQ501-C

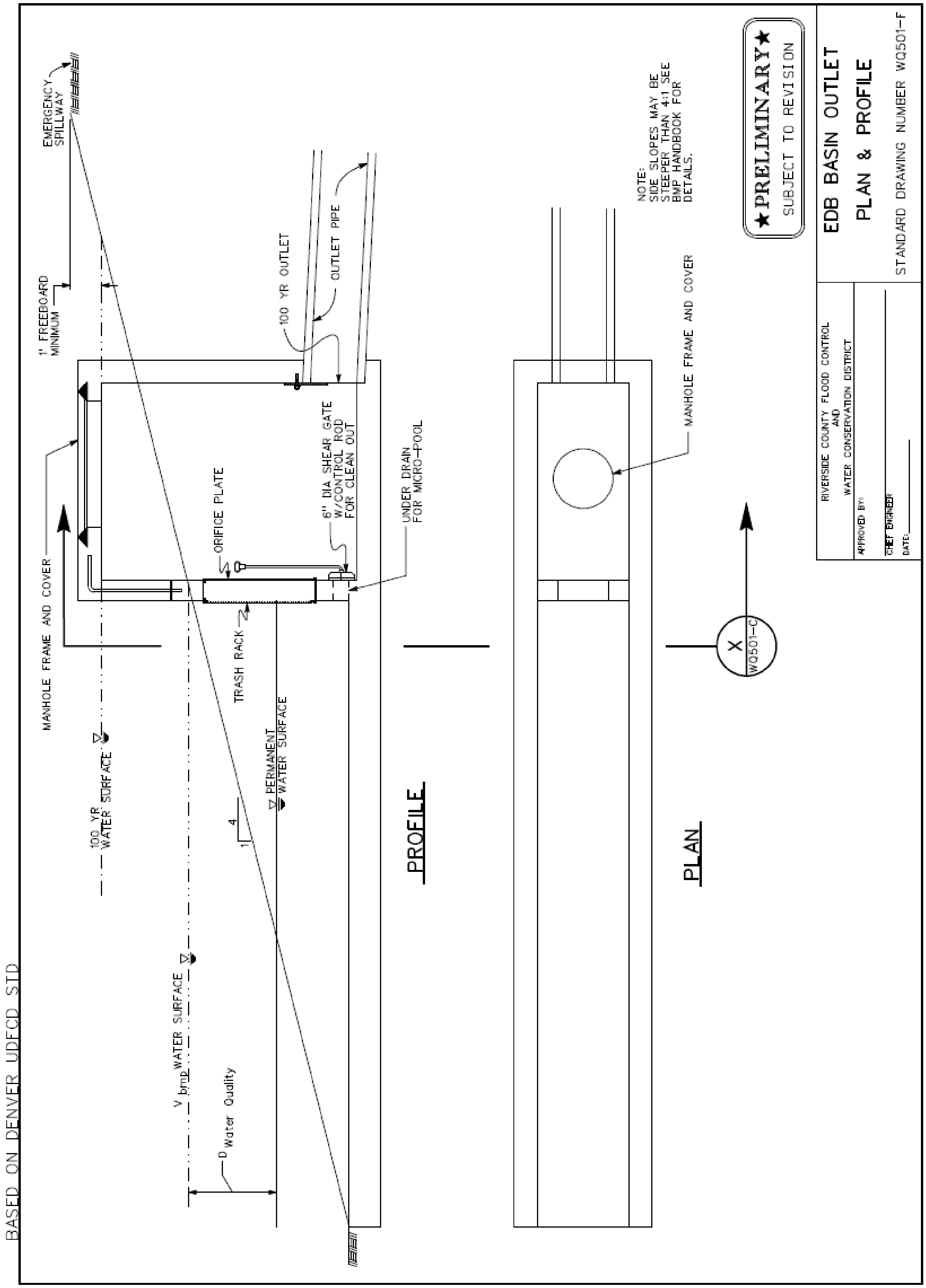
EXTENDED DETENTION BASIN BMP FACT SHEET



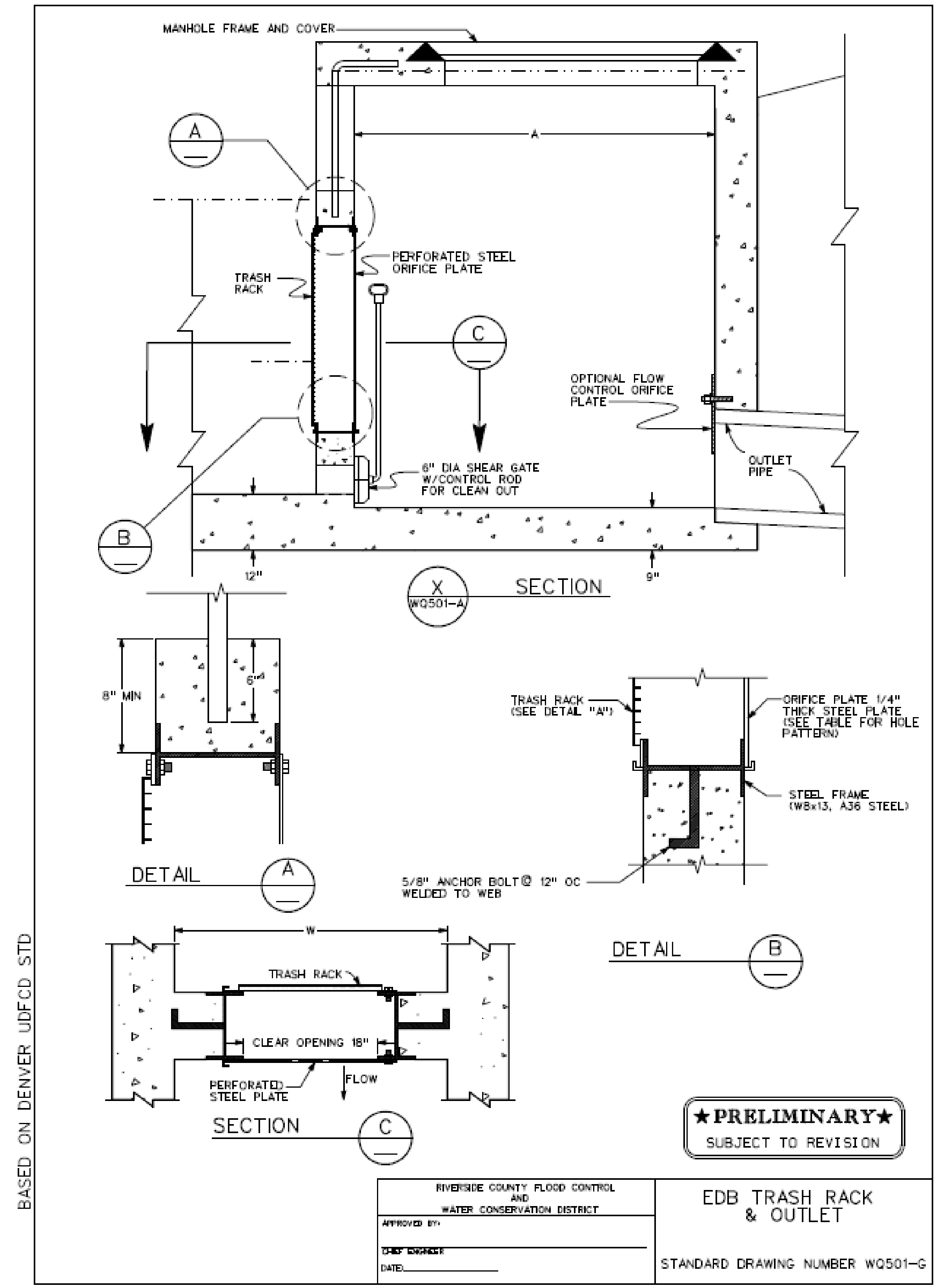


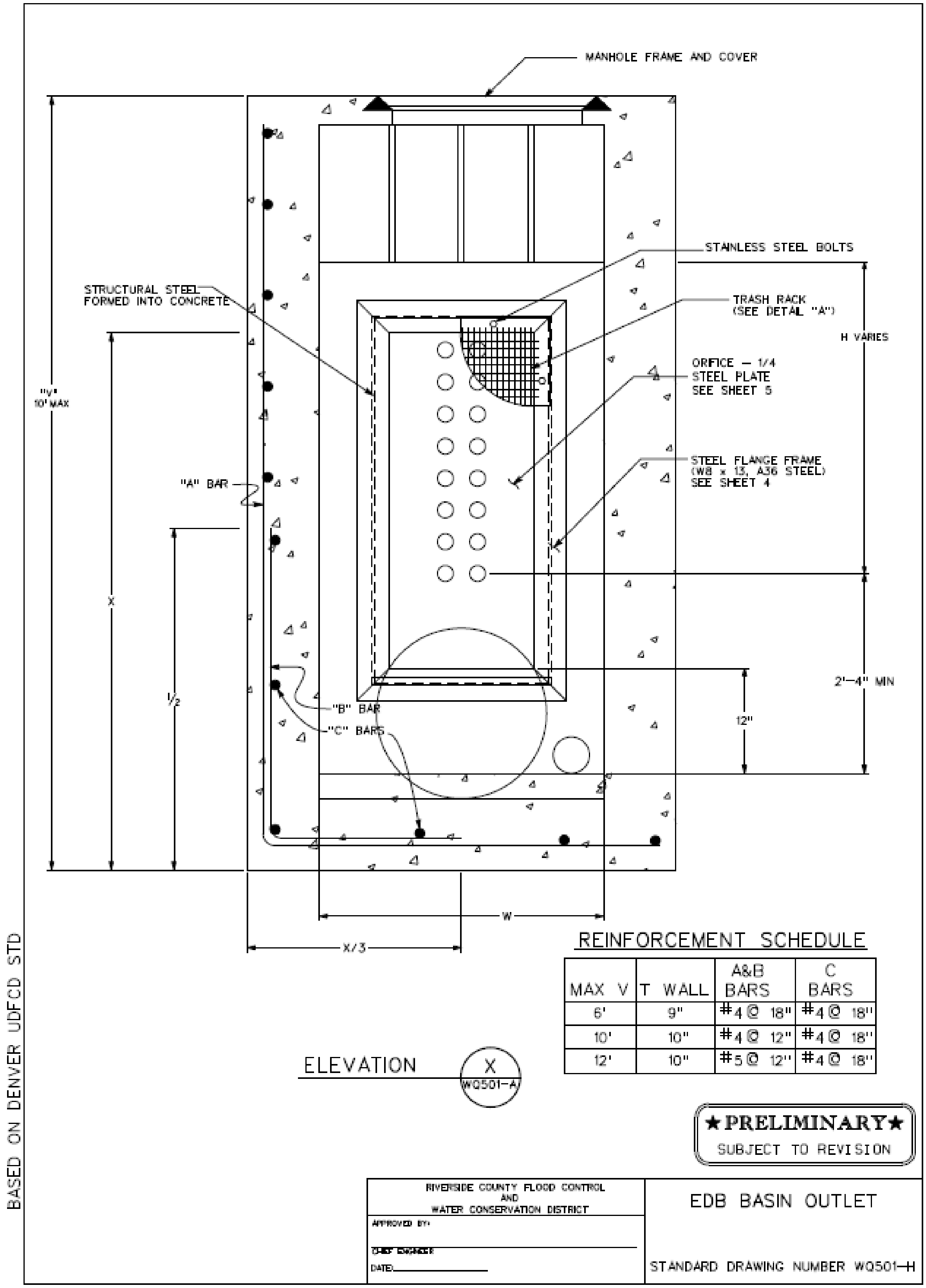
BASED ON DENVER UDFCD STD
22"
2" WIDE x 1/4" THICK STAINLESS STEEL FRAME
OUTSIDE FRAME DIMENSION -4"
WELL SCREEN TRASH RACK
1'-4"
4"
1/2" DRAIN HOLE ON ℄
12" MAX
EXAMPLE PERFORATION PATTERNS
NOTE:
1. THE GOAL IN DESIGNING THE OUTLET IS TO MINIMIZE THE NUMBER OF COLUMNS OF PERFORATIONS THAT WILL DRAIN THE Vbmp IN THE DESIRED TIME. DO NOT, HOWEVER, INCREASE THE DIAMETER OF CIRCULAR PERFORATIONS BEYOND 2 INCHES. USE THE ALLOWED PERFORATION SHAPES AND CONFIGURATIONS SHOWN ABOVE ALONG WITH FIGURE EDB-2 "ORIFICE PLATE PERFORATION SIZING" TO DETERMINE THE PATTERN THAT PROVIDES AN AREA PER ROW CLOSEST TO THAT REQUIRED WITHOUT EXCEEDING IT.
2. PERFORATED PLATE TO BE 1/4" STAINLESS STEEL OR HOT DIP GALVANIZED AND ASPHALT COATED TREATMENT OR BOTH.
★PRELIMINARY★
SUBJECT TO REVISION
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
APPROVED BY:
CHIEF ENGINEER
DATE:
EDB BASIN OUTLET PERFORATED PLATE & WELL SCREEN TRASH RACK
STANDARD DRAWING NUMBER WQ501-E
NO. 93 STAINLESS STEEL "VEE-WIRE" TM (JOHNSON SCREENS[1] OR EQUIV)
WELD SUPPORT BARS TO FRAME PER FABRICATOR INSTRUCTIONS
2"x1/4" STAINLESS STEEL BAR
0.139"
0.090"
SUPPORT BARS TE 0.074"x0.5" 1" O.C.
A
SECTION
WELL SCREEN TRASH RACK DETAILS
[1]JOHNSON SCREENS, ST PAUL, MN USA 1-800-833-9473

EXTENDED DETENTION BASIN BMP FACT SHEET



EXTENDED DETENTION BASIN BMP FACT SHEET





REINFORCEMENT SCHEDULE

MAX V	T WALL	A&B BARS	C BARS
6'	9"	#4 @ 18"	#4 @ 18"
10'	10"	#4 @ 12"	#4 @ 18"
12'	10"	#5 @ 12"	#4 @ 18"

Extended Detention Basin Design Procedure	BMP Subarea No.	Legend:	Required Entries / Calculated Cells

Company Name: Date:

Designed by: County/City Case No.:

Design Volume

Tributary Area (BMP Subarea) A_T = acres

Enter $V_{BMP,}$ determined from Section 2.1 of this Handbook V_{BMP}= ft^3

Basin Footprint

Overall Geometry

Length at Basin Bottom Surface Length = ft

Width at Basin Bottom Surface Width = ft

Meets 1.5 : 1 requirement?

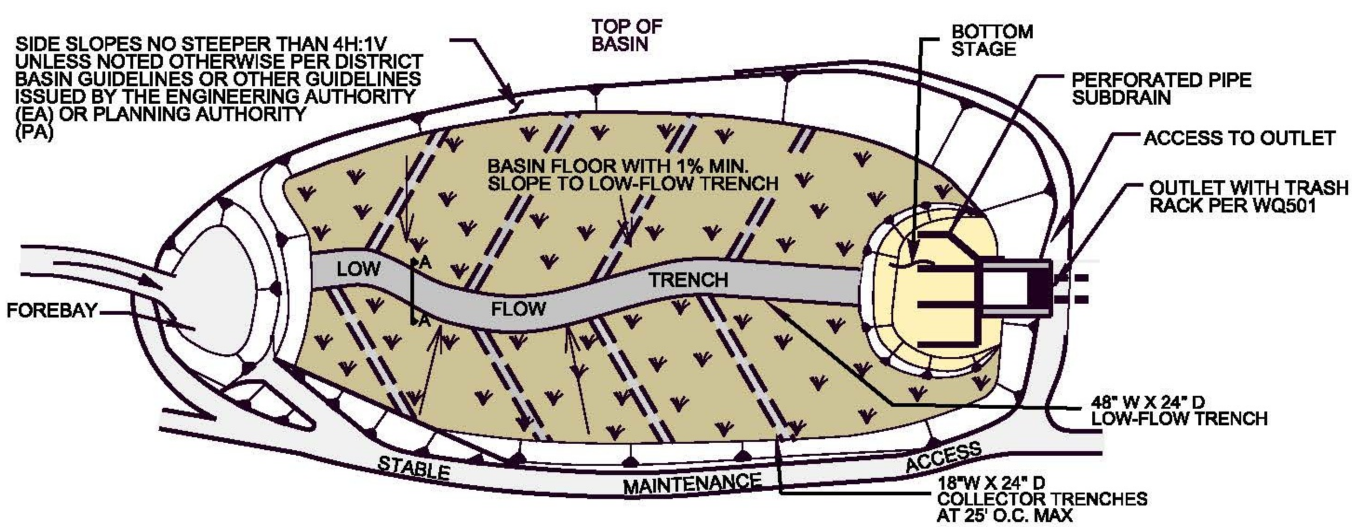
Side Slopes per "Basin Guidelines", Sect. 1.2 z = :1

Proposed Basin Depth (with no freeboard) D_B = ft

Depth of freeboard (if used) D_{FB} = ft

Minimum Required Allowance for Total Depth (including proposed basin depth, freeboard, minimum depth of bottom stage (D_{BS}=0.33') and minimum filter depth (D_{FD}=2.33')) D_{REQ} = ft

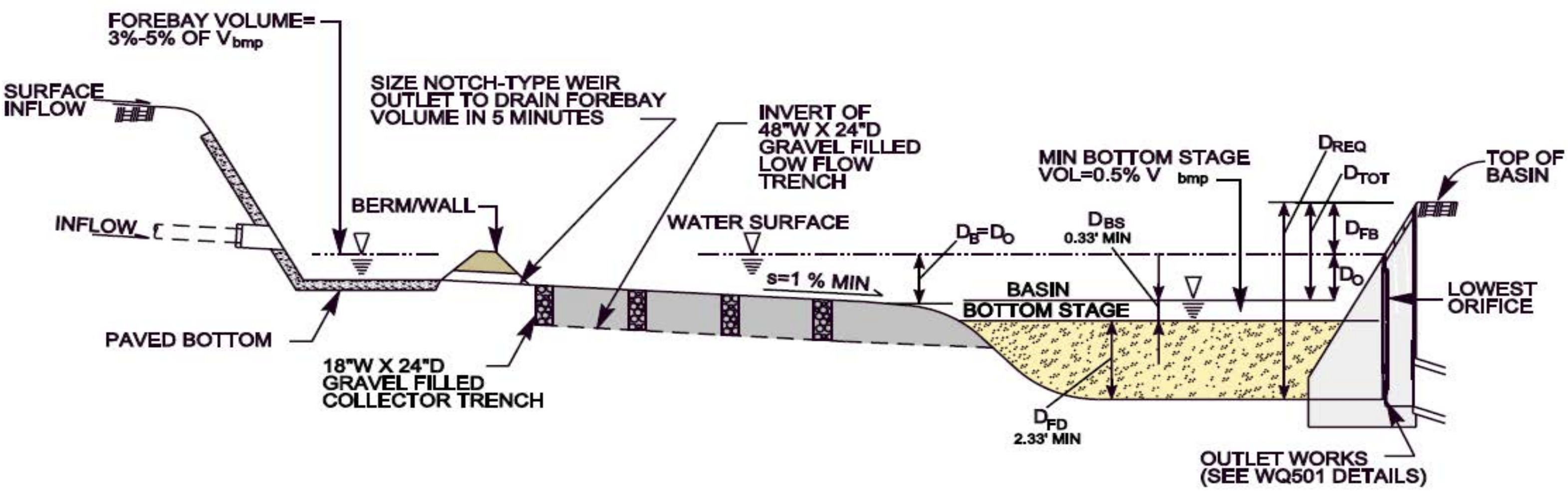
Depth from design water surface elevation to lowest orifice D_O = ft



Basin Design

Basin Design

Proposed Total Basin Depth (proposed depth plus freeboard)	D_{TOT} =		ft
Basin Invert Longitudinal Slope	Slope =		%
Basin Invert Transverse Slope (1% min)	Slope =		%
Basin Volume	V_{Basin} =		ft^3



Forebay Design

Forebay Volume (3 - 5% V_{BMP})	V_{FB} =		ft^3
Forebay Depth (height of berm)	D_{FBY} =		ft
Minimum Forebay Surface Area	A_{FB} =		ft^2
Rectangular weir (notch)	W =		in

Dry Weather and Low-Flow Management

Low-Flow Trench (see graphic below)

Depth (24 inches minimum, gravel filled) — Depth = ____ inches

Width (48 inches minimum) — Width = ____ inches

Trench Invert Longitudinal Slope — Slope = ____ %

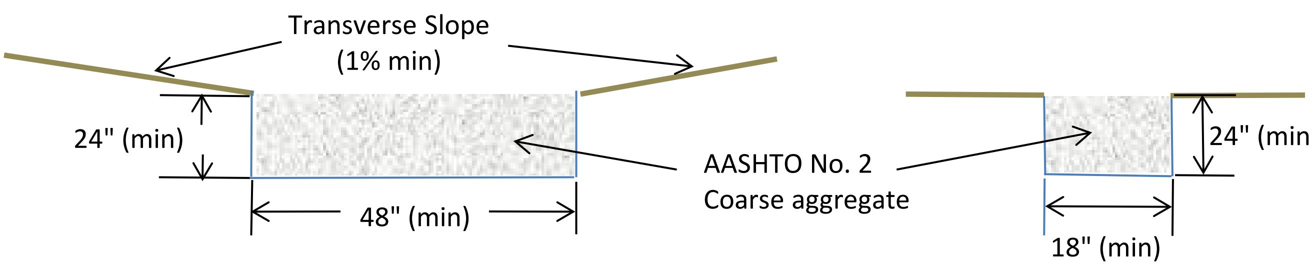
Collector Trenches (see graphic below)

Depth (24 inches minimum) — Depth = ____ inches

Width (18 inches minimum) — Width = ____ inches

Trench Invert Longitudinal Slope — Slope = ____ %

Spacing (25 feet on center maximum) — S = ____ feet



Low-Flow Trench

Collector Trench

Bottom Stage (Sand Filter) Design

Depth of the Bottom Stage (4" minimum ponding) — D_{BS} = ____ in

Surface Area of Bottom Stage — A_{BS} = ____ ft^2

Dry Weather Ponded Volume (above sand layer) — V_{BS} = ____ ft^3

Is V_{BS} no less than 0.5% V_{BMP}? Enter Depth and Surface Area

Depth of ASTM-C33 sand (18 inch minimum)

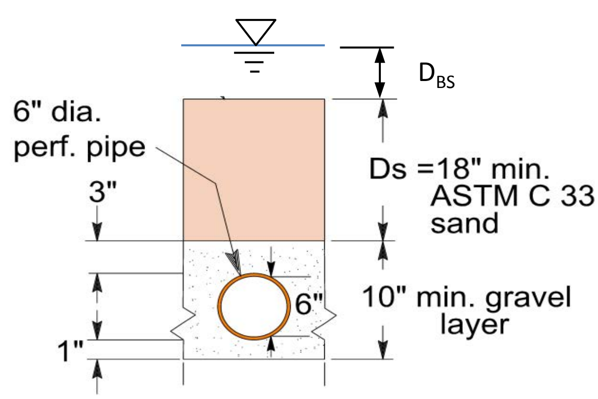
Ds = ____ inches

Diameter of Subdrains

ϕ = ____ in

Subdrain Spacing

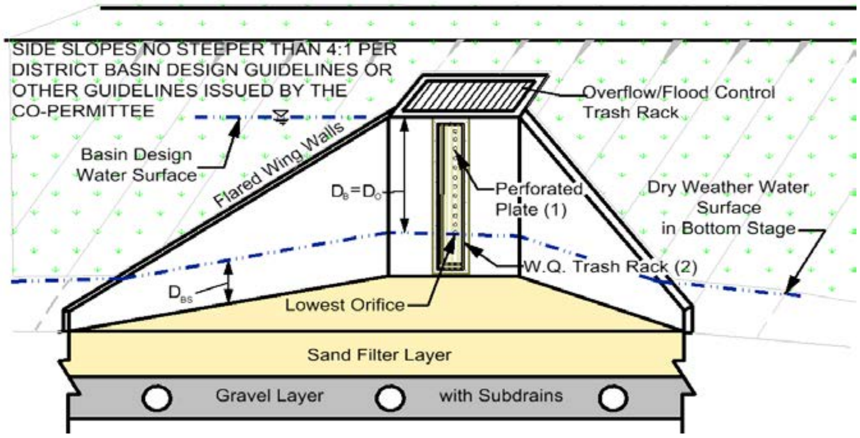
s = ____ ft. on center



Basin Outlet Design

Outlet Design

Assume an orifice area. Based on the information provided above, the spreadsheet provides discharge vs. stage data. Enter the volume vs. stage data for each interval. This information is used to route the volume through the basin. The size of the orifice is acceptable when the data shows that less than 50% of V_{BMP} has drained in 24 hours, and that 100% drawdown occurs within 72 hours.



All values on this worksheet must be filled out to use this calculator

Flow Rate, Q (cfs)

$$Q=CA[2g(H-H_o)]^{0.5}$$

Discharge Coefficient,

Default, C = 0.66

Other, C =

Orifice Area (ft^2)

Orifice Diameter, d; number of orifices per row, n; and number of orifice rows, N (from the bottom up).

d = inches

n = per row

N = rows

Aeff = 0.000 ft^2 per row

or

Aeff = 0.000 in^2 per row

From outflow hydrograph, the time where 50% of V_{BMP} has drained from the basin (24 hour minimum):

Time (50%) = **Error *** hrs

From outflow hydrograph, the time where 100% V_{BMP} has drained from the basin(within 72 hours):

Time (100 %) = **Error *** hrs

Headwater Elev. / Stage (ft)	Discharge (cfs)	Volume (acre-ft)	Δt (hrs.)
0	0.0000	0.0000	
0.33			
0.67			
1.00			
1.33			
1.67			
2.00			
2.33			
2.67			
3.00			
3.33			
3.67			
4.00			
4.33			
4.67			
5.00			
5.33			
5.67			
6.00			
6.33			
6.67			
7.00			
7.33			
7.67			
8.00			
8.33			
8.67			
9.00			
9.33			
9.67			
10.00			
		∑ =	0.00

Notes:

3.7 Sand Filter Basin

Type of BMP	**Treatment**
Treatment Mechanisms	Filtration, Biofiltration
Maximum Tributary Area	25 acres
Other Names	Sand Filter, Media Filter, Pocket Filter

Description

The Sand Filter Basin (SFB) is a basin where the entire invert is constructed as a stormwater filter, using a sand bed above an underdrain system. Stormwater enters the SFB at its forebay where trash and sediment accumulate or through overland sheet flow. Overland sheet flow into the Sand Filter Basin is biofiltered through the vegetated side slopes or other pre-treatment. Flows pass into the sand filter surcharge zone and are gradually filtered through the underlying sand bed. The underdrain gradually dewaters the sand bed and discharges the filtered runoff to a nearby channel, swale, or storm drain.

The primary advantage of the SFB is its effectiveness in removing pollutants where infiltration into the underlying soil is not practical, and where site conditions preclude the use of a Bioretention Facility . The primary disadvantage is a potential for clogging if silts and clays are allowed to flow into the SFB. In addition, this BMP's performance relies heavily on its being regularly and properly maintained.

While this BMP is not currently considered an LID BMP, when designed in accordance with this manual, a Sand Filter Basin is considered to be a highly effective Treatment Control BMP.

Siting Considerations

SFBs should be avoided where onsite configurations include a base flow and/or where this BMP would be put into operation while construction, grading or major landscaping activities are taking place in the tributary catchment. **This BMP has a flat surface area**, so it may be challenging to incorporate into steeply sloping terrain. SFBs should be set away from areas that could discharge fine sediments into the basin such as at the bottom of a slope. **See Section 1 of Riverside County Flood Control and Water Conservation District's "Basin Guidelines" (Appendix C) for additional requirements** (i.e., fencing, maintenance access, etc.) or other guidelines issued by the Engineering Authority (EA)[1].

[1] The Engineering Authority (EA) may choose to alter these guidelines and may have different/additional requirements. These entities, along with the District, will be referred to as the EA.

Sand Filter Basin BMP Fact Sheet

Setbacks

The bottom of the sand filter should remain above the seasonal high groundwater level. Always consult your geotechnical engineer for additional site specific recommendations.

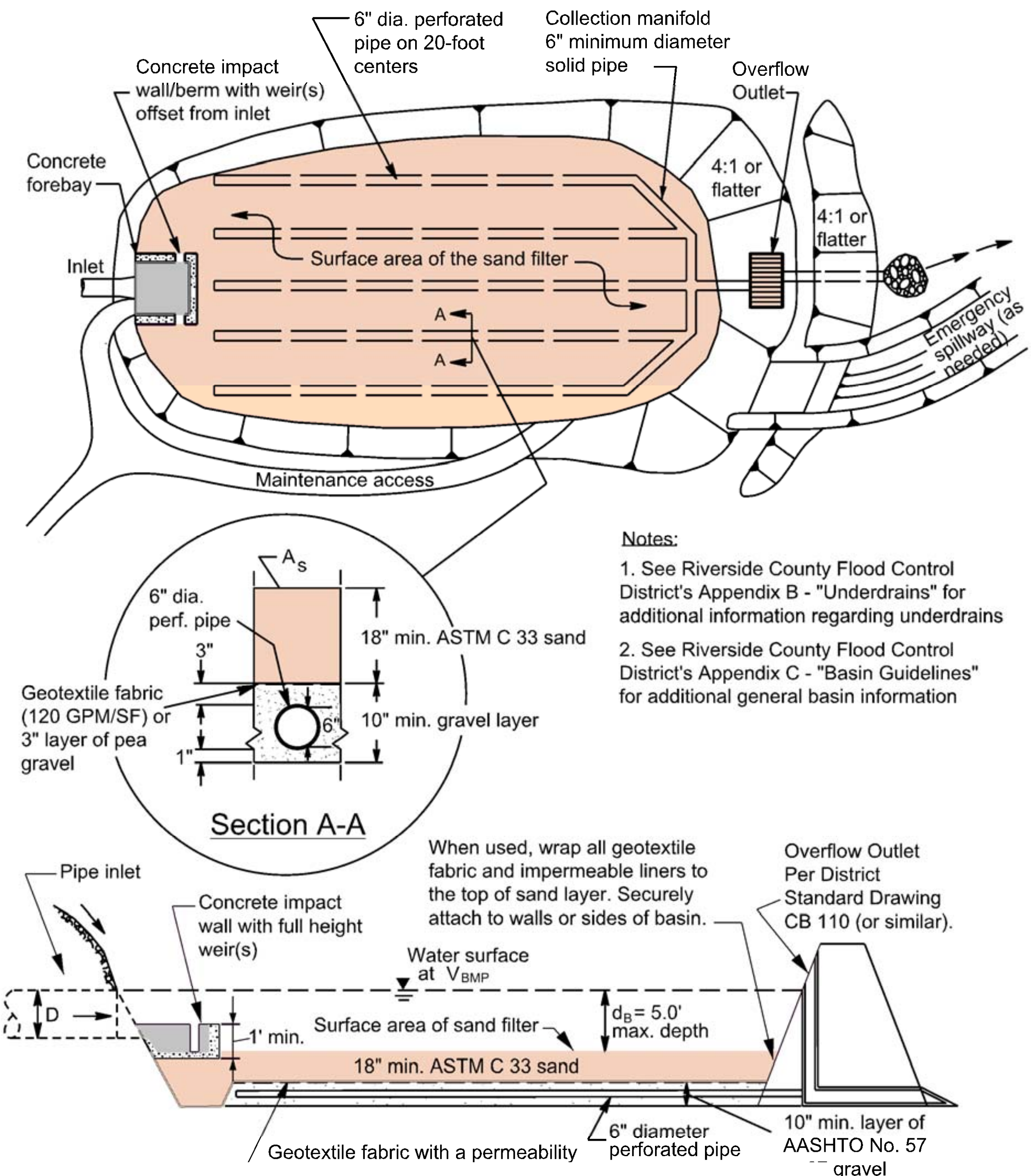


Figure 1 – Plan and Profile Views of SFB Basin

Forebay

A concrete forebay shall be provided to reduce sediment clogging and to reduce erosion. The forebay shall have a design volume of at least 0.5% V_{BMP} and a minimum 1 foot high concrete splashwall. Full height notch-type weir(s), offset from the line of flow from the basin inlet to prevent short circuiting shall be used to outlet the forebay. It is recommended that two weirs be used and that they be located on opposite sides of the forebay (see Figure 1).

Underdrains

Underdrain piping shall consist of a manifold (collector) pipe with perforated lateral branching. The lateral branching conveys the filtered water to the manifold where it is discharged into the outlet structure. See Appendix B for additional information.

Overflow Structure

An overflow must be provided to drain volume in excess of V_{BMP} or to help drain the system if clogging were to occur. Overflows shall flow to an acceptable discharge point such as a downstream conveyance system. Overflows must be placed above the water quality capture volume and near the outlet of the system. The overflow structure shall be similar to the District's Standard Drawing CB 110.

Recommended Maintenance

Table 1 - Recommended Inspection and Maintenance Activities for SFBs

Schedule	Inspection and Maintenance Activity
Semi-monthly including just before the annual storm season and following rainfall events.	• Routine maintenance and inspection. • Remove debris and litter from the entire basin to minimize filter clogging and to improve aesthetics. • Check for obvious problems especially filter clogging and signs of long term ponding. Repair as needed. Address odor, insects, and overgrowth issues associated with stagnant or standing water in the basin bottom. There should be no long-term ponding water. • Check for erosion and sediment laden areas in the basin. Repair as needed. Clean forebay if needed. • Revegetate side slopes where needed.
Annually. If possible, schedule these inspections within 72 hours after a significant rainfall.	• Inspection of hydraulic and structural facilities. Examine the overflow outlet for clogging, the embankment and spillway integrity, and damage to any structural element. • Check side slopes and embankments for erosion, slumping and overgrowth. • Inspect the sand media at the filter drain to verify it is allowing acceptable infiltration. **Scarify the top 3 inches by raking the filter drain's sand surface annually.** • Check the filter drain underdrains for damage or clogging. Repair as needed. • Repair basin inlets, outlets, forebays, and energy dissipaters whenever damage is discovered. • No water should be present 72 hours after an event. No long term standing water should be present at all. No algae formation should be visible. Correct problem as needed.
Every 5 years or sooner depending on the observed drain times (no more than 72 hours to empty the basin).	• Remove the top 3 inches of sand from the filter drain and backfill with 3 inches of new sand to return the sand layer to its original depth. When scarification or removal of the top 3 inches of sand is no longer effective, remove and replace sand filter layer.

Table 2 - Design and Sizing Criteria for SFBs

Design Parameter	Extended Detention Basin
Maximum tributary area	25 acres [2]
Basin design volume	100% of V_{BMP}
Maximum basin depth	5 feet
Forebay volume	0.5 % of V_{BMP}
Longitudinal Slope	0%
Transverse Slope (min.)	0%
Outlet erosion control	Energy dissipaters to reduce velocities[1]

1. **Ventura County's Technical Guidance Manual for Stormwater Quality Control Measures**
2. **CA Stormwater BMP Handbook for New Development and Significant Redevelopment**

Note: The information contained in this BMP Factsheet is intended to be a summary of design considerations and requirements. Additional information which applies to all detention basins may be found in the District's "Basin Guidelines" (Appendix C). In addition, information herein may be superseded by other guidelines issued by the EA.

Design Procedure

1. Enter the Tributary Area, A_{TRIB}
2. Enter the Design Capture Volume, V_{BMP}, determined from Section 2.1 of this Handbook
3. SFB Geometry

   Determine the minimum sand filter area required. The filtration bed surface shall be flat with the maximum depth for the reservoir design volume no greater than 5 feet*. The reservoir design volume does not include the volume of the sand filter. No credit is given for voids in the sand layer toward the reservoir volume since the sand is part of the water quality filter and not a reservoir layer. The design storage volume shall equal 100 percent of V_{BMP}. The minimum sand filter area (As) of the basin's bottom shall be determined using the equation:

   $$A_s = (V_{BMP} / d_B)$$

   Where:

   V_{BMP} = Design Volume, ft^3
   d_B = proposed basin depth (5 feet maximum), ft

   Once the basin side slopes, proposed basin depth and depth of freeboard are entered, the spreadsheet will calculate the minimum total depth required to use this BMP. This is the depth from the top of the basin (including freeboard) down to the bottom of the underdrain gravel layer. This depth can be used to determine if enough vertical separation is available between the BMP and its outlet destination.

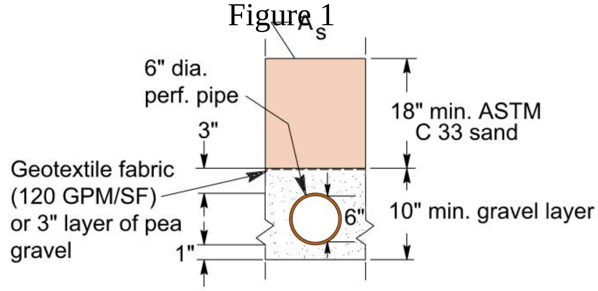
*Note: The 5 foot maximum depth equates to a minimum filter media infiltration rate of 0.83 inches per hour with a 72 hour drawdown time. Studies have shown that while initially most filter media will infiltrate at a much higher rate, it is not uncommon for that rate to decrease significantly over a very short period of time. (Urbonas, 1996)

4. Enter the proposed surface area of the basin.

5. Forebay

   Provide a concrete forebay. Its volume shall be at least 0.5% V_{BMP} with a minimum 1 foot high concrete splashwall. Full-height notch-type weir(s) shall be used to outlet the forebay. The weir(s) must be offset from the line of flow from the basin inlet. It is recommended that two weirs be used and that they be located on opposite sides of the forebay (see Figure 1). Notches shall not be less than 1.5 inches in width.

Figure 1



6. Filter Media

   Provide, as a minimum, an 18-inch layer of filter media (ASTM C-33 sand). Other filter media may be considered with sufficient supporting documentation. Where a medium level of removal efficiency is desired for nutrients, the depth of the sand layer must be increased to 36 inches.

5. Underdrains

   Underdrains shall be provided per the guidelines outlined in Appendix B.

Sand Filter Basin (SFB) - Design Procedure	BMP ID	Legend:	Required Entries / Calculated Cells
Company Name:		Date:	
Designed by:		County/City Case No.:	

Design Volume

Total Tributary area	A_{TRIB} =		ac
Enter V_{BMP} determined from Section 2.1 of this Handbook	V_{BMP}=		ft^3

Basin Geometry

Basin side slopes (no steeper than 4:1)	z =		:1
Proposed basin depth (see Figure 1)	d_B =		ft
Depth of freeboard (if used)	d_{fb} =		ft
Minimum bottom surface area of basin (As = V_{BMP}/d_B)	A_s =		ft^2
Minimum total depth required (includes freeboard, filter media and subdrains)	d_{req} =		ft
Proposed Surface Area			ft^2

Forebay

Forebay volume (minimum 0.5% V_{BMP})	Volume =		ft^3
Forebay depth (height of berm/splashwall. 1 foot min.)	Depth =		ft
Forebay surface area (minimum)	Area =		ft^2
Full height notch-type weir	Width (W) =		in

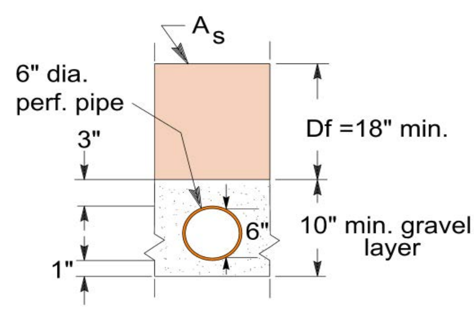
Filter Media

Description of filter media

Sand (ASTM C-33)

Other (Clarify in "Notes" below)

Media depth, df = inches



Underdrains

Diameter of perforated underdrain			in
Spacing of underdrains (maximum 20 feet on center)	OK		ft

Notes:

APPENDIX A

Infiltration Testing

APPENDIX A - INFILTRATION TESTING

Infiltration BMPs use the interaction of chemical, physical, and biological processes between soil and water to filter out sediments and constituents from stormwater. Infiltration BMPs require a maximum drawdown time to avoid nuisance issues. Since drawdown time is contingent on the infiltration rate of the underlying soil, tests are used to help establish the vertical infiltration rate of the soil below a proposed infiltration facility. The tests attempt to simulate the physical process that will occur when the facility is in operation.

Section 1 - General Requirements

1.1 - Summary of Requirements

The following is a brief summary of the requirements for all infiltration test reports submitted to the Engineering Authority (EA)[1] for the purpose of water quality BMP design. A checklist form is included at the end of this document.

1. Where infiltration testing is to be performed (as directed by the EA or in the WQMP), the measured infiltration rate of the underlying soil must be determined using either the single ring infiltrometer test (as described in ASTM D 5126, Section 4.1.2.1), the double ring infiltrometer test (ASTM D 3385), the well permeameter method (USBR 7300-89), or a percolation test per County of Riverside Department of Environmental Health (RCDEH) test procedures. A general explanation of these test methods can be found in Section 2 of this appendix. The minimum number of tests required can be found in Table 1 and is dependent upon the type of infiltration test performed.

2. Test pits and borings (ASTM D 1452) may be used to determine the USCS series and textural class (SM, CL, etc.) of the soil horizons, the thickness of soil and rock strata, and to estimate the historical high groundwater mark[2]. Test pits or boring logs must be of sufficient depth to establish that a minimum of 5 feet of permeable soil exists below the infiltration facility and that there is a minimum of 10 feet between the bottom of the infiltration facility and the historical high groundwater mark (Sections 1.7 and 2.5). The required number of test pits or borings are listed in Table 1.

3. A final report, prepared by a registered civil engineer, geotechnical engineer, certified engineering geologist or certified hydrogeologist shall be provided to the EA which demonstrates through infiltration testing and/or soil logs that the proposed facility location is suitable for the proposed infiltration facility and an infiltration rate shall be recommended. In addition, any requirements associated with impacts to a landslide, erosion or steep slope hazard area should also be addressed in the final report. (Section 1.7)

[1] *County Transportation, Coachella Valley Water District and the City Engineer for incorporated cities within the County may choose to alter these guidelines and may have different/additional requirements. These entities, along with the District, will be referred to as the Engineering Authority (EA).*

[2] *The "historical high groundwater mark" is defined as the groundwater elevation expected due to a normal wet season and shall be obtained by boring logs or test pits.*

4. Tests may be performed only by individuals trained and educated to perform, understand and evaluate the field conditions. The individual(s) supervising the field work must be named in the final report as described in Item 3. (Section 1.7)

5. Preliminary site grading plans shall be provided to the EA showing the proposed BMP locations along with section views through each BMP clearly identifying the extents of cut/fill relative to native soil. (See Section 1.1)

6. For sites where infiltration BMPs have been determined to be feasible and will be used, infiltration tests shall be performed within the boundaries of the proposed infiltration BMP and at the bottom elevation (infiltration surface) of the proposed infiltration BMP to confirm the suitability of infiltration. (See Photo 5)

A Note on "Infiltration Rate" vs. "Percolation Rate"

A common misunderstanding exists that the "percolation rate" obtained from a percolation test is equivalent to the "infiltration rate" obtained from a single or double ring infiltrometer test. While the percolation rate is related to the infiltration rate, percolation rates tend to overestimate infiltration rates and can be off by a factor of ten or more. However, as is discussed in Section 2.3, the percolation rate can be converted to a reasonable estimate of the infiltration rate using the Porchet Method.

1.2 Applicability of Infiltration BMPs

The WQMP guidance applicable to a project (based on the watershed location of the project), may include specific criteria for evaluating whether infiltration BMPs are feasible for a particular project. Where the WQMP requires that infiltration testing be performed as part of an infiltration feasibility evaluation, a testing method approved by the EA shall be used. The District requires the use of the methods described in Section 2 herein. The remainder of Section 1 herein describes requirements that must be implemented whenever an infiltration BMP is to be implemented.

1.3 - Grading Plans

Many projects require a significant amount of grading prior to their construction. It is important to determine if the BMP will be placed in cut or fill since this may affect the performance of the BMP or even the soil. As such, preliminary site grading plans showing the proposed BMP locations are required along with section views through each BMP clearly identifying the extents of cut or fill. In addition, since it is imperative that any testing be performed at the proper elevations and locations, it is highly recommended that the preliminary site grading plans be provided to the engineer/geologist prior to any tests being performed.

1.4 - Cut Condition

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 cut, how can the proposed infiltration surface be tested?

In order to determine an infiltration rate where the proposed infiltration surface is in a cut condition, the following procedures may be used:

1. The USBR 7300-89, "Procedure for Performing Field Permeability Testing by the Well Permeameter Method" (Section 2.4). Note: the result must be converted to an infiltration rate.
2. The Percolation Test per RCDEH (Section 2.3) may be used. Note: the result must be converted to an infiltration rate.

Refer also to the WQMP guidance document applicable to the project, which may identify applicability criteria for infiltration BMPs in cut conditions.

1.5 - Fill Condition

If the bottom of a BMP (infiltration surface) is in a fill location, the infiltration surface may not exist prior to grading. How then can the infiltration rate be determined? For example, if a proposed infiltration BMP is to be located in 12 feet of fill, how could one reasonably establish an infiltration rate prior to the fill being placed?

Unfortunately, no reliable assumptions can be made about the in-situ properties of fill soil. As such, the bottom, or rather the infiltration surface of the BMP, must extend into natural soil. The natural soil shall be tested at the design elevation prior to the fill being placed.

In some cases, the extension of the BMP down to natural soil may prove infeasible. In that case, another BMP must be selected.

1.6 - Factors of Safety

Long term monitoring has shown that the performance of working full-scale infiltration facilities may be far lower than the rate measured by small-scale testing. There are several reasons for this:

- Over time, the surface of infiltration facilities can become plugged as sedimentary particles accumulate at the infiltration surface.
- Post-grading compaction of the site can destroy soil structure and seriously impact the facility's performance.

- Soils and soil strata are rarely homogenous, and variations across a site, and sometimes even within a BMP footprint, can cause tested infiltration rates to vary widely.
- Testing procedures in general are subject to natural variations and errors which can skew the results.

As such, to obtain an appropriate level of confidence in the final design infiltration rate, factors of safety shall be applied to the tested infiltration rate, I_t, in order to determine the design infiltration rate, I_d. These factors are based on such considerations as the type of tests used, the number of tests performed and whether testing is performed at all. Table 1 provides a complete matrix of testing requirements versus factors of safety.

1.7 - Infiltration Testing Requirements

Table 1 is a list of infiltration BMPs with test regime options and their corresponding design factors of safety. The options are summarized below:

Option 1- This test regime includes ring infiltrometer type tests, test pit or boring logs and a final report. The minimum required number of tests is as described in Table 1. The minimum required factor of safety for this option is FS=3.

Option 2- This test regime includes percolation type tests, test pit or boring logs and a final report. The minimum required number of tests is as described in Table 1. The minimum required factor of safety for this option is FS=3.

Option 3- This test regime includes test pit or boring logs only and a final report. The minimum required number of tests is as described in Table 1. An expected infiltration rate shall be included in the final report based on the specifics of the borings or test pits. The minimum required factor of safety for this option is FS=6. This option may be used for projects with a maximum tributary area of 5 acres only.

Option 4- This test regime includes a single test pit or boring log at any representative location on the project site. Plates E-6.1 and E-6.2 of the Riverside County Flood Control and Water Conservation District's (RCFCD) Hydrology Manual shall then be used to establish an approximate infiltration rate based on the appropriate Runoff Index and the Antecedent Moisture Content (AMC) as defined on page C-3 of the Hydrology Manual. The minimum required factor of safety for this option is FS=10.

Table 1 - Infiltration Testing Requirements

Infiltration BMP	Testing Options	Ring Infiltrometer Tests[1]	Percolation Test[2]	Test Pits or Boring Logs[3]	Final Report[4]	Hydrology Manual[5]	Factor of Safety
Infiltration Trench	Option 1►	2 tests min. with at least 1 per trench	not used	1 boring or test pit per trench	Required	not used	FS = 3
	Option 2►	not used	4 tests min. with at least two per trench	1 boring or test pit per trench	Required	not used	FS = 3
	Option 3[7]►	not used	not used	1 boring or test pit per trench	Required	not used	FS = 6
	Option 4►	not used	not used	1 boring or test pit per site	not used	only	FS = 10
Infiltration Basin	Option 1►	2 tests min. with at least 1 per basin[6]	not used	1 boring or test pit per basin	Required	not used	FS = 3
	Option 2►	not used	4 tests min. with at least 2 per basin[6]	1 boring or test pit per trench	Required	not used	FS = 3
	Option 3[7]►	not used	not used	1 boring or test pit per basin	Required	not used	FS = 6
	Option 4►	not used	not used	1 boring or test pit per site	not used	only	FS = 10
Permeable Pavement	Option 1►	2 tests min. with at least 1 every 10,000 ft^2	not used	1 boring or test pit every 10,000 ft^2	Required	not used	FS = 3
	Option 2►	not used	4 tests min. with at least 2 every 10,000 ft^2	1 boring or test pit every 10,000 ft^2	Required	not used	FS = 3

Table Footnotes:

(1) Ring Infiltrometer tests per Section 2.2

(2) Percolation tests per Section 2.3 and Well Permeameter Test per Section 2.4

(3) Test pits or boring logs per Section 2.5

(4) Final Report per Section 1.7

(5) See Plate E-6.2 of the District's Hydrology Manual

(6) For basins in excess of 10,000 ft^2, provide one (1) ring infiltrometer test or two (2) percolation tests for each additional 10,000 ft^2

(7) This option may be used for projects with a maximum tributary area of 5 acres only.

1.8 - Final Report

Where a final report is required, a civil engineer, geotechnical engineer, certified engineering geologist or certified hydrogeologist shall establish whether the location is suitable for the proposed infiltration facility. At least 5 feet of permeable soil must be present below the infiltration facility and a minimum of 10 feet between the bottom of the infiltration facility and the historical high groundwater mark[1] is required. The signed/stamped report shall include discussion and records of the infiltration testing as well as boring log findings. Based on the results of these tests, the report shall provide an estimate of the infiltration rate found at the location of each proposed infiltration BMP in units of inches per hour. The factor of safety specified in Table 1 will be applied to the interpreted test results to determine the design infiltration rate for each infiltration BMP. Any requirements associated with impacts to an erosion hazard area, steep slope hazard area, or landslide hazard area should also be addressed in the report. In addition, the report shall include complete field records with the following information:

- Location of the test site.
- Dates of test, start and finish.
- Weather conditions, start to finish.
- Names(s) of technician(s).
- Description of test site, including assessment of boring profile and USCS soil classification.
- Depth to the water table and a description of the soils to a depth of at least 10 feet below proposed infiltration surface.
- Type of equipment used to construct the boreholes or test holes (such as backhoe, hollow stem auger, etc.)
- Areas of the rings (if used) or test hole diameter.
- Volume constants for graduated cylinder or Mariotte tube (if used).
- Complete field results in tabular format. Sample test data forms, as well as examples, have been provided following the description of each test in Section 2.
- A plot of the infiltration rate versus total elapsed time. An example is provided following the description of each test in Section 2.
- A labeled keymap showing test and boring locations.
- Confirmation that the soil was pre-saturated in accordance with the testing methods described herein.

Section 2 - Accepted Testing Methods

There is a wide range of different methods for measuring the infiltration rate of a given soil with varying degrees of accuracy and reliability. However, the District will accept only the following test methods:

1. Single Ring Infiltrometer (Per ASTM D 5126), Section 2.1.1
2. Double Ring Infiltrometer (Per ASTM D 3385), Section 2.1.2
3. Well Permeameter Method (USBR 7300-89), Section 2.4
4. Percolation Test (per County of Riverside Department of Environmental Health procedure), Section 2.3

[1]The “historical high groundwater mark” is defined as the groundwater elevation expected due to a normal wet season and shall be obtained by boring logs or test pits.

The following pages of this document provide an overview of these tests. It is recommended that the original Standards be referenced.

2.1 - Constant Head vs. Falling Head Method

There are two operational techniques used with all four of the testing techniques herein: the *constant head method* and the *falling head method*. With the *constant head method*, water is consistently added to both the outer and inner rings (ring infiltrometers) or to the test hole (pecolation test and well permeameter) to maintain a constant level throughout the testing. The volume of water needed to maintain the fixed level of the inner ring is measured. Conversely, in the *falling head method*, the water level is allowed to fall and the time that the water level takes to decrease is measured.

2.2 - Overview of Ring Infiltrometer Test Methods

Ring infiltrometers measure the rate of infiltration at the soil surface. Infiltration is influenced by both saturated hydraulic conductivity as well as capillary effects. The term *capillary effects* refers to the ability of dry soil to pull, or wick away, water from a zone of saturation faster than would occur if the soil were uniformly saturated. The magnitude of the capillary effect is determined by initial moisture content at the time of testing, the pore size, soil properties (texture, structure) and a number of other factors. The effects of capillarity are short lived and can greatly skew test results. As such, it is critical to obtain steady-state infiltration so that capillary effects are minimized. (ASTM 5126)

The ***single ring infiltrometer*** and ***double ring infiltrometer*** methods both employ the use of metal cylinders driven to shallow depths into the test soil. The rings are filled with water and the rate at which the water moves into the soil is measured. This rate becomes constant when the saturated hydraulic conductivity for the particular soil has been reached. This is reflected by the flattening out of the curve generated by sample test data as shown in Figure 2, "Plot of Infiltration Rate vs. Time". While we note that infiltration rate is not exactly the same as saturated hydraulic conductivity, for the purposes of this guidance document they are synonymous.

2.2.1 - Single Ring Infiltrometers

Single ring infiltrometer tests using a ring 40 inches or larger in diameter have been shown to closely match full-scale facility performance (Figures 1 and 2, Photo 1). The cylindrical ring is driven approximately 12 inches into the soil. Water is ponded within the ring above the soil surface. The upper surface of the ring is often covered to prevent evaporation. Using the constant head method, the volumetric rate of water added to the ring, sufficient to maintain a constant head within the ring is measured. The test is complete and the tested infiltration rate, I_t, is determined after the flow rate has stabilized. (ASTM D 5126)

Photo 1 – Simple Single Ring Infiltrometer

To help maintain a constant head, a variety of devices may be used. A hook gauge, steel tape or rule, length of steel, or plastic rod pointed on one end can be used for measuring and controlling the depth of liquid (head) in the infiltrometer ring. If available, a graduated Mariotte tube or automatic flow control system may also be used. Care should be taken when driving the ring into the ground as there can be a poor connection between the ring wall and the soil. This poor connection can cause a leakage of water along the ring wall and an overestimation of the infiltration rate.

The volume of liquid used during each measured time interval may be converted into an incremental infiltration velocity (infiltration rate) using the following equation:

$$I_t = \Delta V/(A*\Delta t)$$

Where:

I_t = tested infiltration rate, in/hr
ΔV = volume of liquid used during time interval to maintain constant head in the ring, in^3
A = internal area of ring, in^2
Δt = time interval, hr.

Final Report - Ultimately, as discussed in Section 1.7, a final report shall be provided and, based on the test results, an infiltration rate shall be recommended.

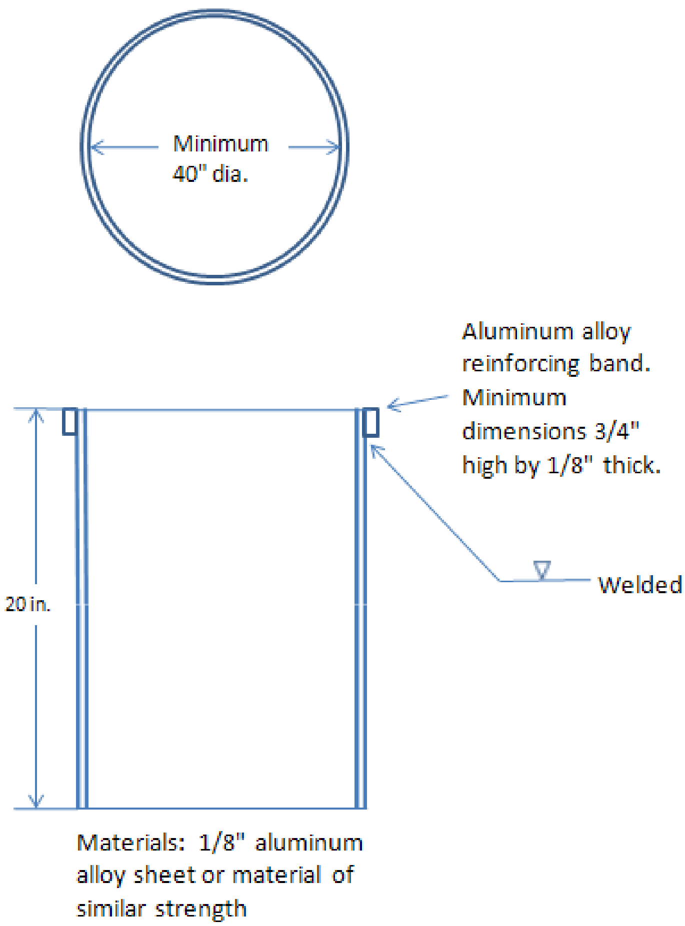


Figure 1- Single Ring Infiltrometer Construction

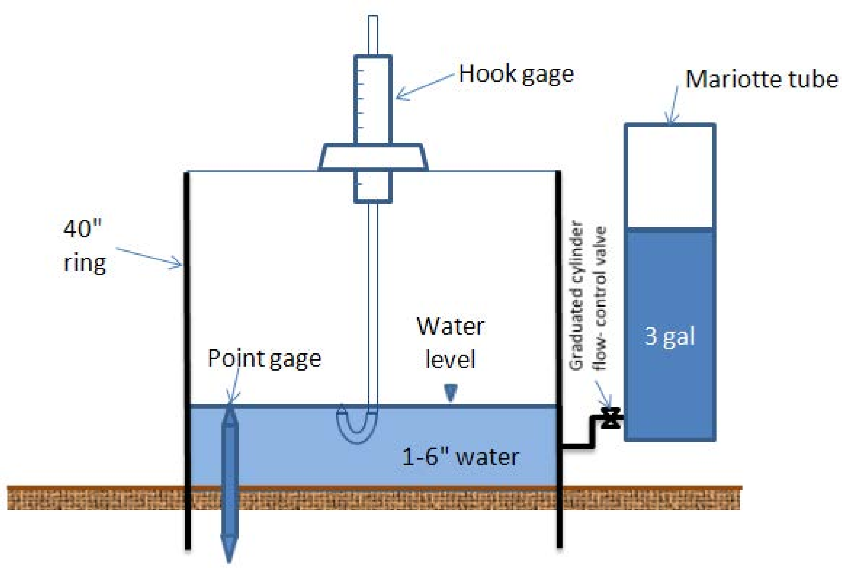


Figure 2- Single Ring Setup with Mariotte Tube

SINGLE RING INFILTROMETER TEST DATA							
Project Name and Test Location:			Constants-	Ring Data		Liquid Containers	
				Ring Area, A_r (in^2)	Depth of Liquid (in)	Reservoir Container Volume, V_r (in^3/in)	
Test By:		USCS Class:		Penetration of Ring into Soil (in.):			
Liquid Used:		pH:		Ground Temp (·F):		at Depth:	
Date of Test:		Depth to Water Table:					
Liquid Level Maintained by using:	( ) Flow Valve ( ) Float Valve ( ) Marriotte Tube ( ) Other:						
Additional Comments:							

Time interval	Time (hr:min)	Dt (min) & Total	Flow Readings: Elev., H (In)	Flow Readings: ΔH (in) & Q_f* (in^3)	Liquid Temp (°F)	Infiltratn Rate , I**(in/hr)	Remarks
1 - Start							
End							
2 - Start							
End							
3 - Start							
End							
4 - Start							
End							
5 - Start							
End							
6 - Start							
End							
7 - Start							
End							
8 - Start							
End							
9 - Start							
End							
10 - Start							
End							
11 - Start							
End							
12 - Start							
End							
13 - Start							
End							
14 - Start							
End							
15 - Start							
End							

*Flow, $Q_f = \Delta H \times V_r$ **Infiltration Rate, $I = (Q_f/A_r)/$

Table 2 – Sample Test Data Form for Single Ring Infiltrometer Test

SINGLE RING INFILTROMETER TEST DATA							
Project Name and Test Location: ACME IND. SITE 24166 ELM, RIVERDALE *WESTERN CORNER OF SITE (NEAR WAREHOUSE)		Constants-	Ring		Liquid Containers		
			Ring Area, A_r (in^2)	Depth of Liquid (in)	Reservoir Container Volume, V_r (in^3/in)		
			1256	4.0	78.54		
Test By:	CMD	USCS Class:	SM	Penetration of Ring into Soil (in.):	3.0		
Liquid Used:	TAP WATER	pH:	8.0	Ground Temp (°F):	57	at Depth:	16″
Date of Test:	3-21-09	Depth to Water Table:	40 FEET				
Liquid Level Maintained by using:	( ) Flow Valve ( ) Float Valve (X) Marriotte Tube ( ) Other:						
Additional Comments:	DRY GROUND						

Time interval	Time (hr:min)	Dt (min) & Total	Flow Readings: Elev., H (In)	Flow Readings: ΔH (in) & Q_r* (in^3)	Liquid Temp (°F)	Infiltratn Rate, I**(in/hr)	Remarks
1 - Start	10:00	15	3.0	1.45	59	0.36	CLOUDY, SLIGHT WIND
End	10:15	(15)	4.45	114	59		
2 - Start	10:15	15	4.45	2.7	59	0.68	
End	10:30	(30)	7.15	212	59		
3 - Start	10:30	15	7.15	3.35	59	0.84	
End	10:45	(45)	10.5	263	59		
4 - Start	10:45	15	10.5	3.9	59	0.97	
End	11:00	(60)	14.4	306	60		
5 - Start	11:00	30	14.4	9.65	60	1.2	
End	11:30	(90)	24.05	758	61		
6 - Start	11:30	30	24.05	10.8	61	1.4	
End	12:00	(120)	34.85	848	62		
7 - Start	12:10	60	3.5	24.7	62	1.5	REFILLED TUBES
End	13:10	(180)	28.25	1944	63		
8 - Start	13:20	60	2.4	23.9	64	1.5	)(
End	14:20	(240)	26.3	1877	64		
9 - Start	14:30	60	4.3	21.6	64	1.4	)(
End	15:30	(300)	25.9	1696	64		
10 - Start	15:40	60	2.2	20.2	64	1.3	)(
End	16:40	(360)	22.4	1586	64		CLOUDY, SLIGHT WIND
11 - Start							
End							
12 - Start							
End							
13 - Start							
End							
14 - Start							
End							
15 - Start							
End							

*Flow, $Q_r = \Delta H \times V_r$ **Infiltration Rate, $I = (Q_r/A_r)/\Delta t$

FIGURE 3 – Sample Test Data

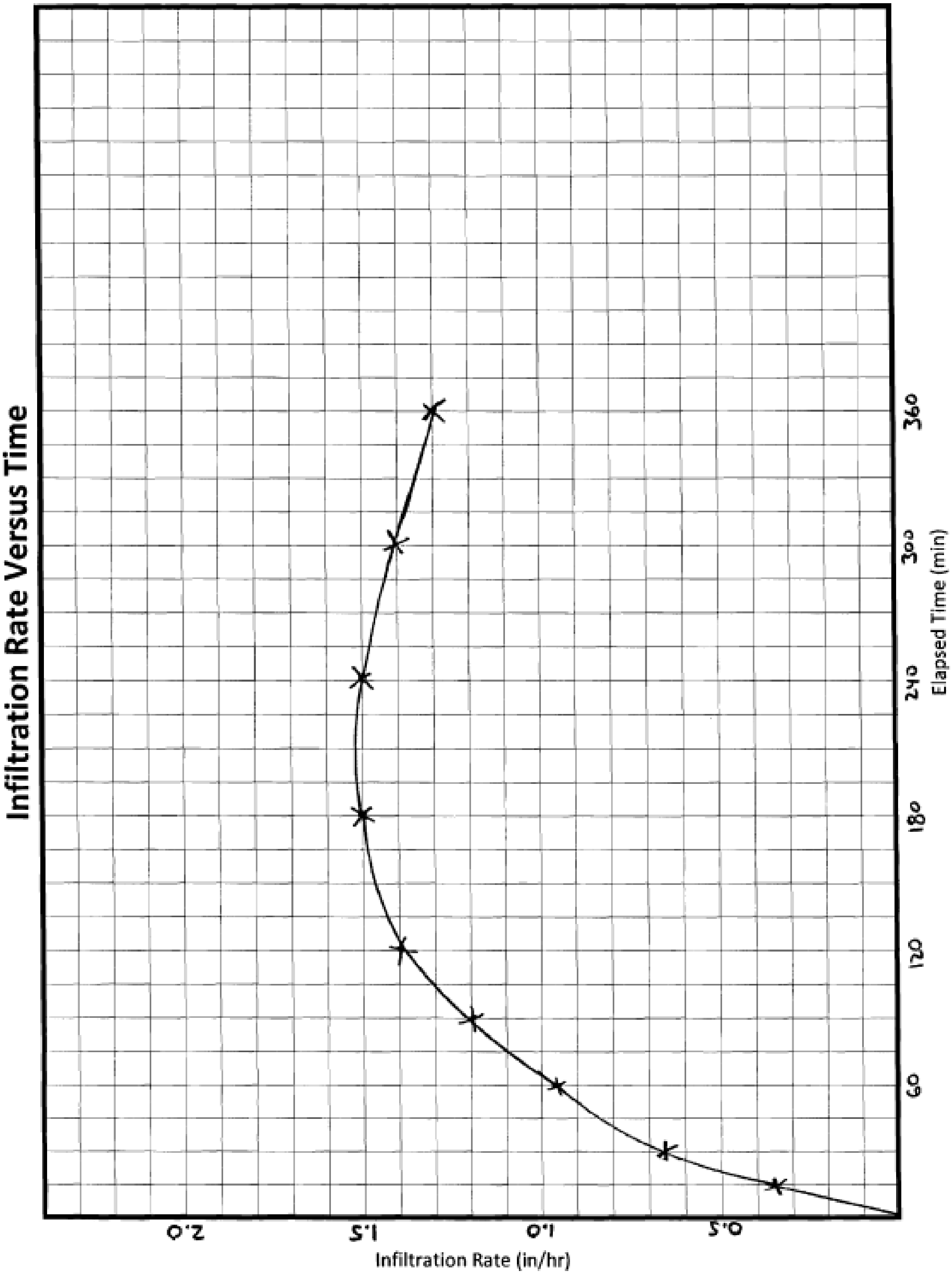


FIGURE 4 – Plot of Sample Test Data for Single Ring Infiltrometer Test

2.2.2 - Double Ring Infiltrometers

The ***double ring infiltrometer*** test (ASTM D 3385) is a well recognized and documented technique for directly measuring the soil infiltration rate of a site (see Figure 5, 6 and 7; Photos 2, 3, 4 and 5). Double ring infiltrometers were developed in response to the fact that smaller (less than 40 inch diameter) single ring infiltrometers tend to overestimate vertical infiltration rates. This has been attributed to the fact that the flow of water beneath the cylinder is not purely vertical and diverges laterally. Double ring infiltrometers minimize the error associated with the single-ring method because the water level in the outer ring forces vertical infiltration of water in the inner ring. Care should be taken when driving the rings into the ground as there can be a poor connection between the ring wall and the soil. This poor connection can cause a leakage of water along the ring wall and an overestimation of the infiltration rate. Another potential source of error is attributed to the size of the cylinders. As such, the use of cylinder sizes less than those prescribed in ASTM D 3385 is not recommended.

A typical double ring infiltrometer would consist of a 12 inch inner ring and a 24 inch outer ring. While there are two operational techniques used with the double-ring infiltrometer, the constant head method and the falling head method, ASTM D3385 mandates the use of the constant head method. With the constant head method, water is consistently added to both the outer and inner rings to maintain a constant level throughout the testing. The volume of water needed to maintain the fixed level of the inner ring is measured. To help maintain a constant head, a variety of devices may be used. A hook gauge, steel tape or rule, or length of steel or plastic rod pointed on one end, can be used for measuring and controlling the depth of liquid (head) in the infiltrometer ring. If available, a graduated Mariotte tube or automatic flow control system may also be used.

The volume of liquid used during each measured time interval may be converted into an incremental infiltration velocity (infiltration rate) using the following equation:

$$I_t = \Delta V/(A*\Delta t)$$

Where:

I_t = tested infiltration rate, in/hr

ΔV = volume of liquid used during time interval to maintain constant head in the inner ring, in^3

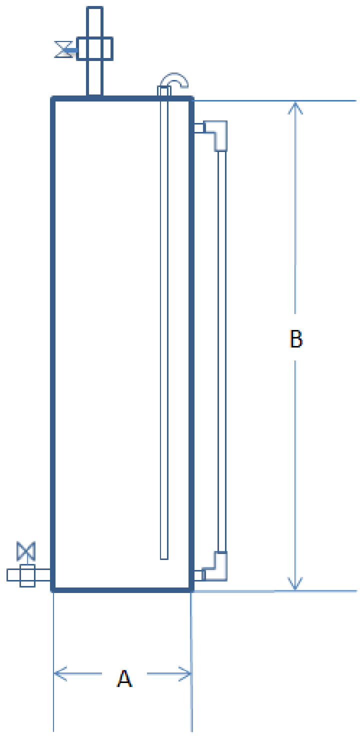
A = area of inner ring, in^2

Δt = time interval, hr.

Final Report - Ultimately, as discussed in Section 1.7, a final report shall be provided and, based on the test results, an infiltration rate shall be recommended.

Photo 2 – Simple Double Ring Infiltrometer

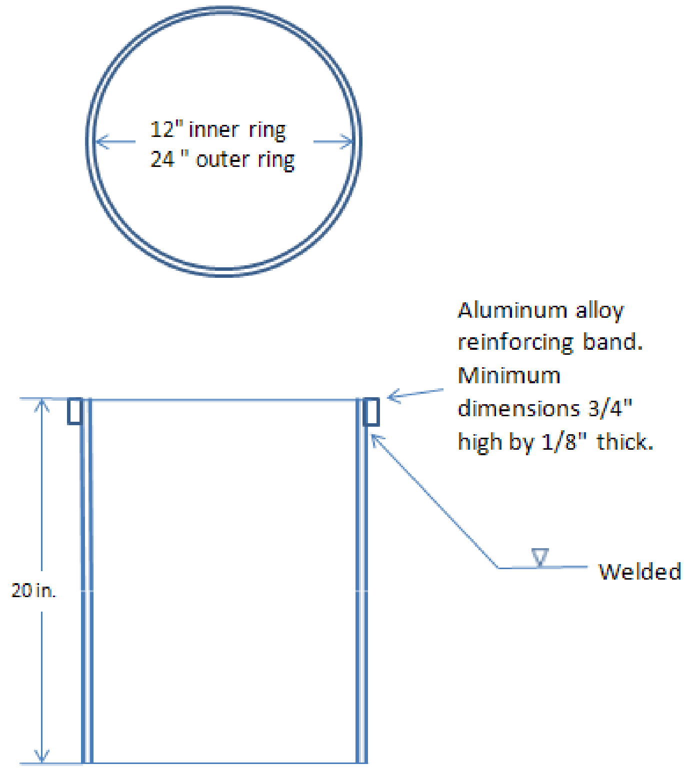
Photo 3 – Pre-fabricated Double Ring Infiltrometer
(Photo courtesy of Turf-Tec International)



Mariotte Tube
Useful Capacity

	1 gal	3 gal
A =	3 in.	6 in.
B =	18 in.	24 in.

Figure 5 - Mariotte Tube



Materials: 1/8" aluminum alloy sheet or material of similar strength

Figure 6- Double Ring Infiltrometer Construction

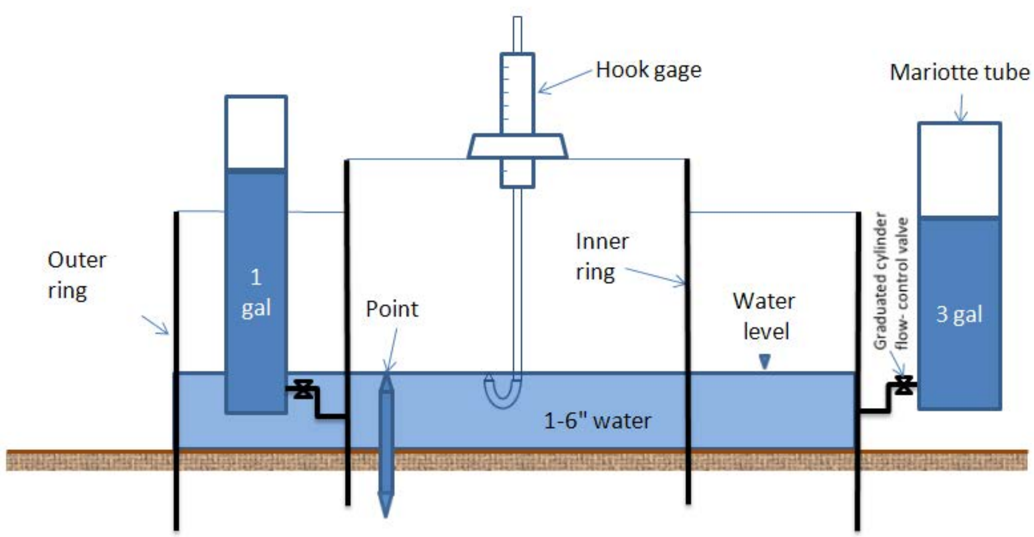


Figure 7- Double Ring Setup with Mariotte Tubes

Photo 4- Double Ring Infiltrometer Set-up with Mariotte Tubes (Photo courtesy of Turf-Tec International)

Photo 5 – Double Ring Infiltrometer Set-up for Test at Basin Surface Elevation (Photo courtesy of Turf-Tec International)

DOUBLE RING INFILTROMETER TEST DATA														
Project Name and Test Location:					Constants-				Ring Data		Liquid Containers	
									Area, A_r (in^2)	Depth of Liquid (in)	No.	Vol., V_r (in3/in)
					Inner Ring:							
Test By:		USCS Class:			Annular Space:							
Water Table Depth:			Penetration of Rings into Soil (in.):						Inner:		Outer:	
Date of Test:		Liquid Used:			pH:		Ground Temp (·F):				at Depth:	
Liquid Level Maintained by using:			( ) Flow Valve ( ) Float Valve ( ) Marriotte Tube ( ) Other:									
Additional Comments:												

Time interval	Time (hr:min)	Dt (min) & Total	Inner Ring		Annular Ring		Liquid Temp °F	Infiltration Rate, I**		Remarks
			Elev., H (In)	ΔH (in) &	Elev., H (In)	ΔH (in) &		Inner in/hr	Outer in/hr	
1 - Start										
End										
2 - Start										
End										
3 - Start										
End										
4 - Start										
End										
5 - Start										
End										
6 - Start										
End										
7 - Start										
End										
8 - Start										
End										
9 - Start										
End										
10 - Start										
End										
11 - Start										
End										
12 - Start										
End										
13 - Start										
End										
14 - Start										
End										
15 - Start										
End										

***Flow, Qf = ΔH x Vr   **Infiltration Rate, I = (Qf/Ar)/Δt**

Table 3 – Sample Test Data Form for Double Ring Infiltrometer Test

DOUBLE RING INFILTROMETER TEST DATA

Project Name and Test Location:	Constants-	Ring Data: Area, A_r (in^2)	Ring Data: Depth of Liquid (in)	Liquid Containers: No.	Liquid Containers: Vol., V_r (in3/in)
ACME Industrial Site 24166 Elm, Riverdale (Western corner of site, near warehouse)	Inner Ring:	113	4	1	78.54
Test By: CMD USCS Class: SM	Annular Space:	339	4.1	2	176.7
Water Table Depth: 40 ft.	Penetration of Rings into Soil (in.):	Inner:	3.0	Outer:	7.0
Date of Test: 3/22/09 Liquid Used: tap water pH: 8.0	Ground Temp (·F):	57.2	at Depth:	16 in.	

Liquid Level Maintained by using: ( ) Flow Valve ( ) Float Valve (X) Marriotte Tube ( ) Other:

Additional Comments: Dry Gound

Time interval	Time (hr:min)	Dt (min) & Total	Inner Ring Elev., H (In)	Inner Ring ΔH (in) &	Annular Ring Elev., H (In)	Annular Ring ΔH (in) &	Liquid Temp °F	Infiltration Rate, I** Inner in/hr	Infiltration Rate, I** Outer in/hr	Remarks
1 - Start	9:00	15	3	0.2	3	0.4	59	0.6	0.8	Cloudy, slight wind
End	9:15	15	3.2	15.71	3.4	70.68	59			
2 - Start	9:15	15	3.2	0.35	3.4	0.6	59	1.0	1.3	
End	9:30	30	3.55	27.49	4	106	59			
3 - Start	9:30	15	3.55	0.5	4	0.9	59	1.4	1.9	
End	9:45	45	4.05	39.27	4.9	159	59			
4 - Start	9:45	15	4.05	0.65	4.9	1.2	59	1.8	2.5	
End	10:00	60	4.7	51.05	6.1	212	60			
5 - Start	10:00	30	4.7	1.5	6.1	2.65	60	2.1	2.8	
End	10:30	90	6.2	117.8	8.75	468.3	61			
6 - Start	10:30	30	6.2	1.7	8.75	2.75	61	2.4	2.9	
End	11:00	120	7.9	133.5	11.5	485.9	62			
7 - Start	11:10	60	3.25	3.75	2.5	5.9	62	2.6	3.1	
End	12:10	180	7	294.5	8.4	1043	63			Refilled tubes
8 - Start	12:20	60	3.5	3.9	3	5.7	64	2.7	3.0	
End	13:20	240	7.4	306.3	8.7	1007	64			Refilled tubes
9 - Start	13:30	60	3	3.6	3.1	5.5	64	2.5	2.9	
End	14:30	300	6.6	282.7	8.6	971.9	64			Refilled tubes
10 - Start	14:40	60	3.25	3.45	3	5.4	64	2.4	2.8	
End	15:40	360	6.7	271	8.4	954.2	64			Refilled tubes
11 - Start	15:50	60	3.3	3.4	2.9	5	64	2.4	2.6	
End	16:50	420	6.7	267	7.9	883.5	64			Refilled tubes
12 - Start	18:00	60	3	3.5	3.1	4.9	64	2.4	2.6	Refilled tubes
End	19:00	480	6.5	274.9	8	865.8	64			Cloudy, no wind
13 - Start										
End										
14 - Start										
End										
15 - Start										
End										

*Flow, $Qf = \Delta H \times Vr$ **Infiltration Rate, $I = (Qf/Ar)/\Delta t$

Table 4 – Sample Test Data Form for Double Ring Infiltrometer Test

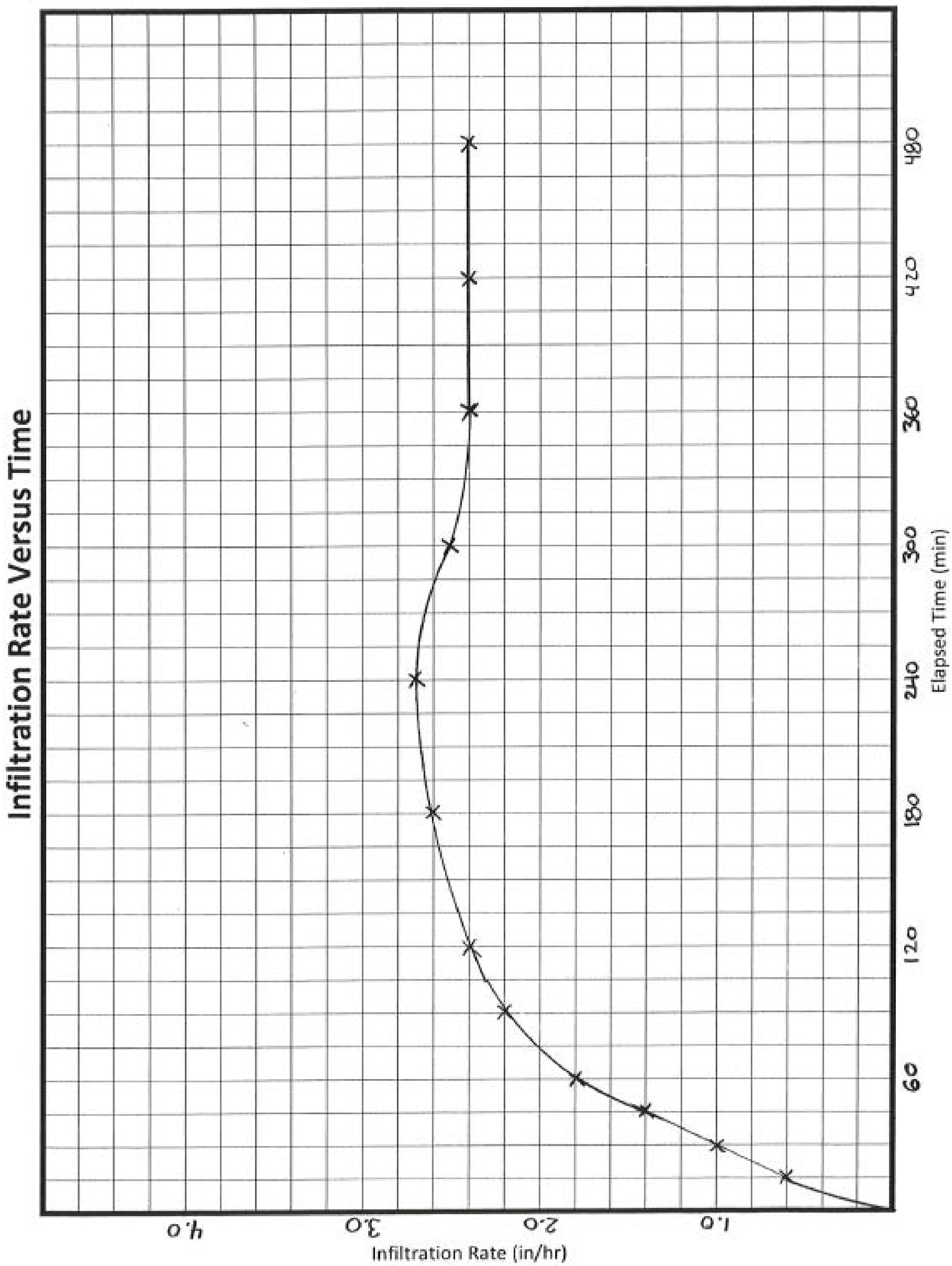


FIGURE 8 – Plot of Sample Test Data for Double Ring Infiltrometer Test

2.3 - Percolation Tests

The ***percolation test*** is widely used for assessing the suitability of a soil for onsite wastewater disposal. Depending on the required depth of testing, there are two versions of the percolation test. For shallow depth testing (less than 10 feet), the procedure would be as shown in Figure 8 (Photo 6). For deep testing (10 feet to 40 feet), the procedure is as shown in Figure 9. For deep testing, special care must be taken to ensure that caving of the sidewalls does not occur.

This test measures the length of time required for a quantity of water to infiltrate into the soil and is often called a "percolation rate". It should be noted that the percolation rate is related to, but not equal to, the infiltration rate. While an infiltration rate is a measure of the speed at which water progresses downward into the soil, the percolation rate measures not only the downward progression but the lateral progression through the soil as well. This reflects the fact that the surface area for infiltration testing would include only the horizontal surface while the percolation test includes both the bottom surface area and the sidewalls of the test hole. However, there is a relationship between the values obtained by a percolation test and infiltration rate. Based on the [1]"Porchet Method", the following equation may be used to convert percolation rates to the tested infiltration rate, I_t:

$$I_t = \frac{\Delta H\, \pi r^2\, 60}{\Delta t(\pi r^2 + 2\pi r H_{avg})} = \frac{\Delta H\, 60\, r}{\Delta t(r + 2H_{avg})}$$

Where:

I_t = tested infiltration rate, inches/hour
ΔH = change in head over the time interval, inches
Δt = time interval, minutes
$^*r$ = effective radius of test hole
H_{avg} = average head over the time interval, inches

An example of this procedure is provided on Page 26 based data form Table 5, *Sample Percolation Test Data*. Figure 11 provides a plot of the converted percolation test data.

*Where a rectangular test hole is used, an equivalent radius should be determined based on the actual area of the rectangular test hole. (i.e., $r = (A/\pi)^{0.5}$)

Note to the designer: The values obtained using this method may vary from those obtained from methods considered to be more accurate. The designer is encouraged to explore the derivation of these equations (Ritzema; Smedema)

Final Report - Ultimately, as discussed in Section 1.7, a final report shall be provided and, based on the test results, an infiltration rate shall be recommended.

[1]H.P. Ritzema, "Drainage Principles and Applications," International Institute for Land Reclamation and Improvement (ILRI), Publication 16, 2nd revised edition, 1994, Wageningen, The Netherlands.

Percolation Test Procedure

Only those individuals trained and educated to perform, understand and evaluate the field conditions and tests may perform these tests. This would include those who hold one of the following State of California credentials and registrations: Professional Civil and Geotechnical Engineers, Certified Engineering Geologist and Certified Hyrdrogeologist. The District will only approve the percolation test method described in this Chapter.

When the percolation testing has been completed, a 3 foot long surveyor's stake (lath) shall be flagged with highly visible banner tape and placed in the location of the test indicating date, test hole number as shown on the field data sheet, and firm performing the test. Field data shall be included in the Final Report as described in Section 1.7.

Shallow Percolation Test (less than 10 feet)

Test Preparation

1.) The test hole opening shall be between 8 and 12 inches in diameter or between 7 and 11 inches on each side if square.

2.) The bottom elevation of the test hole shall correspond to the bottom elevation of the proposed basin (infiltration surface). Keep in mind that this procedure will require the test hole to be filled with water to a depth of at least 5 times the hole's radius.

3.) The bottom of the test hole shall be covered with 2 inches of gravel.

4.) The sides of the hole shall remain undisturbed (not smeared) after drilling and any cobbles encountered left in place.

5.) **Pre-soaking** shall be used with this procedure. Invert a full 5 gallon bottle (more if necessary) of clear water supported over the hole so that the water flow into the hole holds constant at a level at least 5 times the hole's radius above the gravel at the bottom of the hole. Testing may commence after all of the water has percolated through the test hole or after 15 hours has elapsed since initiating the pre-soak. However, to assure saturated conditions, testing must commence no later than 26 hours after all pre-soak water has percolated through the test hole. The use of the "continuous pre-soak procedure" is no longer accepted. When sandy soils (as described below) are present, the test shall be run immediately.

Test Procedure

Test hole shall be carefully filled with water to a depth equal to at least 5 times the hole's radius (H/r>5) above the gravel at the bottom of the test hole prior to each test interval.

- In **sandy soils**, when 2 consecutive measurements show that 6 inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Measurements shall be taken with a precision of 0.25 inches or better. The drop that occurs during the final 10 minutes is used to calculate the percolation rate. Field data must show the two 25 minute readings and the six 10 minute readings.

- In **non-sandy soils**, obtain at least twelve measurements per hole over at least six hours with a precision of 0.25 inches or better. From a fixed reference point, measure the drop in water level over a 30 minute period for at least 6 hours, refilling after every 30 minute reading. The total depth of the hole must be measured at every reading to verify that collapse of the borehole has not occurred. The drop that occurs during the final reading is used to calculate the percolation rate.

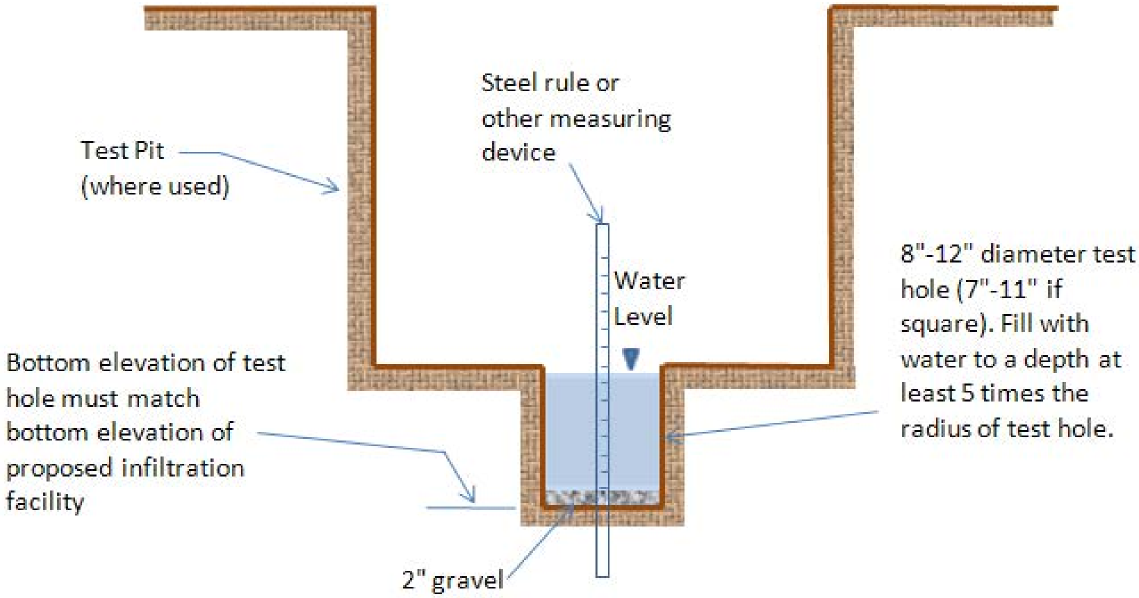


Figure 9- Test Pit for Shallow Percolation Test

Deep Percolation Test (Depths 10-40 feet)

Test Preparation

1.) Borehole diameter shall be either 6 inch or 8 inch only. No other diameter test holes will be accepted.

2.) The bottom elevation of the test hole shall correspond to the bottom elevation of the proposed basin (infiltration surface). Keep in mind that this procedure will require the test hole to be filled with water to a depth of at least 5 times the hole's radius.

3.) The bottom of the test hole shall be covered with 2 inches of gravel.

4.) The sides of the hole shall remain undisturbed (not smeared) after drilling and any cobbles encountered left in place. Special care should be taken to avoid cave-in.

5.) **Pre-soaking** shall be used with this procedure. Invert a full 5 gallon bottle of clear water supported over the hole so that the water flow into the hole holds constant at a maximum depth of 4 feet below the surface of the ground or if grading cuts are anticipated, to the approximate elevation of the **top** of the basin but at least 5 times the hole's radius ($H/r>5$). Pre-soaking shall be performed for 24 hours unless the site consists of sandy soils containing little or no clay. If sandy soils exist as described below, the tests may then be run after a 2 hour pre-soak. However, to assure saturated conditions, testing must commence no later than

26 hours after all pre-soak water has percolated through the test hole. The use of the "continuous pre-soak procedure" is no longer accepted. When sandy soils (as described below) are present, the test shall be run immediately.

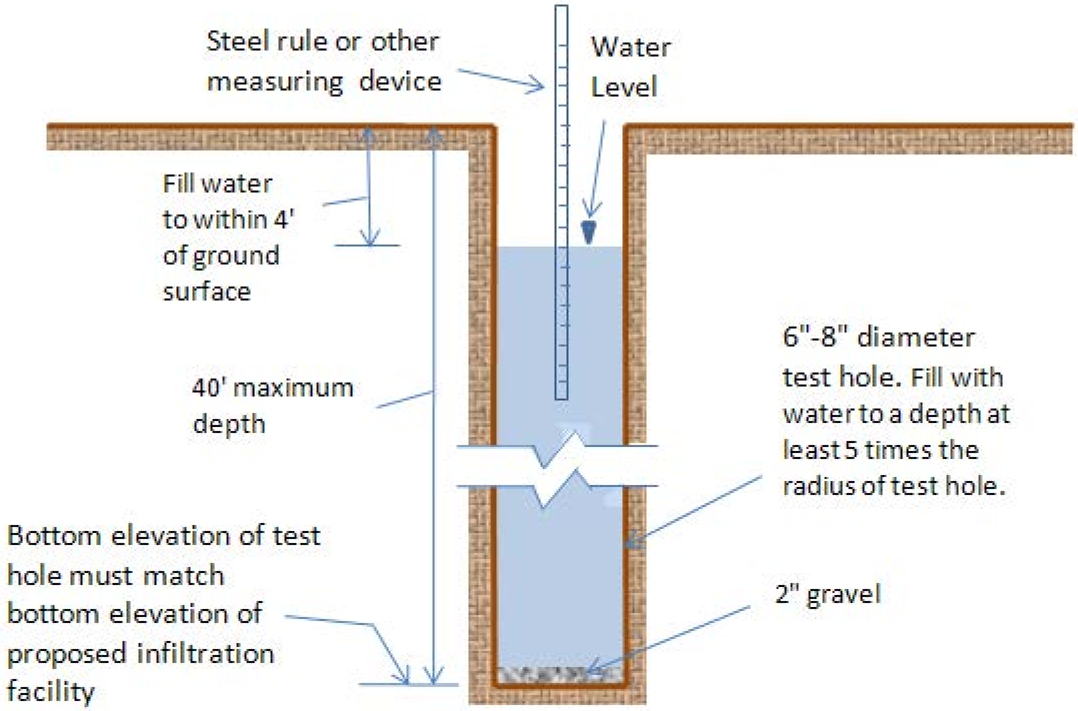


Figure 10- Test Pit for Deep Percolation Test

Test Procedure

Carefully fill the hole with clear water to a maximum depth of 4 feet below the surface of the ground or, if grading cuts are anticipated, to the approximate elevation of the **top** of the basin. However, at a minimum, the bore hole shall be filled with water to a depth equal to 5 times the hole's radius (H/r>5).

- In **<u>sandy soils</u>**, when 2 consecutive measurements show that 6 inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Measurements shall be taken with a precision of 0.25 inches or better. The drop that occurs during the final 10 minutes is used to calculate the percolation rate. Field data must show the two 25 minute readings and the six 10 minute readings.

- In **<u>non-sandy soils</u>**, the percolation rate measurement shall be made on the day following initiation of the pre-soak as described in Item #5 above. From a fixed reference point, measure the drop in water level over a 30 minute period for at least 6 hours, refilling after every 30 minute reading. Measurements shall be taken with a precision of 0.25 inches or better. The total depth of hole must be measured at every reading to verify that collapse of the borehole has not occurred. The drop that occurs during the final reading is used to calculate the percolation rate.

Photo 6 – Percolation Test Pit. Use of perforated PVC pipe is a variation.

Percolation Test Data Sheet

Project:			Project No:			Date:	
Test Hole No:			Tested By:				
Depth of Test Hole, D_T:			USCS Soil Classification:				
Test Hole Dimensions (inches)					Length	Width	
Diameter (if round)=			Sides (if rectangular)=				
Sandy Soil Criteria Test*							
Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6"? (y/n)
1							
2							

*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Other wise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".

Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D_o Initial Depth to Water (in.)	D_f Final Depth to Water (in.)	ΔD Change in Water Level (in.)	Percolation Rate (min./in.)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

COMMENTS:

Table 5 – Sample Test Data Form for Percolation Test

Percolation Rate Conversion

Example:

The bottom of a proposed infiltration basin would be at 5.0 feet below natural grade. Percolation tests are performed within the boundaries of the proposed basin location with the depth of the test hole set at the infiltration surface level (bottom of the basin). The Percolation Test Data Sheet (Table 5) is prepared as the test is being performed. After the minimum required number of testing intervals, the test is complete. [1]**The data collected at the final interval is as follows:**

Time interval, Δt = 10 minutes
Final Depth to Water, D_f = 13.75 inches
[2]Test Hole Radius, r = 4 inches
Initial Depth to Water, D_0 = 12.25 inches
Total Depth of Test Hole, D_T = 60 inches

The conversion equation is used:

$$I_t = \frac{\Delta H\ 60\ r}{\Delta t(r+2H_{avg})}$$

"H_o" is the initial height of water at the selected time interval.

$H_o = D_T - D_0 = 60 – 12.25 =$ **47.75 inches**

"H_f" is the final height of water at the selected time interval.

$H_f = D_T - D_0 = 60 - 13.75 =$ **46.25 inches**

"ΔH" is the change in height over the time interval.

$\Delta H = \Delta D = H_o - H_f = 47.75 – 46.25 =$ **1.5 inches**

"H_{avg}" is the average head height over the time interval.

$H_{avg} = (H_o - H_f)/2 = (47.75 – 46.25)/2 =$ **47.0 inches**

"I_t" is the tested infiltration rate.

$$I_t = \frac{\Delta H\ 60\ r}{\Delta t(r+2H_{avg})} = \frac{(1.5\text{ in})(60\text{ min/hr})(4\text{ in})}{(10\text{ min})((4\text{ in}) + 2(47\text{ in}))} = \textbf{0.37 in/hr.}$$

Percolation Test Data Sheet

Project:	ACME SITE	Project No:	1106 B	Date:	2-18-09
Test Hole No:	3	Tested By:	CMD		
Depth of Test Hole, D_T:	60 IN.	USCS Soil Classification:	SM		

Test Hole Dimensions (inches)			Length	Width	
Diameter (if round)=	8	Sides (if rectangular)=			

Sandy Soil Criteria Test*

Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6"? (y/n)
1	8:00	8:25	25	12.0	19.5	7.5	Y
2	8:30	8:55	25	12.0	18.75	6.75	Y

*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Other wise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".

Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D_o Initial Depth to Water (in.)	D_f Final Depth to Water (in.)	ΔD Change in Water Level (in.)	Percolation Rate (min./in.)
1	9:00	9:10	10	12.0	14.25	2.25	4.4
2	9:10	9:20	10	11.5	13.5	2.0	5.0
3	9:20	9:30	10	12.0	14.0	2.0	5.0
4	9:30	9:40	10	11.75	13.5	1.75	5.7
5	9:40	9:50	10	12.0	13.5	1.5	6.7
6	9:50	10:00	10	12.25	13.75	1.5	6.7
7							
8							
9							
10							
11							
12							
13							
14							
15							

Data used for conversion to Infiltration rate.

COMMENTS: OVERCAST (62° F). GROUND DRY. FIRST (2) MEASUREMENTS MET SANDY SOIL CRITERIA.

Table 6 – Sample Percolation Test Data

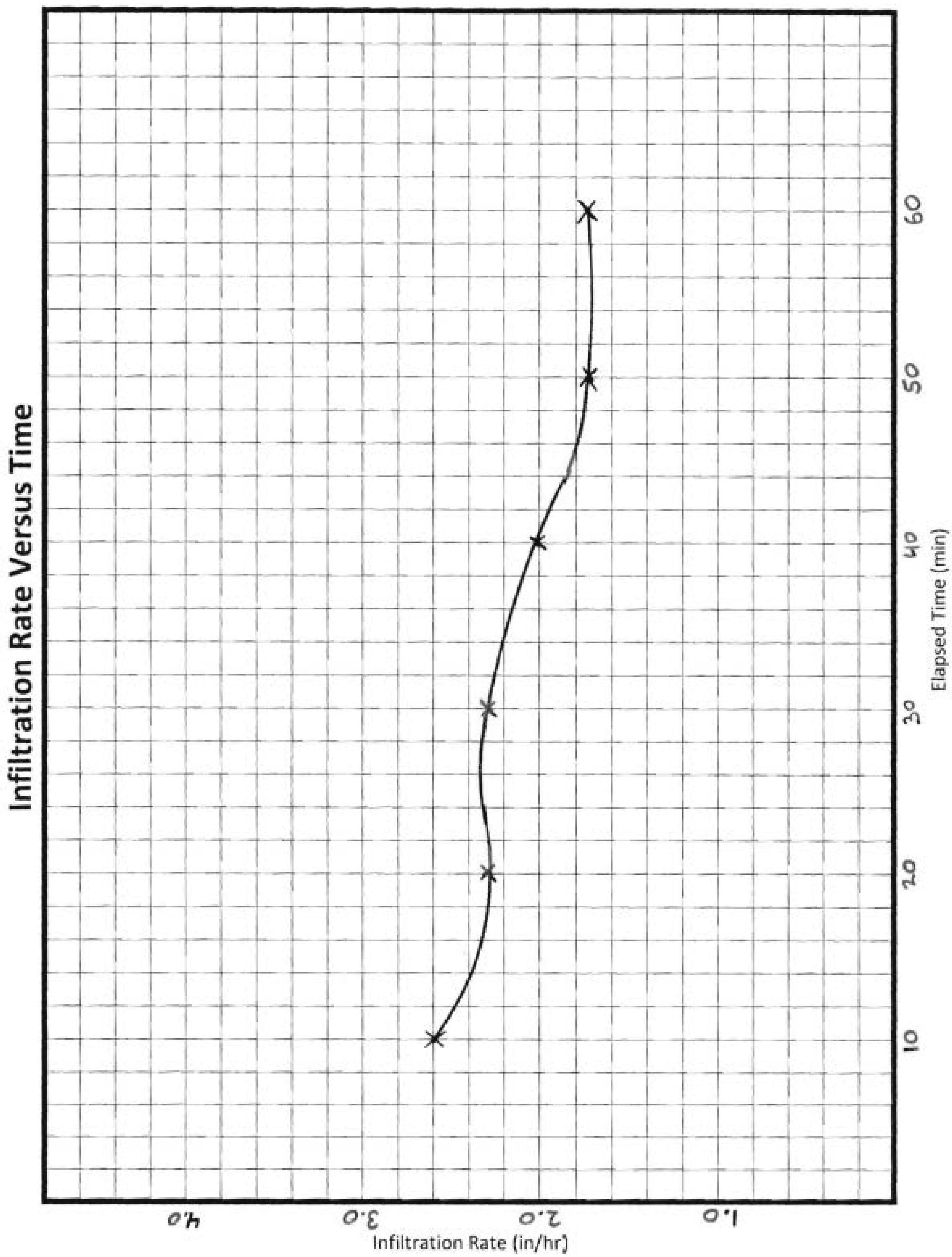


FIGURE 11 – PLOT OF CONVERTED PERCOLATION TEST DATA

2.4 - Field Permeability Test (Well Permeameter Method USBR 7300-89)

Similar to a constant-head version of the percolation test used for seepage pit design is the Well Permeameter Method of the United States Bureau of Reclamation. [1]USBR 7300-89 is an in-hole hydraulic conductivity test performed by drilling test wells with a 6-8 inch diameter auger to the desired depth. This test measures the rate at which water flows into the soil under constant-head flow conditions and is used to determine field-saturated hydraulic conductivity. As with the percolation test, the rate determined with this test is a "percolation rate" and is related, but not equal, to the infiltration rate. Infiltration rate is a measure of the speed at which water progresses downward into the soil. A percolation rate measures not only the downward progression but the lateral progression through the soil. However, this procedure uses the following equation(s) to establish an infiltration rate:

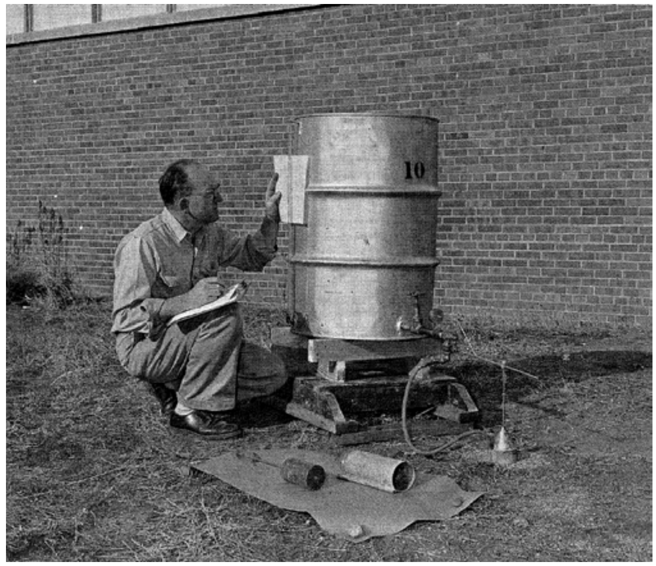


Photo 7 - Typical Well Permeamater Test Installation

Condition I: Typical condition (See Figure 12). The distance between the historical high water mark[2] and the water surface in the well is at least three (3) times the height of water in the well. In addition, there must be at least 10 feet from the bottom of the well to the historical high water table and at least 5 feet to impervious strata.

$$K_s = \frac{Q(\mu_T/\mu_{20})}{2\pi H^2}\left[\ln\left[\frac{H}{r}+\sqrt{\left(\frac{H}{r}\right)^2+1}\right]-\frac{\sqrt{1+\left(\frac{H}{r}\right)^2}}{\frac{H}{r}}+\frac{r}{H}\right]$$

Where:

K_s = saturated hydraulic conductivity (infiltration rate, inches/hour)
H = height of water in well (inches)
Q = percolation flow rate from selected time interval (cubic inches/hour)
r = effective radius of well (inches)
μ_T = viscosity of water at test temperature, T
μ_{20} = viscosity of water at 20°C

[1]A detailed description of this procedure along with a complete example using the associated equations can be found in the United States Bureau of Mines and Reclamation (USBR) document 7300-89.

[2]The "historical high groundwater mark" is defined as the groundwater elevation expected due to a normal wet season and shall be obtained by boring logs or test pits.

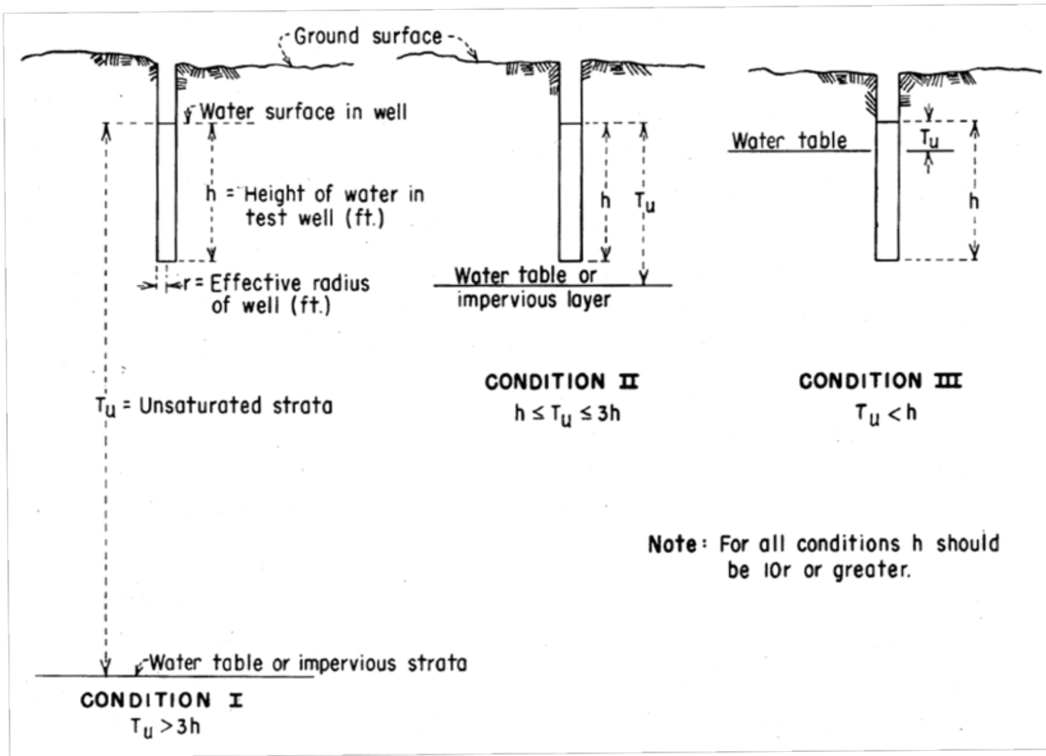


Figure 12 – Site Conditions Govern Procedure to be Used

Condition II: The distance between the historical high groundwater mark[1] and the water surface in the well is less than three (3) times, but at least equal to, the height of water in the well. In addition, there must be at least 10 feet from the bottom of the well to the historical high water mark[1] and at least 5 feet to impervious strata.

$$K_s = \frac{Q(\mu_{20}/\mu_T)}{2\pi H^2}\left[\frac{\ln\left(\frac{H}{r}\right)}{\left[\frac{1}{6}+\frac{1}{3}\left(\frac{H}{T_u}\right)^{-1}\right]}\right]$$

Where:

K_s = saturated hydraulic conductivity (infiltration rate, inches/hour)
H = height of water in well (inches)
Q = percolation flow rate from selected time interval (cubic inches/hour)
r = effective radius of well (inches)
μ_T = viscosity of water at water temperature, T
μ_{20} = viscosity of water at 20° C
T_u = unsaturated distance between the water surface and the water table or impervious strata

Condition III: Unacceptable location. The distance between the historical high groundwater mark and the water surface in the well is less than the height of water in well. As such, the base of the BMP would not be 10 feet above the historical high water mark or 5 feet from impervious strata.

Final Report - Ultimately, as discussed in Section 1.7, a final report shall be provided and, based on the test results, an infiltration rate shall be recommended.

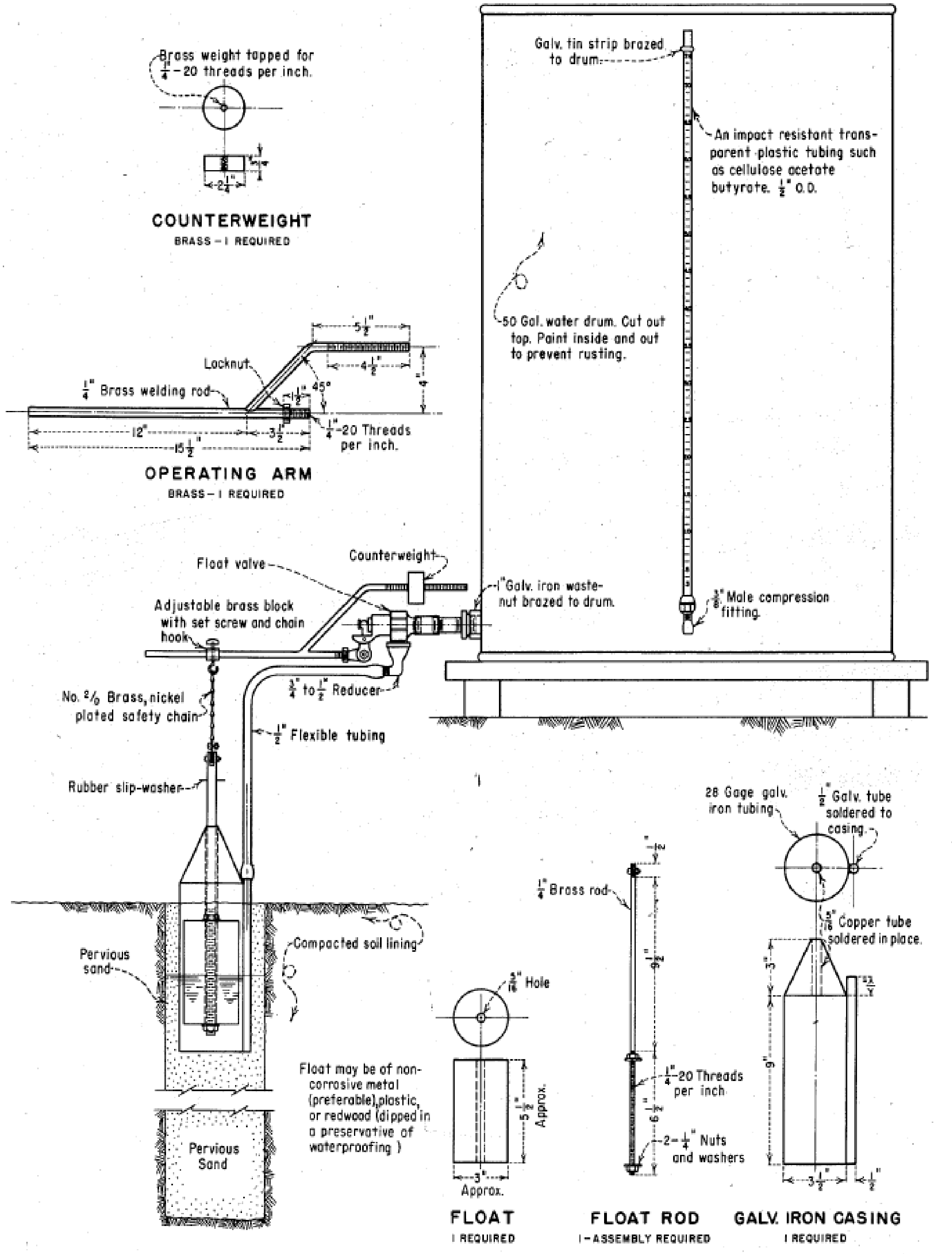


Figure 11 – Well Permeameter Test Equipment

2.5 - Borings and Test Pits

Borings and test pits are used to determine the thickness of soil and rock strata, estimate the depth to groundwater, obtain soil or rock specimens and perform field tests such as standard penetration tests (SPTs) or cone penetration tests (CPTs).

Test pits and trenches may be used to evaluate near-surface conditions up to about 15 feet deep but are often used for performing subsurface exploration at shallower depths. Test pits are often square in plan view and may be dug with shovels in less accessible areas. Trenches are long and narrow excavations usually made by a backhoe or bulldozer.

Borings (ASTM D 1452) are generally used to investigate deeper subsurface conditions. A cylindrical hole is drilled into the ground for the purpose of investigating subsurface conditions, performing field tests, and obtaining soil, rock, or underground specimens for testing. Borings can be excavated by hand (e.g., hand auger), although the usual procedure is to use mechanical equipment to excavate the borings.

Whatever method is used, testing shall be sufficient to establish USCS series and textural class (SM, CL, etc) of the soil beneath the infiltration surface of the BMP and of sufficient depth to establish that a minimum of 5 feet of permeable soil exists below the infiltration facility and that there is a minimum of 10 feet between the bottom of the infiltration facility and the historical high groundwater mark[1].

Photo 8- Auger Boring Rig

Photo 9 – Test Pit Excavation

[1]The "historical high groundwater mark" is defined as the groundwater elevation expected due to a normal wet season and shall be obtained by boring logs or test pits.

Infiltration Test Requirement Checklist

___ Where infiltration testing is to be performed, the measured infiltration rate of the underlying soil must be determined using either the single ring infiltrometer test (as described in ASTM D 5126, Section 4.1.2.1), the double ring infiltrometer test (ASTM D 3385), the well permeameter method (USBR 7300-89), or a percolation test per County of Riverside Department of Environmental Health (RCDEH) test procedures. A general explanation of these test methods can be found in Section 2 of this appendix. The minimum number of tests required can be found in Table 1 and is dependent upon the type of infiltration test performed.

___ Test pits and borings (ASTM D 1452) may be used to determine the USCS series and textural class (SM, CL, etc.) of the soil horizons throughout the depth of boring log or pit, the thickness of soil and rock strata, and estimate the historical groundwater depth. Test pits or boring logs must be of sufficient depth to establish that a minimum of 5 feet of permeable soil exists below the infiltration facility and that there is a minimum of 10 feet between the bottom of the infiltration facility and the historical high groundwater mark[1] (Section 1.7 and 2.5). The required number of test pits or borings is listed in Table 1.

___ A final report, prepared by a registered civil engineer, geotechnical engineer, certified engineering geologist or certified hydrogeologist shall be provided to the District or other EA which demonstrates through infiltration testing and/or soil logs that the proposed facility location is suitable for the proposed infiltration facility and an infiltration rate shall be recommended. In addition, any requirements associated with impacts to a landslide, erosion or steep slope hazard area should also be addressed in the final report. (Section 1.7)

___ Tests may be performed only by individuals trained and educated to perform, understand and evaluate the field conditions. The individual(s) supervising this field work must be named along with their education or training background in the final report as described in Item 3. (Section 1.7)

___ Preliminary site grading plans shall be provided to the District or other EA showing the proposed BMP locations along with section views through each BMP clearly identifying the extents of cut/fill.

___ All infiltration tests shall be performed within the boundaries of the proposed infiltration BMP and at the bottom elevation (infiltration surface) of the proposed infiltration facility. (See Photo 5)

[1]The "historical high groundwater mark" is defined as the groundwater elevation expected due to a normal wet season and shall be obtained by boring logs or test pits.

APPENDIX B

Underdrains

APPENDIX B – UNDERDRAINS

Where underdrains are specified, the following information provides guidance for underdrain requirements.

Underdrain Material Types

Underdrain pipe shall be 6-inch diameter ABS pipe or PVC pipe. ABS pipe shall meet the requirements of ASTM Designation D-2751, SDR 23.5, and PVC pipe shall meet the requirements of ASTM Designation D-2665. Perforations shall be as described in ASTM Designation C-700. It should be noted that placing the pipe such that the perforations are oriented upward may help to maximize infiltration in unlined BMP's with underdrains. If the BMP is constructed with an impermeable liner, the perforations should be angled downward to maximize the volume of water that will be drained from the BMP.

Underdrain Connections

Pipe joints and storm drain structure connections must be adequately sealed to avoid piping conditions (water seeping through pipe or structure joints). Pipe sections shall be coupled using suitable connection rings and flanges. Field connections to storm drain structures and pipes shall be sealed with polymer grout material that is capable of adhering to surfaces. Underdrain pipe shall be capped (at structure) until completion of site construction. Underdrains connected directly to a storm drainage structure shall be non-perforated for an appropriate distance from the structure interface to avoid possible piping problems.

Underdrain Slope

Underdrains must "daylight" or connect to an existing drainage system to achieve positive flow. All underdrains must be placed with a minimum slope of 0.5% (s = 0.005 ft/ft).

Underdrains Layout and Spacing

Typically, there are two main layouts for underdrains. One is a non-perforated central collector pipe with perforated lateral feeder pipes, the other is simply a series of longitudinal perforated pipes. Both layouts connect to a non-perforated outlet pipe before "daylighting" or connecting to an existing drainage system. The minimum spacing is shown below.

BMP Type	Underdrains Center to Center Spacing
Sand Filter Basin	20'
Extended Detention Basins (Bottom stage 500 sq ft. or greater)	20'
Extended Detention Basins (Bottom stage < 500 sq ft.)	10'
Bioretention Facility	5'

Underdrain Gravel

Gravel bed materials should be used to protect an underdrain pipe and to reduce clogging potential. Placement of gravel over the underdrain must be done with care. Avoid dropping the gravel from excessive heights from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually.

Recommended construction specifications for gravel used to protect underdrains are as follows:

- AASHTO #57 stone preferred
- Geotextile fabrics should be avoided because tearing and/or plugging can dramatically affect performance. If the designer is concerned about the engineered soil media migrating into the underdrain, a 3-inch thick layer of "pea gravel" may be added to create a "choker" course.

Maintenance

Access for cleaning underdrains is required for each system. Clean-outs, with diameters equal to the underdrain, should extend 6 inches above the media and have a lockable screw cap for easy access. Cleanouts should be located for every 50 feet of lateral, at the collector drain line connection, and at any bends.

Underdrain Orifice Plate

When designing a BMP to meet Hydraulic Conditions of Concern (HCOC) criteria in addition to water quality criteria, it is sometimes necessary to install an orifice plate near the downstream end of the underdrain system. The orifice plate restricts the opening of the underdrain to mitigate flows to a specific lower flow threshold. Proper maintenance access should be provided to the orifice plate location to facilitate maintenance activities, specifically the removal of accumulated sediment and debris upstream of the orifice plate.

APPENDIX C

Basin Guidelines

APPENDIX C – BASIN GUIDELINES

This appendix is broken up into two sections. Section 1 presents guidelines and standards for the design and maintenance of water quality and increased runoff basins used within Riverside County. Applicable water quality basins include infiltration, sand filter and extended detention basins but do not include Bioretention BMPs. Section 2 is devoted to guidelines and standards for debris basins. Regional Basins are only loosely governed by this document and are largely considered on a case-by-case basis.

These guidelines are *intended* to be used on both private and public facilities throughout Riverside County and *shall* be adhered to for all facilities to be maintained by the Riverside County Flood Control and Water Conservation District (District). It is anticipated that County Transportation, Coachella Valley Water District and the City Engineer for incorporated cities within the County may choose to alter these guidelines and may have different/additional requirements. These entities, along with the District, will be referred to as the Engineering Authority (EA). Similarly, County or City Planning Departments, Parks Departments and Parks Districts may also have different/additional requirements. These entities will be referred to as the Planning Authority (PA). Both the EA and PA should be consulted regarding their specific requirements.

Section 1- Detention and Water Quality Basins

1.1 General Criteria

Off-line versus In-stream Mitigation – All water quality mitigation basins must be flow-through. In-stream mitigation is extremely difficult to accomplish unless the basin is designed to accommodate all upstream tributary area and to mitigate for all impacts due to upstream development. Therefore most EAs will not allow in-stream water quality mitigation basins. It shall be noted that while flow mitigation BMPs may be allowed to be constructed within "jurisdictional waters", water quality mitigation BMPs will not be permitted.

Dam Safety Compliance – Basin designs that would be considered "jurisdictional" and fall under the Division of Safety of Dams (DSoD) review are not recommended.

Standard Details - Most EAs would prefer standardization of elements of outlet structures that are likely to wear (e.g., trash racks). Outflow control structures shall be designed in accordance with the EA's standards unless site-specific conditions preclude it. The District requires the use of Standard Drawing WQ501 for most basins. However a modified District CB110 overflow outlet is recommended for infiltration and sand filter basins. Minor modifications to provide supplemental hydraulic routing characteristics above the water quality storage volume are acceptable.

General Sizing Criteria – These guidelines relate to the basic features to be included in the various types of basins and the general geometrics of the basins design criteria. This appendix does not include the volumetric sizing of facilities. Follow the appropriate increased runoff guidelines or BMP fact sheet sizing.

Geotechnical Reports – A geotechnical report prepared by either a licensed geotechnical engineer, civil engineer or certified engineering geologist is required for all basins. The minimum content of the Geotechnical report shall include the following:

- Slope stability - Discussion shall include the affect the basin may have on the stability of adjacent slopes as a result of the basin's proposed location.
- Compaction, cut and fill - Issues due to soil compaction and/or cut and fill conditions with regards to the safety and effectives of the basin shall be discussed.
- Setbacks from buildings, slopes, wells - The report shall include recommendations for the minimum setback required from buildings, onsite walls, and slopes. In addition, the report shall determine the location of any pre-existing wells (onsite or offsite) and clarify that the minimum 100 foot horizontal setback has been maintained.
- Embankment design - For embankments over 5 feet in height, the geotechnical report shall include recommendations as to its construction and clarify that the embankment meets the requirements herein.
- Boring logs - Boring logs shall be provided within the report and a discussion of their findings included. Any subsurface conditions which may be pertinent to the safety and effectiveness of the basin shall be discussed.
- High Groundwater Level - The historic high groundwater level shall be determined. It shall be clarified that a minimum 10 foot vertical separation from the bottom of the basin to the top of the historic high groundwater level will be maintained.

In addition, where infiltration basins are to be utilized on the site the following topics shall be discussed:

- Existing Conditions (i.e., legacy pollutants) - Where existing soil contains unusually high levels of pollutants, the report shall clarify the extent of the pollution, mitigation efforts and the viability of using an infiltration BMP effectively as a result.
- Infiltration Testing - The use of infiltration BMPs may require an infiltration rate be established as described in Appendix A, "Infiltration Testing Guidelines". An infiltration testing report may be required and documented as described therein

Parking Lot Detention - Parking lots <u>shall not</u> be used to provide additional surface (above ground) storage for either water quality BMPs or to address HCOCs.

Seeps and Springs- Intermittent seeps along cut slopes are typically fed by a shallow groundwater source (interflow) flowing along a relatively impermeable soil stratum. These flows are precipitation driven and should discontinue after a few weeks of dry weather. No special provisions are needed when directing these flows through the basin. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper groundwater source. When continuous flows are intercepted and directed through basins, adjustments to the approved facility design may be required to account for the additional base flow (unless already considered in design).

Privately Owned Basins - All of the criteria herein apply to privately maintained basins except that retaining walls may be used for a portion of interior slopes. Privately owned basins are only acceptable for commercial projects, multi-family residential projects and single family residential communities with a viable maintenance mechanism. Retaining walls may not be used to support water impounding embankments. Retaining walls shall not exceed one third of the outside perimeter of the basin. Detailed structural design calculations must be submitted with every retaining wall proposal. A fence shall be provided along the top of the wall. **The use of retaining walls in a basin requires approval prior to tentative project approval.** The EA or PA may reject the proposed use of retaining walls due to aesthetic and maintenance concerns relating to nuisance and graffiti abatement.

1.2 - Basin Grading Parameters

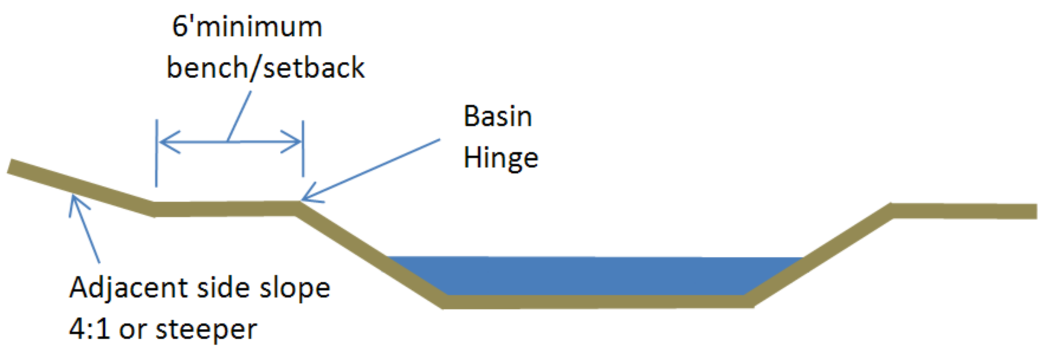
Basins must meet the following requirements for side slopes, fencing, and embankments:

Interior Side Slopes - At least 50 percent of the facility perimeter shall have interior sides no steeper than 4H:1V and in no case steeper than 2H:1V (even if fenced) to minimize safety risks. Side slopes shall be no steeper than 4H:1V whenever adjacent to down-gradient external property lines, roadways, sidewalks and trails.

Embankments - Embankment fill slopes (external and internal) may be no steeper than 4:1 with no exceptions. Basin embankment height will be based on the vertical distance from the design overflow water surface (typically the spillway invert elevation) to the lowest downstream toe of embankment fill. Basin embankments higher than 5 feet shall require design by a geotechnical engineer and shall have a top width not less than 20 feet. For embankments 5 feet or less in height, the minimum top width shall be 6 feet. Embankments for water quality basins may not exceed 3 feet in height.

Setbacks - All basin grading impacts shall be set back a minimum of 6 feet from down-gradient external property lines. This requirement applies to both the top of a cut-slope and the toe of any exterior slope embankment, along with rip-rap energy dissipaters relative to the property line (excluding road right of way). The cut-slope setback requirement is intended to avoid situations where future offsite grading/cut-slopes could turn an incised basin into an embankment-impounded reservoir. For all cases, depending on the amount of discharge and site characteristics, additional setback may be required unless appropriate easements are secured from the affected property owner(s).

There shall be a minimum 6 foot setback between a basin and an adjacent slope 4:1 or steeper measured horizontally from the basin hinge to the toe of the slope.



Forebay - A forebay shall be placed at each inlet to the basin to allow for the settlement and collection of larger particles. A relatively smooth concrete bottom surface should be provided to facilitate mechanical removal of accumulated sediment, trash and debris. A rock or concrete berm separates the forebay from the remainder of the basin. The forebay's design volume must be from 3 to 5% of the design volume, with the exception of infiltration and sand filter basins whose forebays should be 0.5% of the design volume. A full height notch-type weir shall be made through the berm to convey water to the main body of the basin. This notch shall be offset from the inflow streamline to prevent low-flows from short circuiting.

Basin Floor Slopes - Surface slopes should be kept at a minimum to allow for as much infiltration/groundwater recharge as is possible while still meeting vector concerns. All detention and extended detention basins shall have transverse and longitudinal bottom surface slopes of 1% minimum. For infiltration and sand filter basins, the basin floor should be level.


Gravel filled low-flow trench

Dry Weather Flow Management – All increased runoff or extended detention basins (**excluding** infiltration or sand filter basins) shall be designed to accommodate dry weather flows without impairing wet weather function or creating potential nuisance or maintenance issues. The basin shall have a network of gravel filled low-flow and collector trenches covering the entire basin floor area along with a sand filter drain adjacent to the outlet structure. See Figure 1 on following page.

A 48-inch wide by 24-inch deep low-flow trench conveys flow from the forebay to the filter drain. With a mild longitudinal slope of at least 1% to promote infiltration, the unlined low-flow trench shall be filled with 2" gravel (ASTM No. 2 or similar) to the finished surface and shall not use perforated subdrains.

Collector trenches beneath the top stage shall be arranged in accordance with Figure 1 with a maximum slope of 0.5% to promote infiltration and must extend from the low-flow channel to the toe of the basin side slopes. They shall be 18-inches wide by 24-inches deep and filled with 2" gravel (ASTM No. 2 or similar) to the finished surface. The collector trenches shall not have perforated subdrains and shall be constructed with a maximum spacing of 25 feet on center. See Figure 1 on following page.

A sand filter drain shall be constructed at the low point (or bottom-stage) of the basin adjacent to the outlet structure. To avoid clogging at the lowest orifice of the outlet structure, the top of the filter drain is offset below the lowest orifice of the outlet structure by 0.33 feet (4 inches). The sand filter drain shall include an 18 inch layer of sand (fine aggregate per

ASTM C-33) over a 10-inch gravel subdrain system and shall line the entire bottom stage. The total depth of the sand filter drain, D_{FD}, shall therefore not be less than 2.33 feet. See Appendix B for standard subdrain construction. The filter drain's design volume must be a minimum of 0.5% of V_{BMP} and the minimum bottom stage area is $A_{BS} = V_{BMP} / D_{BS}$.

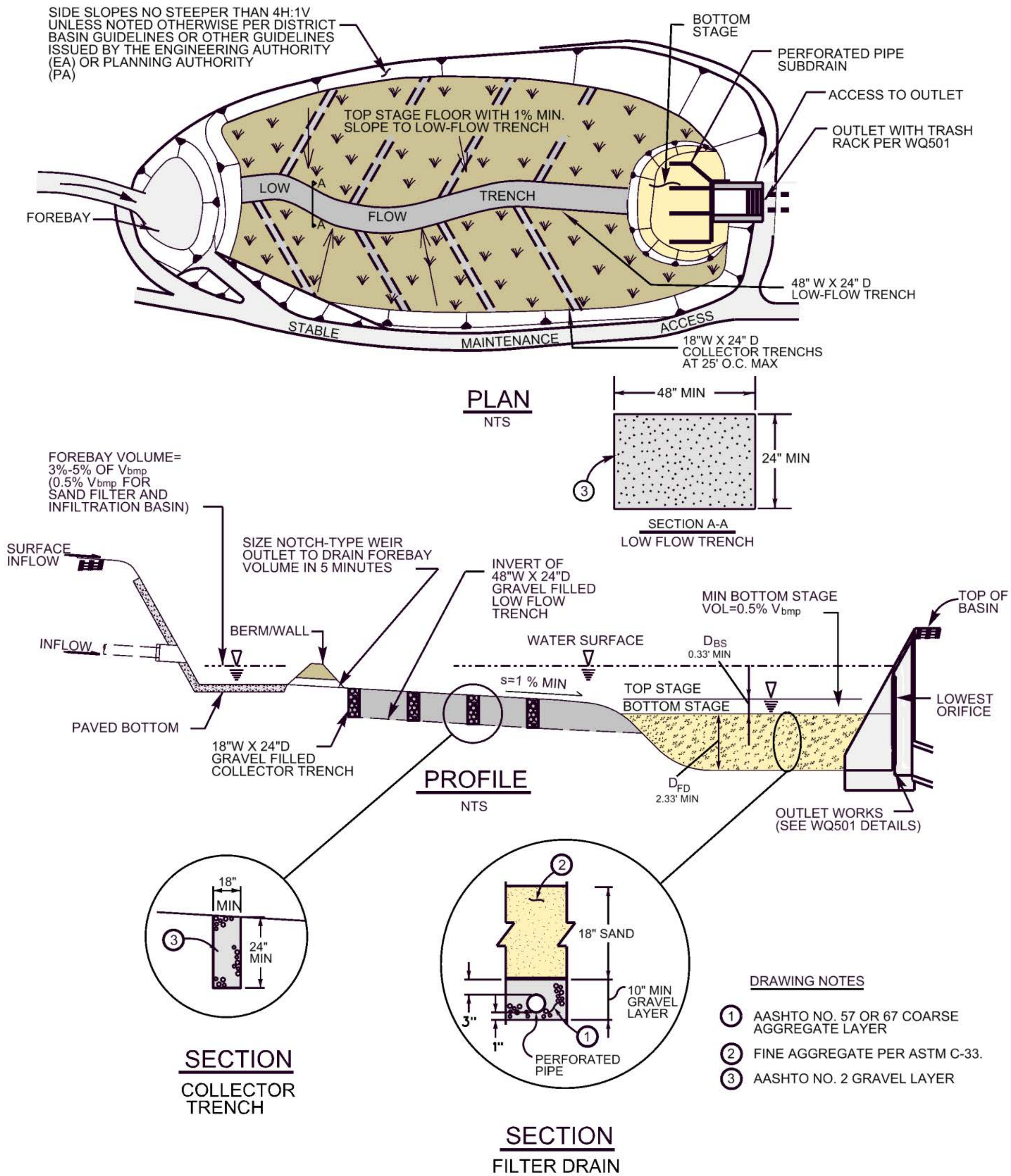
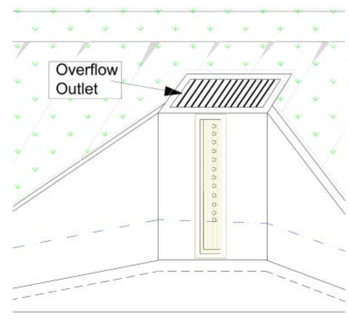


Figure 1 –Dry Weather Management Features

Outlet Structure and Spillway - Outlet structures shall conform to District Standard Drawing WQ501 unless approved in advance by the EA. This standardization is important in order to provide for efficient maintenance.

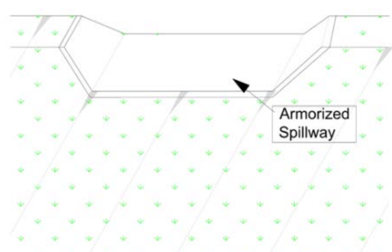
a. **Water Quality Outlet Trash Rack/Screen** - The outlet's orifice plate shall be protected with a conforming trash rack with at least six square feet of open surface area or 25 times the total orifice area, whichever is greater. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.

b. **Overflow Outlet** - In all basins, a primary overflow (usually integrated into the control structure) must be provided to pass flows greater than the design volume up to the 100-year event. The design must provide controlled discharge directly into the downstream conveyance system or an acceptable discharge point.



c. **Emergency Overflow** - In addition to the above overflow requirements, basins must have an emergency overflow escape path sized to safely pass the 100-year tributary developed peak flow in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow pathways are intended to control the location of basin overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.

d. **Emergency Overflow Spillway -** Basins with constructed embankment over 3 feet in height and for BMP embankments of any height, or located on grades in excess of 5% must provide an emergency overflow spillway structure. The emergency overflow spillway must be designed to pass the 100-year developed peak flow, with a minimum 12 inches of freeboard, directly to the downstream conveyance system or an acceptable discharge point. The emergency overflow spillway shall be armored full width, beginning at a point midway across the berm embankment and extending downstream to an adequate outlet point. Design of emergency overflow spillways generally requires the analysis of a broad-crested trapezoidal weir.



Access Roads and Ramps - Maintenance access road(s) shall be provided to the top of the control structure and other drainage structures associated with the basin (e.g., inlet/forebay, emergency overflow or bypass structures). All basins shall have unobstructed access from a public street (see Section 1.4, "Right-of-Way") with commercial size curb cut-outs and driveway approaches. Flood control basins designed to attenuate the 100 year flood event shall have an access road around the entire basin. Manhole and catch basin lids should be within or at the edge of the access road and shall be at least three feet from a property line. Rims shall be set at the access road grade.

On large, deep basins (at least 1500 square feet bottom area, measured without the ramp, and over 4 feet deep), an access ramp must extend to the basin bottom at the forebay for removal of sediment with a trackhoe and truck. This is necessary so truck loading can be done in the basin bottom.

However, on small deep basins (less than 1500 square feet, but over 4 feet deep), the truck can remain on the ramp for loading. As such, the ramp may end at an elevation up to 4 feet above the basin bottom provided the basin side slopes are 4:1 or flatter.

On small shallow basins (less than 1500 square feet bottom area, and 4 feet deep or less), a ramp to the bottom is not required if the trackhoe can load a truck parked at the basin edge (trackhoes can negotiate mild interior basin side slopes).

No ramp is required for <u>any</u> basin 4-feet or less in depth if vehicular access is provided to the top of slope at the forebay and the side slopes are 4:1 or flatter. (Depth trigger for ramp is measured from top of slope adjacent to forebay invert.)

Design of access roads and ramps shall meet the following design criteria:

a. Maximum grade (measured along ramp centerline) shall be 15% for asphalt or concrete paving and 10% for soft surface or modular grid paving.
b. Inside turning radius shall be 35 feet, minimum.
c. Fence gates shall be located only on straight sections of road.
d. Access roads shall be constructed with an asphalt, concrete, 3-inch layer of compacted Class 2 aggregate road base material, decomposed granite or modular grid pavement.
e. Access roads and ramps shall be 15 feet in width on curves, 12 feet on straight sections. A paved apron shall be provided where access roads connect to paved public roadways.

1.3 - Landscaping

Landscaping will likely be required by the Planning Authority. Landscaping requirements shall be in accordance with Riverside County Ordinance 859 or equivalent agency ordinance. Care must be taken to ensure that landscaping does not hinder maintenance operations.

a. Facilities shall be designed so that they do not require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. A 6-foot minimum width must be provided to allow a mower to pass (see Figure 2).

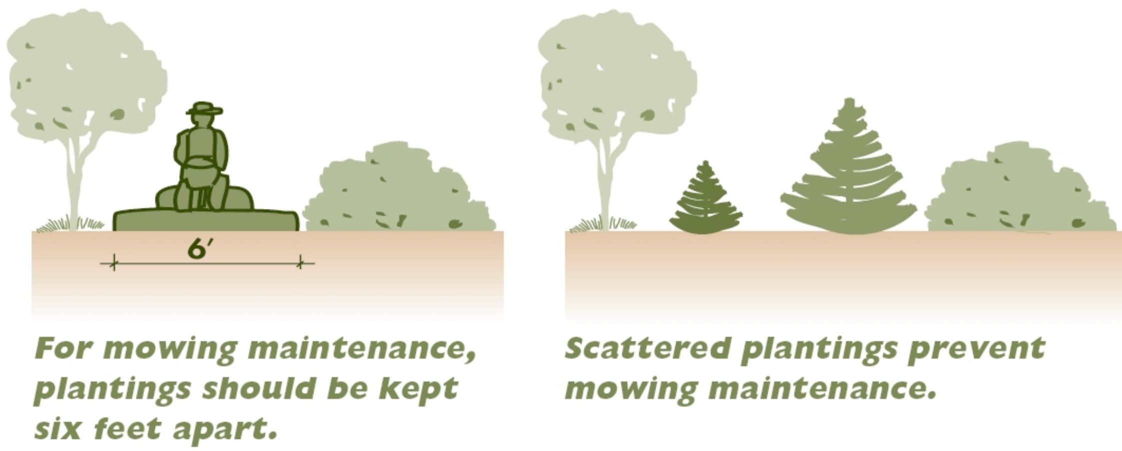


Figure 2- Landscaping setbacks (Source: King County WLR)

b. Turf and lawn areas are not allowed for publicly maintained basins unless an appropriate landscape maintenance entity is identified.

c. Planting is restricted on embankments that impound water either permanently or temporarily during storms (see figure 3). This reduces the likelihood of blown down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on embankments that retain water.

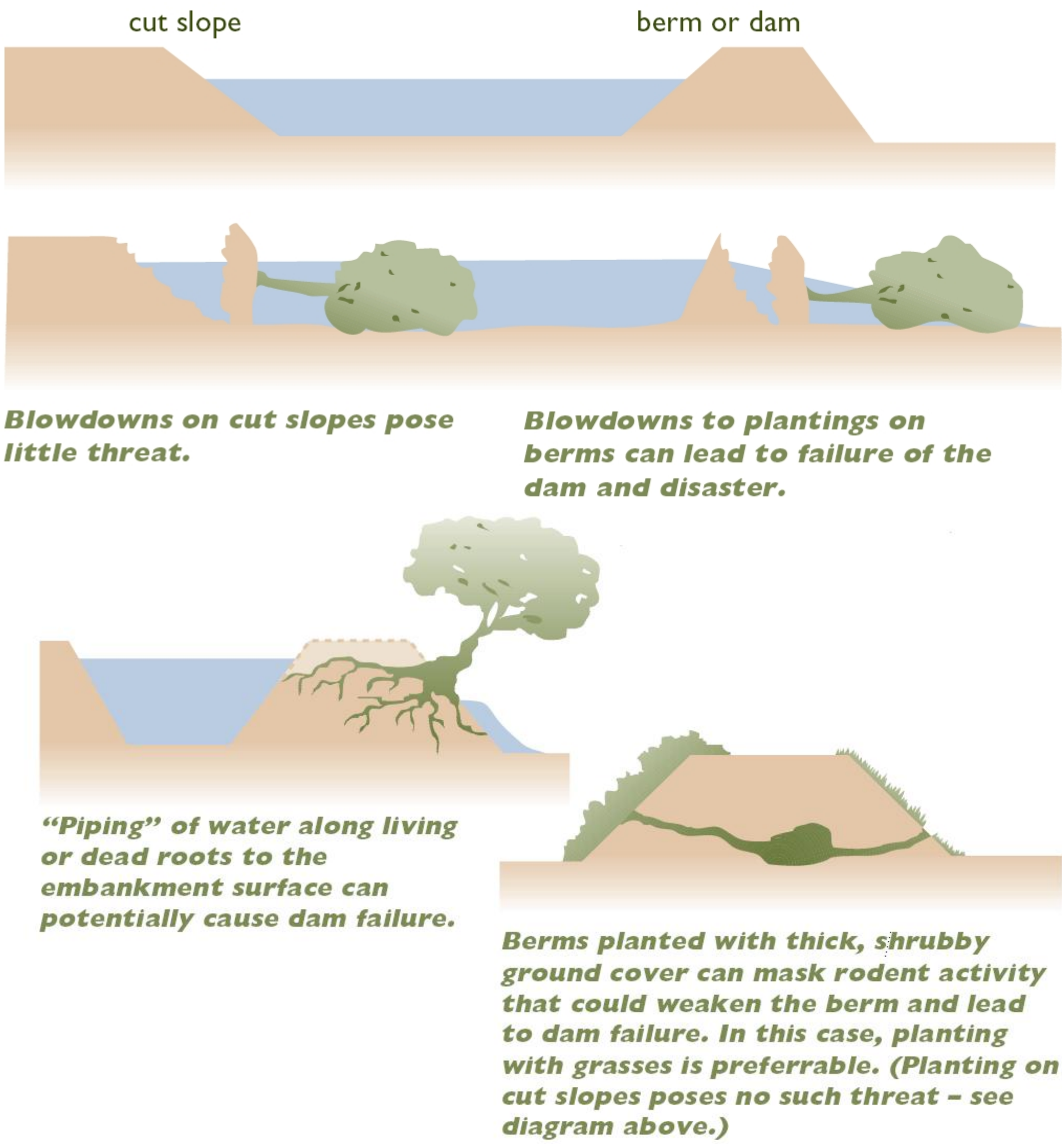


Figure 3 - Hazardous Landscaping Practices (Source: King County WLR)

Note: *This restriction does not apply to cut slopes that form basin banks, only to embankments.*

d. No trees or shrubs may be planted within 10 feet of inlet or outlet pipes or from manmade drainage structures such as spillways or flow spreaders.

e. Trees with roots that seek water, such as willow or poplar, should be avoided within 50 feet of pipes or manmade structures.

f. Evergreen trees and others that produce relatively little leaf-fall (such as locust) are preferred in areas draining to the basin. Trees should be set back so branches do not extend over the outlet structure area of the basin (to help prevent clogging). Drought tolerant species are recommended.

g. Trees or shrubs may not be planted on portions of water-impounding embankments taller than four feet high. Only grasses may be planted on embankments taller than four feet.

1.4 - Additional Requirements

Fencing Criteria - The requirements for slopes and fencing are intended to discourage access to portions of a basin where steep side slopes (steeper than 4:1) increase the potential for slipping into the basin, and to allow easy egress for those who have fallen with slopes that are mild enough (flatter than 4:1 and unfenced) to allow for easy escape. If the basin will hold water deeper than 2 feet, a physical barrier as demarcation of the basin limits is required:

a. Where interior slopes are steeper than 4:1, the barrier shall be a fence 6 feet in height (see District Standard Drawing M-801 for chain link fence details). In joint use ventures where a special district or agency has agreed to maintain landscape facilities, tubular steel fencing such as that meeting Valley Wide Recreation and Parks District landscape standard LC-10 is also acceptable. Functionally equivalent designs may be acceptable on a case by case basis.

b. Where interior slopes are 4:1 or milder, the physical demarcation shall be (3-foot minimum height) vinyl or PVC rail fence, post-and-cable, masonry wall, or densely planted hedges. Functionally equivalent designs may be acceptable on a case by case basis.

c. If the side slopes undulate, and segments of the slope are steeper than 4:1, the barrier standard from "b." above may be used in place of the 6-foot fence for the short lengths of slope as specified here: The barriers described in "b." may be used for sections of 2:1 slope not to exceed 20 lineal feet and sections of 3:1 slope not exceeding 50 lineal feet.

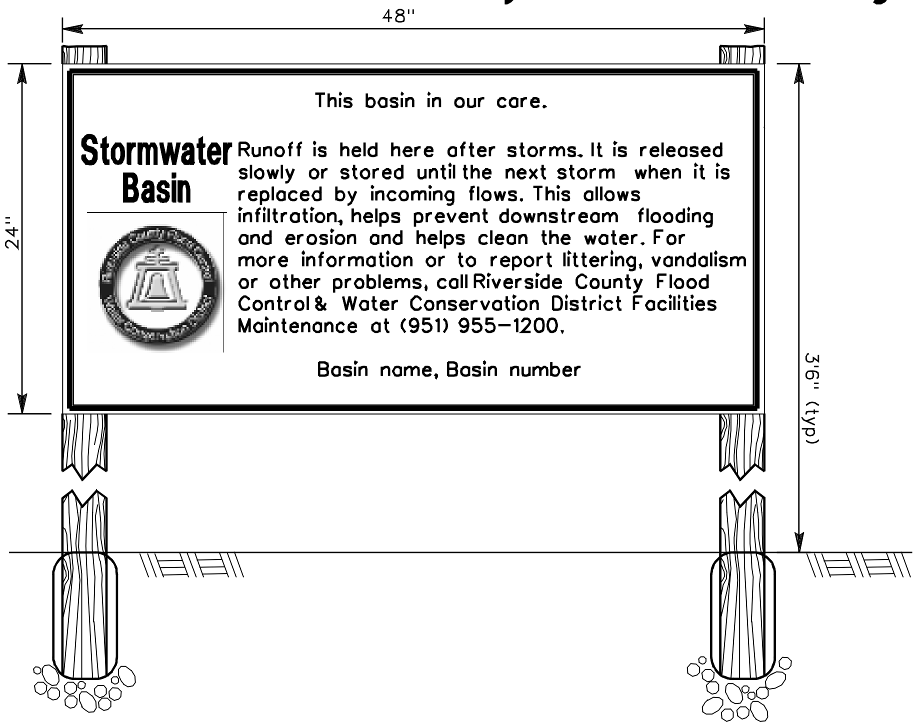
d. If required, fencing shall be placed at or above the overflow water surface. Side slope and attendant fencing requirements are not applicable to slopes above the overflow water surface.

Gates - Vehicular access shall be limited by a double-posted gate if a fence is required, or by bollards. Access road gates shall be 14 feet in width consisting of two swinging sections 7 feet in width (see the District's Standard Drawing M-801 for details). Alternately, two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards may be used. Additional vehicular access gates may be required as needed to facilitate maintenance access. Pedestrian access gates (if needed) shall be 4 feet in width.

Signage - All basins to be maintained by the District shall have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. The sign shall meet the design and installation requirements illustrated in Figure 4.

Right-of-Way - Basins shall not be located in a dedicated public road right-of-way. Publicly maintained basins shall be in a lot dedicated to the public. Any lot not abutting the public right-

Permanent Water Quality Informational Sign



SPECIFICATIONS:

Size:	48 inches by 24 inches
Material:	0.125-gauge aluminum
Face:	Non-reflective vinyl or 3 coats outdoor enamel (sprayed).
Lettering:	Silk screen enamel where possible, or vinyl letters.
Colors:	Beige background, navy blue letters.
Type face:	Electrical condensed. Title: 3 inch; Sub-Title: 1 1/2-inch; Text: 1 inch; Outer border: 1/inch border distance from edge: 1/4-inch; all text 1 3/4-inch from border.
Posts:	Pressure treated, beveled tops, 1/2-inch higher than sign.
Installation:	Secure to fence if available. Otherwise, install two 4"x4" post, pressure treated, mounted atop a gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter), with the top of sign no higher than 42 inches from ground surface.
Placement:	Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g. manholes, spillways, pipe inlets).

Note: If the facility has a liner to restrict infiltration of stormwater, the following note must be added to the face of the sign: "This facility is lined to protect groundwater quality."

RIVERSIDE COUNTY FLOOD CONTROL

SUBJECT TO REVISION

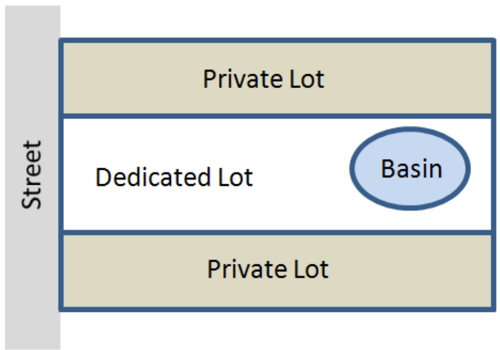
CHIEF ENGINEER

DATE:

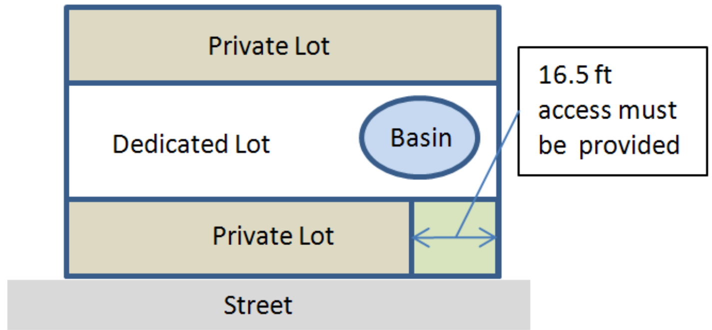
STANDARD DRAWING NUMBER WQ502

Figure 4- Typical Basin Signage

of-way will require a 16.5-foot wide extension of the lot to an acceptable access location.



Case 1 - Access available to public road right-of-way.



Case 2 - Access must be acquired through adjacent lot to public road right-of-way.

1.5 - Basins in Recreational Spaces

Any basin site with a bottom surface area larger than one acre will likely be required to incorporate active use area and shall be designed only after consultation with the PA to establish site-specific guidance which may increase the total facility footprint.

If multiple uses are being contemplated, consider the following:

- Place the active use areas such as ballparks, playing fields, and picnic areas above the water quality design volume (V_{BMP}) ponding limit.
- Use a multiple-stage detention basin to limit inundation of passive recreational areas to one or two occurrences a year.
- Side slopes shall not exceed 25% (4:1) unless they are existing, natural, and covered with vegetation.
- Locate the basin in a separate lot.
- Incorporate a bypass system or emergency overflow pathway that does not present a safety hazard or discharge into active recreation areas.
- The basin shall be landscaped in a manner to enhance passive recreational opportunities such as trails and aesthetic viewing. Inquire with the PA whether the basin can be compatible with the open space value and functions.

If the criteria above are met, projects may be able to receive some reduction in required onsite recreational space if approved in advance of tentative project approval by the PA.

Section 2 - Debris Basins

Debris basins differ from stormwater detention and water quality basins in that they are not intended to detain flows or to mitigate pollutants (other than debris). They are simply utilized to collect large debris from storm flows for later removal. The guidelines in this section apply to debris basins only.

Site access – Debris basins shall have unobstructed access from a public street (see Section 1.4, "Right-of-Way") with commercial size curb cut-outs and driveway approaches.

Fencing – The entire facility shall be enclosed with 6-foot high chain link fencing and 14-foot high double drive gates. Where the perimeter fencing crosses a streambed, cable or barbed wire fencing across streambed will be provided.

Maintenance access - Maintenance access shall extend around the entire perimeter of the facility. Roads shall be a minimum of 15 feet wide (20 feet wide if on an embankment of 3 feet or higher). The minimum design turning radius shall be 35 feet. Ramps shall be a minimum of 15 feet wide with a maximum longitudinal slope of 10%. Both roads and ramps shall be surfaced (full width) with 3" of compacted Class 2 base material.

Basin Cut/Fill slopes – All basin slopes shall not be steeper than 3:1.

Stockpile/Staging Area – Shall be situated immediately adjacent to the basin. The minimum acreage shall be sufficient to temporarily store 20% of volume of debris accumulated in the 100-yr-frequency design event. Surface acreage shall be calculated assuming a stockpile of 10 feet high with 2:1 fill slopes. A minimum 15-foot wide access road with a 35-foot wide turning radius shall be provided to accommodate equipment access. In addition, a 70-foot long by 15-foot wide strip is required for equipment loading and unloading within an area of sufficient size to maneuver heavy construction equipment.

Minimum Basin Floor Surface Area – Basin floors 1,400 square or greater must be provided with a minimum width of 30 feet.

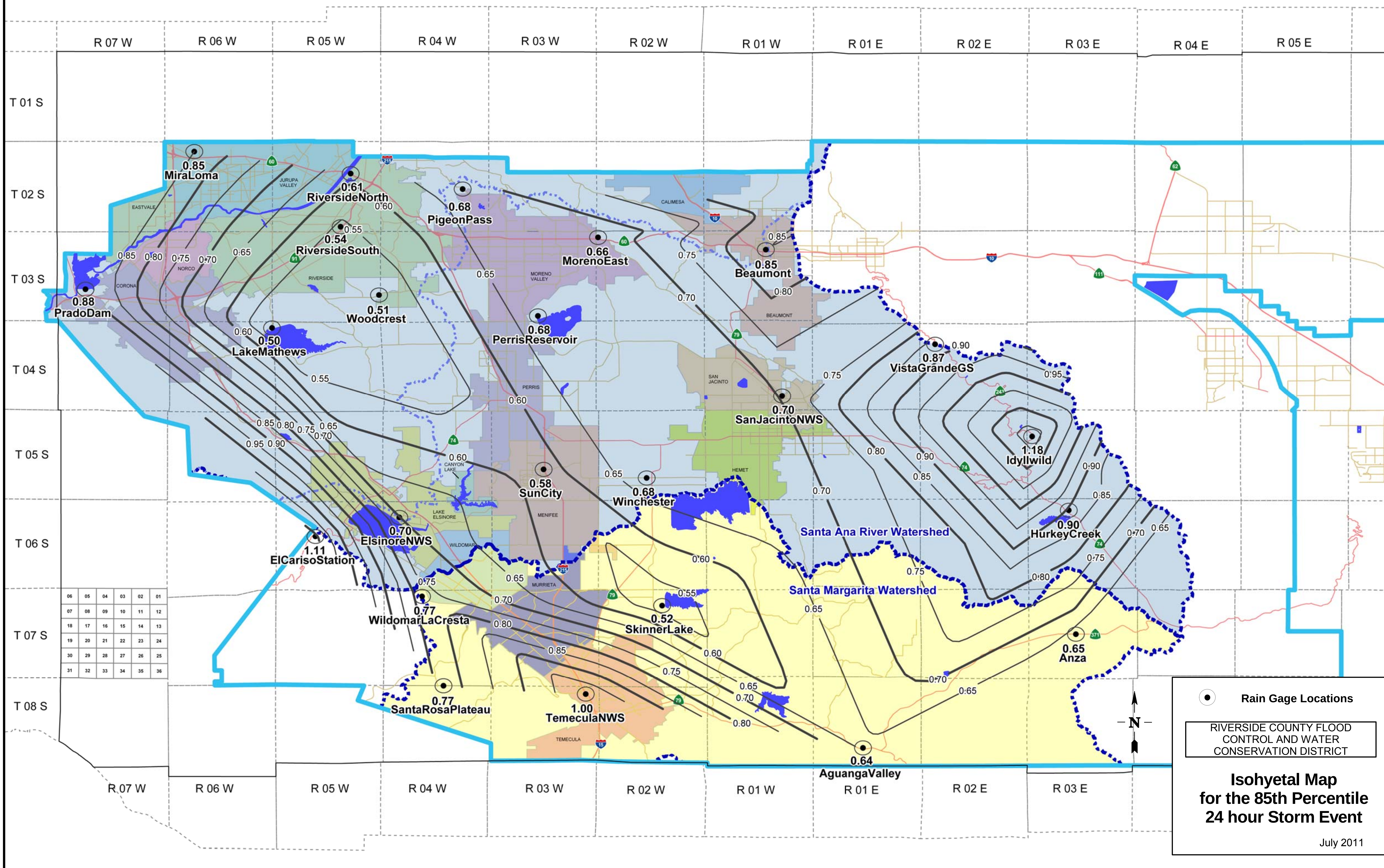
Outlet Structure – A tower-type outlet is not permitted. Use outlet structure design similar to that used in designs for Tahquitz Creek and Oak Street Debris Basins (slotted/slanted grate). All structures and ramps to structures shall include safety rails/belly bars at all stairways and wherever appropriate. A minimum of two (2) visible depth (paddle) gauges shall be provided.

APPENDIX D

Isohyetal Map for the 85th Percentile 24-hour Storm Event

For the Santa Ana and Santa Margarita Watersheds

Administrative Record Page No. 031461



APPENDIX E

BMP Pollutant Removal Effectiveness

APPENDIX E
BMP POLLUTANT REMOVAL EFFECTIVENESS

BMP Pollutant Removal Effectiveness [1]

Pollutant of Concern	Harvest and Use [8]	Infiltration BMPs [3]	Bioretention	Extended Detention Basins [2]	Sand Filter Basin [7]
Sediment	H	H	H	M	H
Nutrient	H	H	[5]	M [4]	L [6]
Trash	H	H	H	H	H
Metal	H	H	H	M	M
Bacteria	H	H	H	M	M
Oil & Grease	H	H	H	M	H
Organic Compounds	H	H	H	M	H
Pesticides	H	H	H	U	U

Abbreviations:

L: Low removal efficiency M: Medium removal efficiency H: High removal efficiency U: Unknown

Notes:

(1) Periodic performance assessment and updating of this table may be performed based on updated information from studies from the District, CASQA, Caltrans or others. These effectiveness ratings are based on the specific BMP designs incorporated into this manual.

(2) Effectiveness based upon total 72-hour drawdown time.

(3) Includes infiltration basins, infiltration trenches, and permeable pavements.

(4) Medium for soil types A & B only. Low for soil types C & D.

(5) Removal rating is dependent on the soil media depth. L=Min. 18" deep, M= Min. 24" deep, H=Max. 30"-36" deep.

(6) Medium where sand filter layer is increased to 36".

(7) Considered to be a Treatment Control BMP. See the WQMP to determine if this BMP can be used.

(8) Cisterns, when associated with an adequate and reliable (year-round) demand for non-potable use of captured storm water (see the applicable WQMP for any specific requirements), have a High effectiveness at removing all pollutants from stormwater runoff. If there is inadequate demand to reliably drain the cistern through a non-potable use throughout the year, pollutant removal effectiveness will be Low.

APPENDIX F

Worksheets for calculating V_{BMP} and Q_{BMP}

Santa Ana Watershed

V_{BMP} and Q_{BMP} worksheets

These worksheets are to be used to determine the required

Design Capture Volume (V_{BMP})
or the
Design Flow Rate (Q_{BMP})

for BMPs in the Santa Ana Watershed

To verify which watershed your project is located within, visit

www.rcflood.org/npdes

and use the 'Locate my Watershed' tool

If your project is not located in the Santa Ana Watershed,

Do not use these worksheets! Instead visit

www.rcflood.org/npdes/developers.aspx

To access worksheets applicable to your watershed

Use the tabs across the bottom
to access the worksheets for the Santa Ana Watershed

Santa Ana Watershed - BMP Design Volume, V_{BMP}

(Rev. 10-2011)

Legend: Required Entries / Calculated Cells

*(Note this worksheet shall **only** be used in conjunction with BMP designs from the **LID BMP Design Handbook**)*

Company Name | Date
Designed by | Case No
Company Project Number/Name

BMP Identification

BMP NAME / ID

Must match Name/ID used on BMP Design Calculation Sheet

Design Rainfall Depth

85th Percentile, 24-hour Rainfall Depth,
from the Isohyetal Map in Handbook Appendix E

D_{85}= inches

Drainage Management Area Tabulation

Insert additional rows if needed to accommodate all DMAs draining to the BMP

DMA Type/ID	DMA Area (square feet)	Post-Project Surface Type	Effective Imperivous Fraction, I_f	DMA Runoff Factor	DMA Areas x Runoff Factor	*Design Storm Depth (in)*	*Design Capture Volume, V_{BMP} (cubic feet)*	*Proposed Volume on Plans (cubic feet)*
	0		***Total***		**0**			

Notes:

Santa Ana Watershed - BMP Design Flow Rate, Q_{BMP}

(Rev. 10-2011)

Legend: Required Entries | Calculated Cells

*(Note this worksheet shall **only** be used in conjunction with BMP designs from the **LID BMP Design Handbook**)*

Company Name

Date

Designed by

Case No

Company Project Number/Name

BMP Identification

BMP NAME / ID

Must match Name/ID used on BMP Design Calculation Sheet

Design Rainfall Depth

Design Rainfall Intensity I = 0.20 in/hr

Drainage Management Area Tabulation

Insert additional rows if needed to accommodate all DMAs draining to the BMP

	DMA Type/ID	DMA Area (square feet)	Post-Project Surface Type (use pull-down menu)	Effective Imperivous Fraction, I_f	DMA Runoff Factor	DMA Areas x Runoff Factor	*Design Rainfall Intensity (in/hr)*	*Design Flow Rate (cfs)*	*Proposed Flow Rate (cfs)*
DMAs									
		0	*Total*			0	0.20		

Notes:

Effective Impervious Fraction

Developed Cover Types	Effective Impervious Fraction
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40
Mixed Surface Types	

Use this table to determine the effective impervious fraction for the V_{BMP} and Q_{BMP} calculation sheets

Santa Margarita Watershed

V_{BMP} and Q_{BMP} worksheets

These worksheets are to be used to determine the required

Design Capture Volume (V_{BMP})
or the
Design Flow Rate (Q_{BMP})

for BMPs in the Santa Margarita Watershed

To verify which watershed your project is located within, visit

www.rcflood.org/npdes

and use the 'Locate my Watershed' tool

If your project is not located in the Santa Margarita Watershed,

Do not use these worksheets! Instead visit

www.rcflood.org/npdes/developers.aspx

To access worksheets applicable to your watershed

Use the tabs across the bottom
to access the worksheets for the Santa Margarita Watershed

Santa Margarita Watershed

BMP Design Volume, V_{BMP} (Rev. 03-2012)

Legend: Required Entries / Calculated Cells

(Note this worksheet shall **only** be used in conjunction with BMP designs from the **LID BMP Design Handbook**)

Company Name | Date

Designed by | County/City Case No

Company Project Number/Name

Drainage Area Number/Name

Enter the Area Tributary to this Feature A_T = acres

85th Percentile, 24-hour Rainfall Depth, from the Isohyetal Map in Handbook Appendix E

Site Location

Township

Range

Section

Enter the 85th Percentile, 24-hour Rainfall Depth D_{85} =

Determine the Effective Impervious Fraction

Type of post-development surface cover (use pull down menu): Roofs

Effective Impervious Fraction I_f =

Calculate the composite Runoff Coefficient, C for the BMP Tributary Area

Use the following equation based on the WEF/ASCE Method

$C = 0.858I_f^3 - 0.78I_f^2 + 0.774I_f + 0.04$ C =

Determine Design Storage Volume, V_{BMP}

Calculate V_U, the 85% Unit Storage Volume $V_U = D_{85} \times C$ V_u = (in*ac)/ac

Calculate the design storage volume of the BMP, V_{BMP}.

$$V_{BMP}\ (ft^3) = \frac{V_U\ (in\text{-}ac/ac) \times A_T\ (ac) \times 43{,}560\ (ft^2/ac)}{12\ (in/ft)}$$

V_{BMP} = ft^3

Notes:

Santa Margarita Watershed

BMP Design Flow Rate, Q_{BMP} (Rev. 03-2012)

Legend: Required Entries | Calculated Cells

Company Name		Date	
Designed by		County/City Case No	
Company Project Number/Name			
Drainage Area Number/Name			

Enter the Area Tributary to this Feature A_T = acres

Determine the Effective Impervious Fraction

Type of post-development surface cover (use pull down menu) Roofs

Effective Impervious Fraction I_f =

Calculate the composite Runoff Coefficient, C for the BMP Tributary Area

Use the following equation based on the WEF/ASCE Method

$C = 0.858I_f^3 - 0.78I_f^2 + 0.774I_f + 0.04$ C =

BMP Design Flow Rate

$Q_{BMP} = C \times I \times A_T$ Q_{BMP} = ft^3/s

Notes:

Effective Impervious Fraction

Developed Cover Types	Effective Impervious Fraction
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40
Mixed Surface Types	

Use this table to determine the effective impervious fraction for the V_{BMP} and Q_{BMP} calculation sheets

Whitewater Watershed

V_{BMP} and Q_{BMP} worksheets

These worksheets are to be used to determine the required

Design Capture Volume (V_{BMP})
or the
Design Flow Rate (Q_{BMP})

for BMPs in the Whitewater Watershed

To verify which watershed your project is located within, visit

www.rcflood.org/npdes

and use the 'Locate my Watershed' tool

If your project is not located in the Whitewater Watershed,

Do not use these worksheets! Instead visit

www.rcflood.org/npdes/developers.aspx

To access worksheets applicable to your watershed

Use the tabs across the bottom
to access the worksheets for the Whitewater Watershed

Whitewater Watershed

BMP Design Volume, V_{BMP} (Rev. 03-2012)

Legend: Required Entries / Calculated Cells

Company Name		Date	
Designed by		County/City Case No	
Company Project Number/Name			
Drainage Area Number/Name			

Enter the Area Tributary to this Feature A_T = ___ acres

Determine the Effective Impervious Fraction

Type of post-development surface cover (use pull down menu): Roofs

Effective Impervious Fraction I_f =

Calculate the composite Runoff Coefficient, C for the BMP Tributary Area

Use the following equation based on the WEF/ASCE Method

$C = 0.858I_f^3 - 0.78I_f^2 + 0.774I_f + 0.04$ C =

Determine Design Storage Volume, V_{BMP}

Calculate V_U, the 85% Unit Storage Volume $V_U = 0.40 \times C$ V_u = ___ (in*ac)/ac

Calculate the design storage volume of the BMP, V_{BMP}.

$$V_{BMP}\ (ft^3) = \frac{V_U\ (in\text{-}ac/ac) \times A_T\ (ac) \times 43{,}560\ (ft^2/ac)}{12\ (in/ft)}$$

V_{BMP} = ___ ft^3

Notes:

Whitewater Watershed

BMP Design Flow Rate, Q_{BMP} (Rev. 03-2012)

Legend: Required Entries / Calculated Cells

Company Name		Date	
Designed by		County/City Case No	
Company Project Number/Name			
Drainage Area Number/Name			

Enter the Area Tributary to this Feature A_T = acres

Determine the Effective Impervious Fraction

Type of post-development surface cover (use pull down menu): Roofs

Effective Impervious Fraction I_f =

Calculate the composite Runoff Coefficient, C for the BMP Tributary Area

Use the following equation based on the WEF/ASCE Method

$C = 0.858I_f^3 - 0.78I_f^2 + 0.774I_f + 0.04$ C =

BMP Design Flow Rate

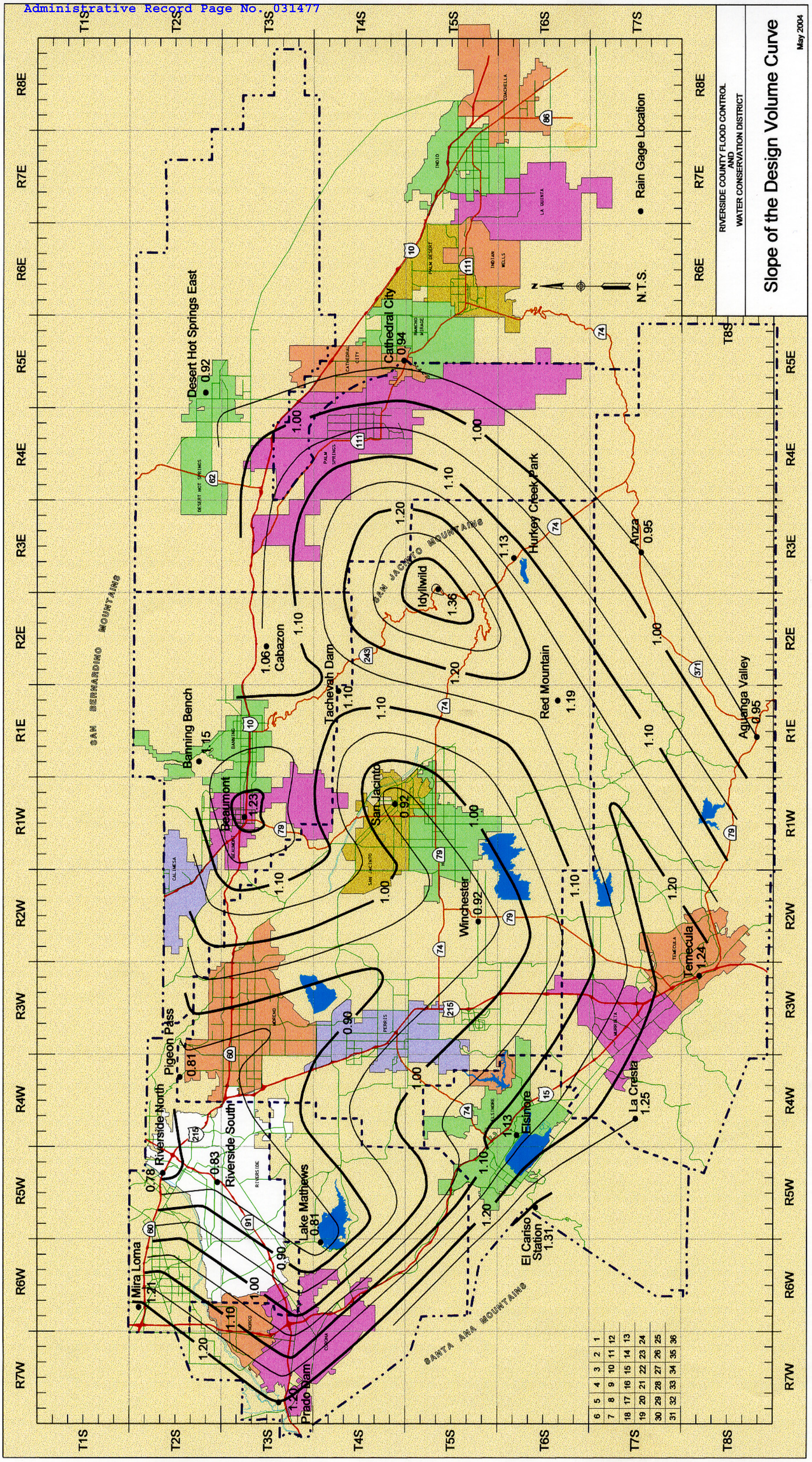
$Q_{BMP} = C \times I \times A_T$ Q_{BMP} = ft^3/s

Notes:

Effective Impervious Fraction

Developed Cover Types	Effective Impervious Fraction
Roofs	1.00
Concrete or Asphalt	1.00
Grouted or Gapless Paving Blocks	1.00
Compacted Soil (e.g. unpaved parking)	0.40
Decomposed Granite	0.40
Permeable Paving Blocks w/ Sand Filled Gap	0.25
Class 2 Base	0.30
Gravel or Class 2 Permeable Base	0.10
Pervious Concrete / Porous Asphalt	0.10
Open and Porous Pavers	0.10
Turf block	0.10
Ornamental Landscaping	0.10
Natural (A Soil)	0.03
Natural (B Soil)	0.15
Natural (C Soil)	0.30
Natural (D Soil)	0.40
Mixed Surface Types	

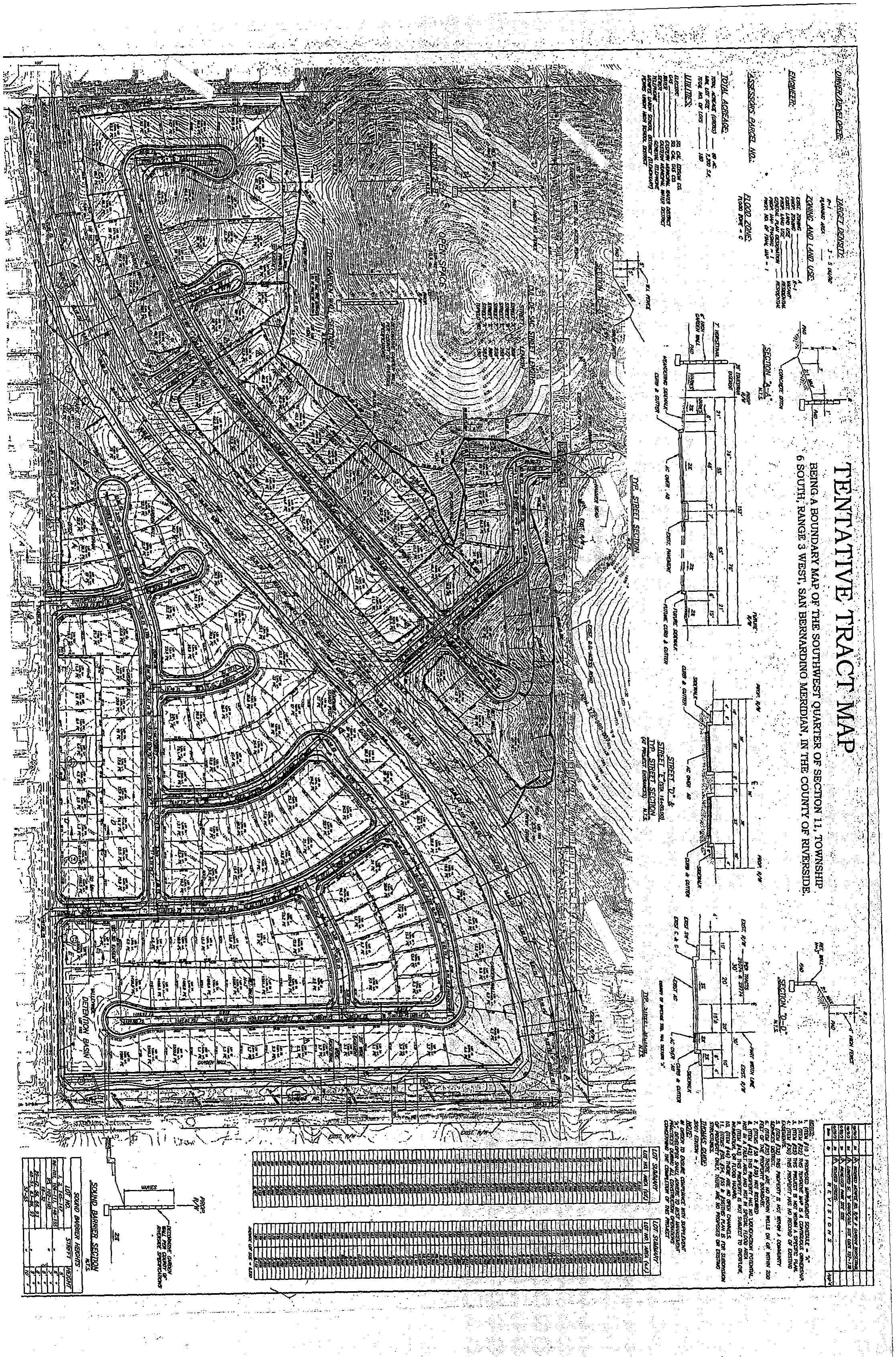
Use this table to determine the effective impervious fraction for the V_{BMP} and Q_{BMP} calculation sheets


RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
Slope of the Design Volume Curve
May 2004
Rain Gage Location
N.T.S.
SAN BERNARDINO MOUNTAINS
SAN JACINTO MOUNTAINS
SANTA ANA MOUNTAINS
Desert Hot Springs East 0.92
Cathedral City 0.94
Hurkey Creek Park 1.13
Anza 0.95
Idyllwild 1.36
Cabazon 1.06
Tachevah Dam 1.10
Red Mountain 1.19
Aguanga Valley 0.95
Banning Bench 1.15
Beaumont 1.23
San Jacinto 0.92
Winchester 0.92
Temecula 1.24
Pigeon Pass 0.81
La Cresta 1.25
Riverside North 0.78
Riverside South 0.83
Elsinore 1.13
Lake Mathews 0.81
El Cariso Station 1.31
Mira Loma 1.21
Prado Dam 1.20
T1S T2S T3S T4S T5S T6S T7S T8S
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E

Appendix B
Stormwater Quality Best Management Practice
Design Handbook

Grass Swale Example

Administrative Record Page No. 031479



Datasheet

Site Conditions:

A_{total} = 80 acres (from worksheet 2)
Q_{BMP} = 9.27 cfs (from worksheet 2)

Design Assumptions:

Swale Geometry:
Initially, some of the swale design parameters must be chosen within the ranges listed for the design criteria. Site constraints may influence some of these values. In this example the following assumptions were made:

Side slope z = 3:1 (maximum)
Channel slope s = 1% (2% maximum, 0.2% minimum)
Depth of flow D = 5" (5" maximum)

These values can be used in the Manning Equation to solve for the required channel width:

$Q_{BMP} = (1.49/n)\ AR^{2/3}\ s^{1/2}$

where A = cross sectional area (ft^2)
R = hydraulic radius (ft) = A/P
P = wetted perimeter (ft)
n = manning n value = 0.15 (standard)

Using Manning's Equation:

Swale bottom width b = 55 ft
Design flow velocity v = 0.4 fps

Design Length:
The design length is based on the following equation for a 7 minute minimum contact time:

L = (7 minutes) x (v) x (60 sec/min)
= 168 feet minimum

Vegetation:
Turf grass chosen as appropriate for the site.

Outflow Collection:
Grated inlet chosen as appropriate for the site.

Table 4. Runoff Coefficients for an Intensity = 0.2 $^{in}/_{hr}$ for Urban Soil Types*

Impervious %	A Soil RI =32	B Soil RI =56	C Soil RI =69	D Soil RI =75
0 (Natural)	0.06	0.15	0.24	0.31
5	0.10	0.18	0.28	0.35
10	0.15	0.23	0.33	0.40
15	0.19	0.27	0.37	0.44
20 (1-Acre)	0.24	0.29	0.38	0.41
25	0.27	0.35	0.43	0.49
30	0.32	0.38	0.46	0.51
35	0.35	0.41	0.47	0.51
40 (1/2-Acre)	0.40	0.45	0.50	0.53
45	0.44	0.48	0.52	0.55
50 (1/4-Acre)	0.49	0.53	0.55	0.59
55	0.53	0.57	0.58	0.62
60	0.57	0.61	0.62	0.66
65 (Condominiums)	0.61	0.65	0.65	0.77
70	0.65	0.69	0.70	0.76
75 (Mobilehomes)	0.69	0.71	0.73	0.75
80 (Apartments)	0.74	0.75	0.77	0.78
85	0.77	0.78	0.79	0.81
90 (Commercial)	0.82	0.83	0.83	0.84
95	0.86	0.86	0.87	0.88
100	0.90	0.90	0.90	0.90

*Complete District's standards can be found in the Riverside County Flood Control Hydrology Manual

Worksheet 2

Design Procedure Form for Design Flow

Uniform Intensity Design Flow

Designer:	**Benjie Cho**
Company:	**Riverside County Flood Control and Water Conservation District**
Date:	**3/1/04**
Project:	**BMP Example**
Location:	

1. Determine Impervious Percentage

a. Determine total tributary area	A_{total} =	**80**	acres	***(1)***
b. Determine Impervious %	i =	**50**	%	***(2)***

2. Determine Runoff Coefficient Values
   Use **Table 4** and impervious % found in step 1

a. A Soil Runoff Coefficient	C_a =	**.49**	***(3)***
b. B Soil Runoff Coefficient	C_b =	**.53**	***(4)***
c. C Soil Runoff Coefficient	C_c =	**.55**	***(5)***
d. D Soil Runoff Coefficient	C_d =	**.59**	***(6)***

3. Determine the Area decimal fraction of each soil type in tributary area

a. Area of A Soil / ***(1)*** =	A_a =	**-**	***(7)***
b. Area of B Soil / ***(1)*** =	A_b =	**-**	***(8)***
c. Area of C Soil / ***(1)*** =	A_c =	**.27**	***(9)***
d. Area of D Soil / ***(1)*** =	A_d =	**.73**	***(10)***

4. Determine Runoff Coefficient

a. C = ***(3)***x***(7)*** + ***(4)***x***(8)*** + ***(5)***x***(9)*** + ***(6)***x***(10)*** **=**	C =	**.579**	***(11)***

5. Determine BMP Design flow

a. Q_{BMP} = C x I x A = ***(11)*** x 0.2 x ***(1)***	Q_{BMP} =	**9.27**	$\frac{ft^3}{s}$	***(12)***

Worksheet 9

Design Procedure Form for Grassed Swale

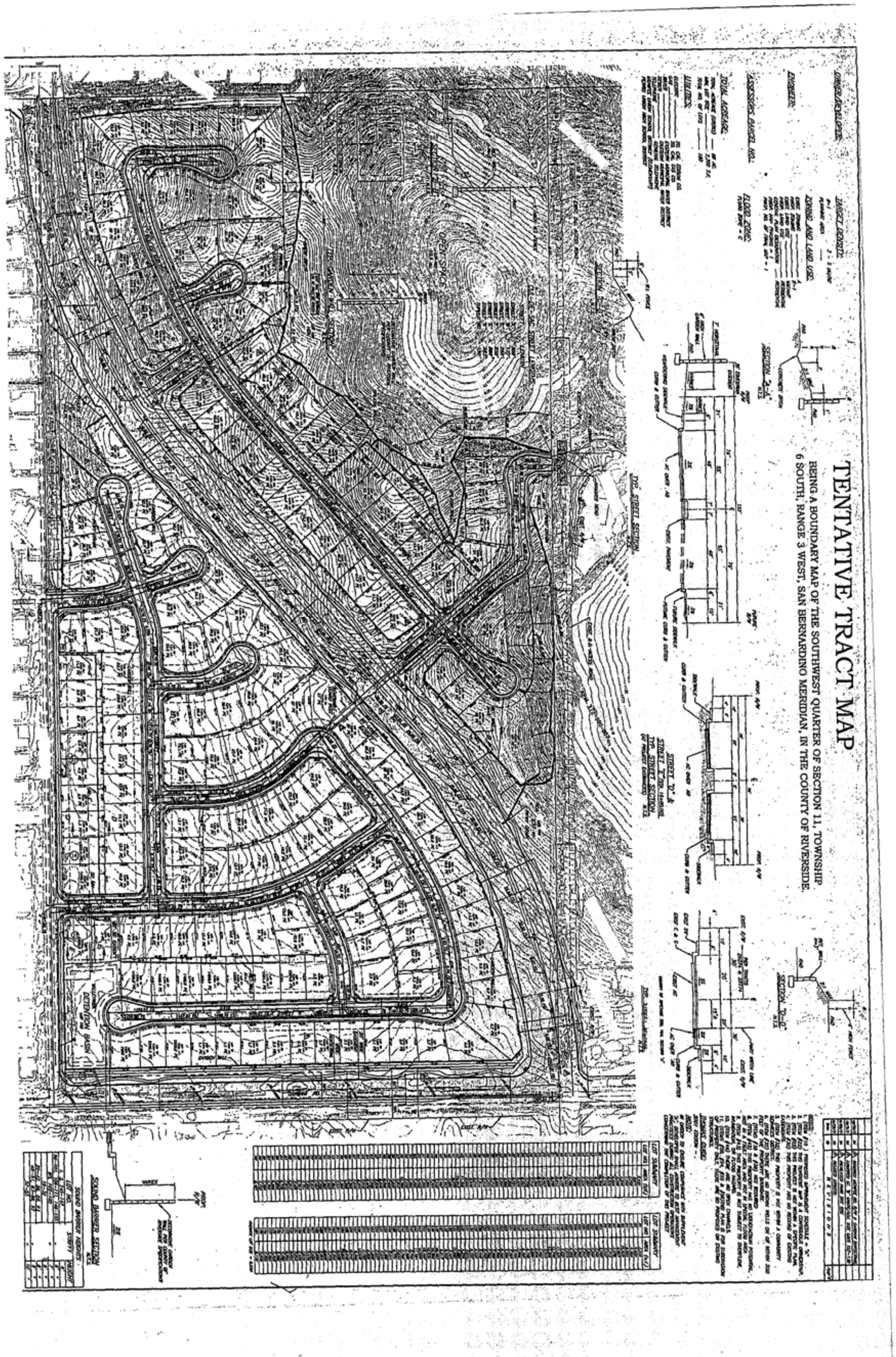
Designer: **Benjie Cho**
Company: **Riverside County Flood Control and Water Conservation District**
Date: **3/1/04**
Project: **BMP Example**
Location:

1. Determine Design Flow (Use Worksheet 2)	Q_{BMP} = **9.27** cfs
2. Swale Geometry a. Swale bottom width (b) b. Side slope (z) c. Flow direction slope (s)	 b = **55** ft z = **3:1** s = **1** %
3. Design flow velocity (Manning n = 0.2)	v = **0.4** ft/s
4. Depth of flow (D)	D = **0.42 (5")** ft
5. Design Length (L) L = (7 min) x (flow velocity, ft/sec) x 60	L = **168** ft
6. Vegetation (describe)	Turf Grass
1. Outflow Collection (check type used or describe "other")	**X** Grated Inlet' ___ Infiltration Trench ___ Underdrain ___ Other________

Notes:
Assuming a depth of 1 foot, this swale will require 0.222 acres of area.

Appendix B
Stormwater Quality Best Management Practice
Design Handbook

Extended Detention Basin Example


TENTATIVE TRACT MAP
BEING A BOUNDARY MAP OF THE SOUTHWEST QUARTER OF SECTION 11, TOWNSHIP
6 SOUTH, RANGE 3 WEST, SAN BERNARDINO MERIDIAN, IN THE COUNTY OF RIVERSIDE.

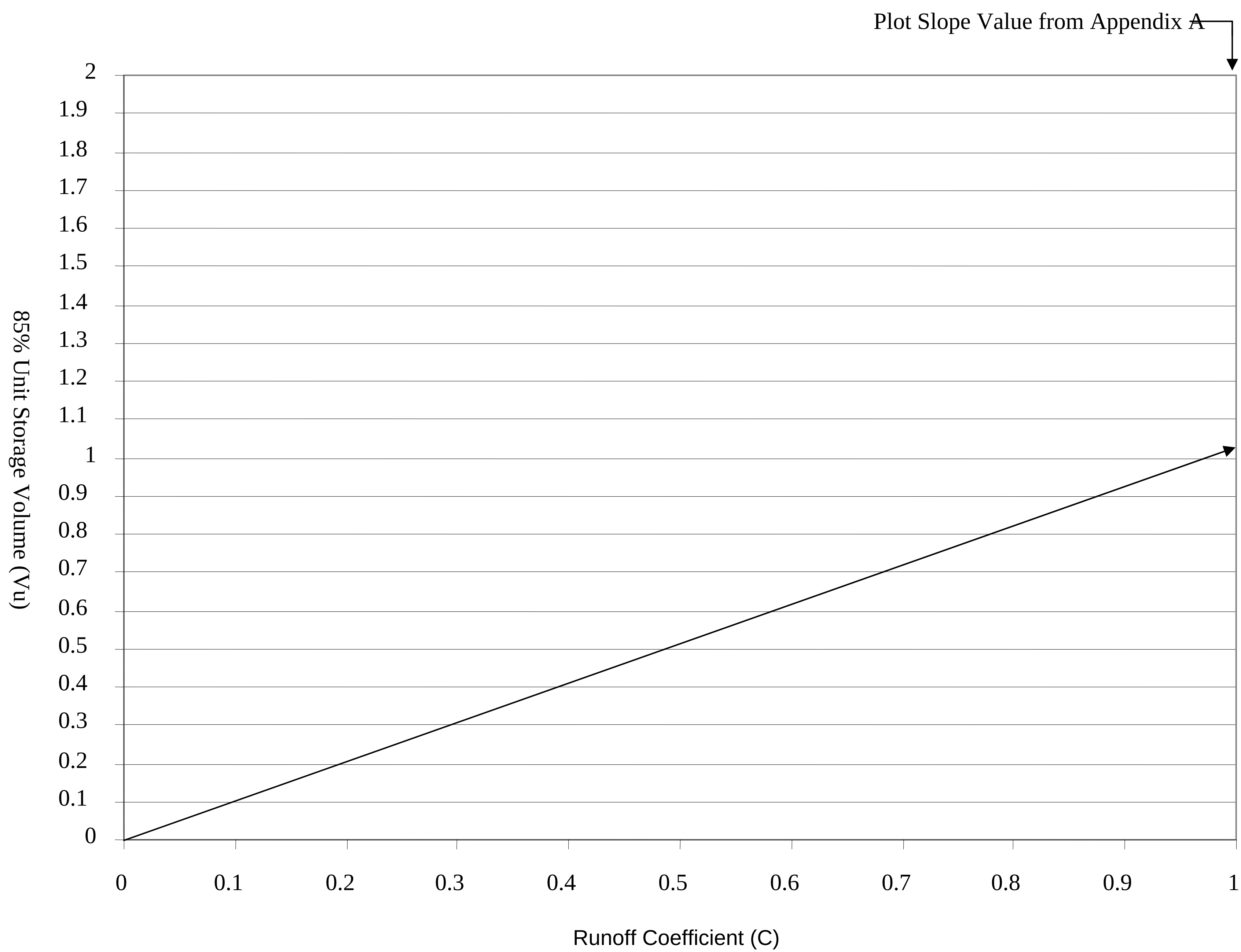


Figure 2 Unit Storage Volume Graph

Datasheet

Site Conditions:

A_{total} = 40 acres (from worksheet 1)
$V_{BMP} = 50820\ ft^3$ (from worksheet 1)
L:W Ratio = 2:1 (min 2:1, consider site constraints)
Basin depth = 4’ (min 3.5’, consider site constraints)

Design Assumptions:

In this example a rectangular basin shape was assumed for simplification. Actual volumes and dimensions will differ based on the configuration of the basin.

Two Stage Design (see Figure 3):
Based on the total depth (outlet to spillway) of 4’, set depth of each stage:
Upper Stage Depth = 2’ (2’ min)
Bottom Stage Depth = 2’ (1.5’ min)

Upper Stage:
The total basin volume must be greater than or equal to the design volume. The bottom stage will hold between 10 and 25 percent of the design volume. The top stage must therefore hold between 75 and 90 percent of the design volume. In this example, the top stage is designed to hold 90 percent of the design volume.

$L = 2 * W$
$0.9V_{BMP} = Depth * (2W^2)$
$45738 = 4*W^2$

W = 106.9’ → round to 110’
L = 220’
$Volume_{US} = 48400\ ft^2$

Bottom Stage:
The bottom stage must hold between 10 and 25 percent of the design volume.

At 10% → $0.1V_{BMP} = D_{Bottom} * W * L_{Bottom}$
$0.1(50820) = (2')*(110')* L_{Bottom}$
$L_{Bottom} = 23.1'$

At 25% → $0.25V_{BMP} = D_{Bottom} * W * L_{Bottom}$
$0.25(50820) = (2')*(110')* L_{Bottom}$
$L_{Bottom} = 57.8'$

Set L_{Bottom} = 30'
Volume$_{BS}$ = 6600 ft^3 (13% of V_{BMP})

Total Basin Volume check:
Volume$_{Basin}$ = $V_{BS} + V_{US}$ = 55000 ft^3 (108% V_{BMP}) $\geq$ V_{BMP} ok

Forebay Design:

In this example a cylindrical forebay shape was assumed for simplification.

Set forebay volume between 5 and 10 percent of the design volume:
$V_F = 0.1V_{BMP}$ = 5082 ft^3
Forebay should drain into low-flow channel in approximately 45 minutes or less. Standing water is not allowable.
Depth$_F$ = 0.8 ft (assumed)
Area$_F$ = (5082)/ depth = 6352.5 ft^2
Diameter$_F$ = SQRT((4* Area$_F$)/ π) = 89.9 → use 90'
For a 45 minute drain time:
Forebay Q_{out} = (5082 ft^3) / (45 min * 60 sec/min) = 1.9 ft^3/s
Size outlet accordingly

Low-flow Channel:

This example assumes a low flow channel depth. The capacity is based on a v-ditch channel at a 2% slope, with side slopes of 2:1. The capacity should be at least twice the forebay outlet rate.

Depth = 0.9 ft (min. 0.75 ft)
Flow capacity = 4.5 ft/s > (2 * Forebay Q_{OUT}) → ok

Basin Outlet:

The stage versus storage graph shows the volume of the proposed basin at various depths:

stage (ft)	storage (ft^3)	storage (acre-ft)
0	0	0.0000
0.5	1650	0.0379
1	3300	0.0758
1.5	4950	0.1136
2	6600	0.1515
2.5	18700	0.4293
3	30800	0.7071
3.5	42900	0.9848
4	55000	1.2626

In this example CivilD was used to route the design volume through the basin for various orifice sizes. After several iterations an appropriate orifice size was chosen of a 2.1-inch diameter. The CivilD program determined the outflow rate at each depth. Please see the attached printout for the routing.

stage (ft)	storage (ft^3)	storage (acre-ft)	Q_{OUT} (cfs)
0	0	0.0000	0.00
0.5	1650	0.0379	0.11
1	3300	0.0758	0.15
1.5	4950	0.1136	0.18
2	6600	0.1515	0.21
2.5	18700	0.4293	0.23
3	30800	0.7071	0.25
3.5	42900	0.9848	0.27
4	55000	1.2626	0.29

For this size orifice:

50% of the V_{BMP} has drained from the basin in 27 hours $\geq$ 24 hours → ok

After 27 hours
Volume Remaining = 0.581 acre-ft
WS Elevation = 2.77 ft

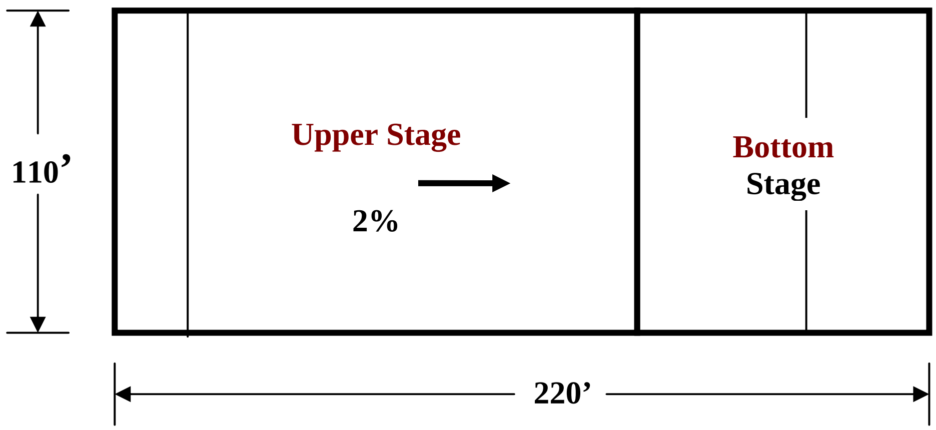
100% of the V_{BMP} has drained from the basin in 60 hours $\geq$ 48 hours
$<$ 72 hours → ok

After 60 hours
Volume Remaining = 0.03 acre-ft
WS Elevation = 0.45 ft

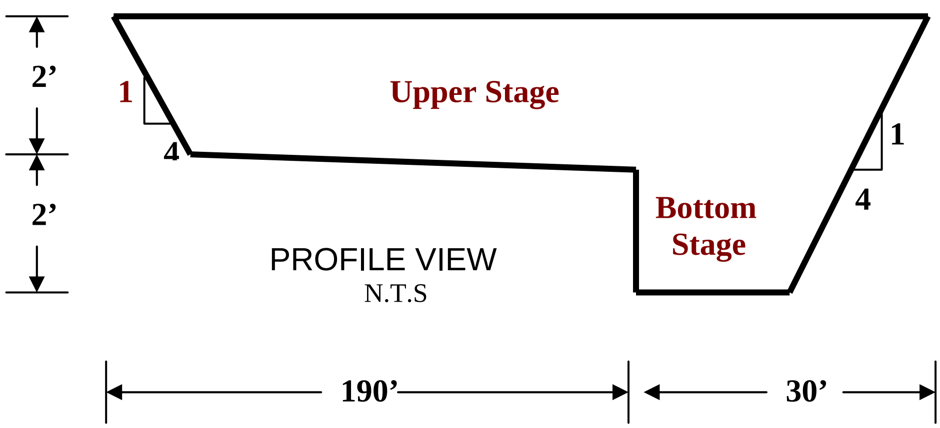
Vegetation:
Native grass chosen as appropriate for the site.

Embankment:
Maximum interior slope of 4:1 and maximum exterior slope of 3:1 chosen.

Access:
Maximum 10% slope and minimum 16' access roads chosen.



PLAN VIEW
N.T.S.



PROFILE VIEW
N.T.S

Worksheet 1

Design Procedure for BMP Design Volume

85th percentile runoff event

Designer:	**Benjie Cho**
Company:	**Riverside County Flood Control and Water Conservation District**
Date:	**3/1/04**
Project:	**BMP Example**
Location:	

Step	Value	Units	Ref.
1. Create Unit Storage Volume Graph			
a. Site location (Township, Range and Section)	T **6** &R **3** Section **11**		***(1)***
b. Slope value from the Design Volume Curve in **Appendix A**.	Slope = **1.03**		***(2)***
c. Plot this value on the Unit Storage Volume Graph shown on **Figure 2**.			
d. Draw a straight line form this point to the origin, to create the graph	Is this graph attached? Yes ☒ No ☐		
2. Determine Runoff Coefficient			
a. Determine total impervious area	$A_{impervious}$ = **20**	acres	***(5)***
b. Determine total tributary area	A_{total} = **40**	acres	***(6)***
c. Determine Impervious fraction i = ***(5)*** / ***(6)***	i = **.50**		***(7)***
d. Use ***(7)*** in **Figure 1** to find Runoff OR $C = .858i^3 - .78i^2 + .774i + .04$	C = **.34**		***(8)***
3. Determine 85% Unit Storage Volume			
a. Use ***(8)*** in **Figure 1** Draw a Vertical line from ***(8)*** to the graph, then a Horizontal line to the desired V_u value.	V_u = **.35**	in-acre / acre	***(9)***
4. Determine Design Storage Volume			
a. V_{BMP} = ***(9)*** x ***(6)*** [in- acres]	V_{BMP} = **14**	in-acre	***(10)***
b. V_{BMP} = ***(10)*** / 12 [ft- acres]	V_{BMP} = **1.17**	ft-acre	***(11)***
c. V_{BMP} = ***(11)*** x 43560 [ft^3]	V_{BMP} = **50820**	ft^3	***(12)***

Notes:

Worksheet 3

Design Procedure Form for Extended Detention Basin

Designer: Jennifer Otterson
Company: Riverside County Flood Control and Water Conservation District
Date: 3/2/04
Project: BMP Example
Location: Winchester/Antelope Valley Area

1. Determine Design Volume (Use Worksheet 1) a. Total Tributary Area (minimum 5 ac.) b. Design Volume, V_{BMP}	A_{total} = 40 acres V_{BMP} = 50820 ft^3
2. Basin Length to Width Ratio (2:1 min.)	Ratio = 2:1 L:W
3. Two-Stage Design a. Overall Design 1) Depth (3.5' min.) 2) Width (30' min.) 3) Length (60' min.) 4) Volume (must be ≥ V_{BMP}) b. Upper Stage 1) Depth (2' min.) 2) Bottom Slope (2% to low flow channel recommended) c. Bottom Stage 1) Depth (1.5' to 3') 2) Length 3) Volume (10 to 25% of V_{BMP})	Depth = 4 ft Width = 110 ft Length = 220 ft Volume = 55000 ft^3 Depth = 2 ft Slope = 2 % Depth = 2 ft Length = 30 ft Volume = 6600 (13%) ft^3
4. Forebay Design a. Forebay Volume (5 to 10% of V_{BMP}) b. Outlet pipe drainage time (≅ 45 min)	Volume = 5082 (10%) ft^3 Drain time = 45 minutes
5. Low-flow Channel a. Depth (9" minimum) b. Flow Capacity (2 * Forebay Q_{OUT})	Depth = 0.9 ft $Q_{Low\ Flow}$ = 4.5 cfs
6. Trash Rack or Gravel Pack (check one)	Trash Rack X Gravel Pack ____

7. Basin Outlet a. Outlet type (check one)	Single orifice __X__ Multi-orifice plate _____ Perforated Pipe _____ Other ____________________
b. Orifice Area c. Orifice Type d. Maximum Depth of water above bottom orifice e. Length of time for 50% V_{BMP} drainage (24 hour minimum) f. Length of time for 100% V_{BMP} drainage (between 48 and 72 hours) g. Attached Documents (all required) 1) Stage vs. Discharge 2) Stage vs. Volume 3) Inflow Hydrograph 4) Basin Routing	Area = 0.024 (2.1" Diameter) ft^2 Type __Pipe__ Depth = __3.8__ ft Time 50% = __27__ hrs Time 100% = __60__ hrs Attached Documents (check) 1) __X__ 2) __X__ 3) __X__ 4) __X__
8. Increased Runoff (optional) Is this basin also mitigating increased runoff? Attached Documents (all required) for 2, 5, & 10-year storms: 1) Stage vs. Discharge 2) Stage vs. Volume/Storage 3) Inflow Hydrograph 4) Basin Routing	Yes _______ No __X__ (if No, skip to #9) Attached Documents (check) 1) ________ 2) ________ 3) ________ 4) ________
9. Vegetation (check type)	__X__ Native Grasses _____ Irrigated Turf _____ Other ____________________
10. Embankment a. Interior slope (4:1 max.) b. Exterior slope (3:1 max.)	Interior Slope = __4:1__ Exterior Slope = __3:1__
11. Maintenance Access a. Slope (10% max.) b. Width (16 feet min.)	Slope = __10__ % Width = __16__ ft

FLOOD HYDROGRAPH ROUTING PROGRAM

Study date: 04/15/04

FOR OFFICIAL USE ONLY - Riverside County Offices - S/N 433

********************* HYDROGRAPH INFORMATION *********************

From study/file name: BMPexampl.rte
********************* Hydrograph Information **********************
From manual input hydrograph

***************************HYDROGRAPH DATA***************************
Number of intervals = 2
Time interval = 5.0 (Min.)
Maximum/Peak flow rate = 84.700 (CFS)
Total volume = 1.167 (Ac.Ft)
Status of hydrographs being held in storage

	Stream 1	Stream 2	Stream 3	Stream 4	Stream 5
Peak (CFS)	0.000	0.000	0.000	0.000	0.000
Vol (Ac.Ft)	0.000	0.000	0.000	0.000	0.000

****

++
Process from Point/Station 1.000 to Point/Station 2.000
**** RETARDING BASIN ROUTING ****

Program computation of outflow v. depth

CALCULATED OUTFLOW DATA AT DEPTH = 0.50(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)
Manning's N = 0.013 No. of pipes = 1
Given pipe size = 2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is 0.600(Ft.)
Pipe friction loss = 0.105(Ft.)
Minor friction loss = 0.495(Ft.) K-factor = 1.50
Calculated flow rate through pipe(s) = 0.111(CFS)

Total outflow at this depth = 0.11(CFS)

CALCULATED OUTFLOW DATA AT DEPTH = 1.00(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)

Manning's N = 0.013 No. of pipes = 1
Given pipe size = 2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is 1.100(Ft.)
Pipe friction loss = 0.193(Ft.)
Minor friction loss = 0.907(Ft.) K-factor = 1.50
Calculated flow rate through pipe(s) = 0.150(CFS)

Total outflow at this depth = 0.15(CFS)

CALCULATED OUTFLOW DATA AT DEPTH = 1.50(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)
Manning's N = 0.013 No. of pipes = 1
Given pipe size = 2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is 1.600(Ft.)
Pipe friction loss = 0.281(Ft.)
Minor friction loss = 1.320(Ft.) K-factor = 1.50
Calculated flow rate through pipe(s) = 0.181(CFS)

Total outflow at this depth = 0.18(CFS)

CALCULATED OUTFLOW DATA AT DEPTH = 2.00(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)
Manning's N = 0.013 No. of pipes = 1
Given pipe size = 2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is 2.100(Ft.)
Pipe friction loss = 0.369(Ft.)
Minor friction loss = 1.732(Ft.) K-factor = 1.50
Calculated flow rate through pipe(s) = 0.207(CFS)

Total outflow at this depth = 0.21(CFS)

CALCULATED OUTFLOW DATA AT DEPTH = 2.50(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)
Manning's N = 0.013 No. of pipes = 1
Given pipe size = 2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is 2.600(Ft.)
Pipe friction loss = 0.457(Ft.)
Minor friction loss = 2.144(Ft.) K-factor = 1.50
Calculated flow rate through pipe(s) = 0.231(CFS)

Total outflow at this depth = 0.23(CFS)

CALCULATED OUTFLOW DATA AT DEPTH = 3.00(Ft.))
Pipe length = 1.00(Ft.) Elevation difference = 0.10(Ft.)

Manning's N = 0.013   No. of pipes = 1
Given pipe size =   2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is   3.100(Ft.)
Pipe friction loss =   0.545(Ft.)
Minor friction loss =   2.557(Ft.)   K-factor =   1.50
Calculated flow rate through pipe(s) =   0.252(CFS)

Total outflow at this depth =   0.25(CFS)

CALCULATED OUTFLOW DATA AT DEPTH =   3.50(Ft.))
Pipe length =   1.00(Ft.)   Elevation difference =   0.10(Ft.)
Manning's N = 0.013   No. of pipes = 1
Given pipe size =   2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is   3.600(Ft.)
Pipe friction loss =   0.633(Ft.)
Minor friction loss =   2.969(Ft.)   K-factor =   1.50
Calculated flow rate through pipe(s) =   0.272(CFS)

Total outflow at this depth =   0.27(CFS)

CALCULATED OUTFLOW DATA AT DEPTH =   4.00(Ft.))
Pipe length =   1.00(Ft.)   Elevation difference =   0.10(Ft.)
Manning's N = 0.013   No. of pipes = 1
Given pipe size =   2.10(In.)
NOTE: Assuming free outlet flow.
NOTE: Normal flow is pressure flow.
The total friction loss through the pipe is   4.100(Ft.)
Pipe friction loss =   0.721(Ft.)
Minor friction loss =   3.381(Ft.)   K-factor =   1.50
Calculated flow rate through pipe(s) =   0.290(CFS)

Total outflow at this depth =   0.29(CFS)

Total number of inflow hydrograph intervals = 2
Hydrograph time unit = 5.000 (Min.)
Initial depth in storage basin =   0.00(Ft.)

Initial basin depth =   0.00 (Ft.)
Initial basin storage =   0.00 (Ac.Ft)
Initial basin outflow =   0.00 (CFS)

Depth vs. Storage and Depth vs. Discharge data:

Basin Depth (Ft.)	Storage (Ac.Ft)	Outflow (CFS)	(S-O*dt/2) (Ac.Ft)	(S+O*dt/2) (Ac.Ft)
0.000	0.000	0.000	0.000	0.000
0.500	0.038	0.111	0.038	0.038

1.000	0.076	0.150	0.075	0.077
1.500	0.114	0.181	0.113	0.115
2.000	0.152	0.207	0.151	0.153
2.500	0.429	0.231	0.428	0.430
3.000	0.707	0.252	0.706	0.708
3.500	0.985	0.272	0.984	0.986
4.000	1.263	0.290	1.262	1.264

Hydrograph Detention Basin Routing

Graph values: 'I'= unit inflow; 'O'=outflow at time shown

Time (Hours)	Inflow (CFS)	Outflow (CFS)	Storage (Ac.Ft)	.0 21.2 42.35 63.53 84.70	Depth (Ft.)
0.083	84.70	0.22	0.291	O | | | I	2.25
0.167	84.70	0.26	0.873	O | | | I	3.30
0.250	0.00	0.28	1.162	O | | | |	3.82
0.333	0.00	0.28	1.160	O | | | |	3.82
0.417	0.00	0.28	1.158	O | | | |	3.81
0.500	0.00	0.28	1.157	O | | | |	3.81
0.583	0.00	0.28	1.155	O | | | |	3.80
0.667	0.00	0.28	1.153	O | | | |	3.80
0.750	0.00	0.28	1.151	O | | | |	3.80
0.833	0.00	0.28	1.149	O | | | |	3.79
0.917	0.00	0.28	1.147	O | | | |	3.79
1.000	0.00	0.28	1.145	O | | | |	3.79
1.083	0.00	0.28	1.143	O | | | |	3.78
1.167	0.00	0.28	1.141	O | | | |	3.78
1.250	0.00	0.28	1.139	O | | | |	3.78
1.333	0.00	0.28	1.137	O | | | |	3.77
1.417	0.00	0.28	1.135	O | | | |	3.77
1.500	0.00	0.28	1.133	O | | | |	3.77
1.583	0.00	0.28	1.131	O | | | |	3.76
1.667	0.00	0.28	1.129	O | | | |	3.76
1.750	0.00	0.28	1.127	O | | | |	3.76
1.833	0.00	0.28	1.125	O | | | |	3.75
1.917	0.00	0.28	1.124	O | | | |	3.75
2.000	0.00	0.28	1.122	O | | | |	3.75
2.083	0.00	0.28	1.120	O | | | |	3.74
2.167	0.00	0.28	1.118	O | | | |	3.74
2.250	0.00	0.28	1.116	O | | | |	3.74
2.333	0.00	0.28	1.114	O | | | |	3.73
2.417	0.00	0.28	1.112	O | | | |	3.73
2.500	0.00	0.28	1.110	O | | | |	3.72
2.583	0.00	0.28	1.108	O | | | |	3.72
2.667	0.00	0.28	1.106	O | | | |	3.72
2.750	0.00	0.28	1.104	O | | | |	3.71
2.833	0.00	0.28	1.102	O | | | |	3.71
2.917	0.00	0.28	1.100	O | | | |	3.71
3.000	0.00	0.28	1.098	O | | | |	3.70
3.083	0.00	0.28	1.097	O | | | |	3.70
3.167	0.00	0.28	1.095	O | | | |	3.70
3.250	0.00	0.28	1.093	O | | | |	3.69
3.333	0.00	0.28	1.091	O | | | |	3.69
3.417	0.00	0.28	1.089	O | | | |	3.69

3.500	0.00	0.28	1.087	O	|	|	|	|	3.68
3.583	0.00	0.28	1.085	O	|	|	|	|	3.68
3.667	0.00	0.28	1.083	O	|	|	|	|	3.68
3.750	0.00	0.28	1.081	O	|	|	|	|	3.67
3.833	0.00	0.28	1.079	O	|	|	|	|	3.67
3.917	0.00	0.28	1.077	O	|	|	|	|	3.67
4.000	0.00	0.28	1.075	O	|	|	|	|	3.66
4.083	0.00	0.28	1.074	O	|	|	|	|	3.66
4.167	0.00	0.28	1.072	O	|	|	|	|	3.66
4.250	0.00	0.28	1.070	O	|	|	|	|	3.65
4.333	0.00	0.28	1.068	O	|	|	|	|	3.65
4.417	0.00	0.28	1.066	O	|	|	|	|	3.65
4.500	0.00	0.28	1.064	O	|	|	|	|	3.64
4.583	0.00	0.28	1.062	O	|	|	|	|	3.64
4.667	0.00	0.28	1.060	O	|	|	|	|	3.64
4.750	0.00	0.28	1.058	O	|	|	|	|	3.63
4.833	0.00	0.28	1.056	O	|	|	|	|	3.63
4.917	0.00	0.28	1.055	O	|	|	|	|	3.63
5.000	0.00	0.28	1.053	O	|	|	|	|	3.62
5.083	0.00	0.28	1.051	O	|	|	|	|	3.62
5.167	0.00	0.28	1.049	O	|	|	|	|	3.61
5.250	0.00	0.28	1.047	O	|	|	|	|	3.61
5.333	0.00	0.28	1.045	O	|	|	|	|	3.61
5.417	0.00	0.28	1.043	O	|	|	|	|	3.60
5.500	0.00	0.28	1.041	O	|	|	|	|	3.60
5.583	0.00	0.28	1.039	O	|	|	|	|	3.60
5.667	0.00	0.28	1.037	O	|	|	|	|	3.59
5.750	0.00	0.27	1.036	O	|	|	|	|	3.59
5.833	0.00	0.27	1.034	O	|	|	|	|	3.59
5.917	0.00	0.27	1.032	O	|	|	|	|	3.58
6.000	0.00	0.27	1.030	O	|	|	|	|	3.58
6.083	0.00	0.27	1.028	O	|	|	|	|	3.58
6.167	0.00	0.27	1.026	O	|	|	|	|	3.57
6.250	0.00	0.27	1.024	O	|	|	|	|	3.57
6.333	0.00	0.27	1.022	O	|	|	|	|	3.57
6.417	0.00	0.27	1.020	O	|	|	|	|	3.56
6.500	0.00	0.27	1.019	O	|	|	|	|	3.56
6.583	0.00	0.27	1.017	O	|	|	|	|	3.56
6.667	0.00	0.27	1.015	O	|	|	|	|	3.55
6.750	0.00	0.27	1.013	O	|	|	|	|	3.55
6.833	0.00	0.27	1.011	O	|	|	|	|	3.55
6.917	0.00	0.27	1.009	O	|	|	|	|	3.54
7.000	0.00	0.27	1.007	O	|	|	|	|	3.54
7.083	0.00	0.27	1.005	O	|	|	|	|	3.54
7.167	0.00	0.27	1.003	O	|	|	|	|	3.53
7.250	0.00	0.27	1.002	O	|	|	|	|	3.53
7.333	0.00	0.27	1.000	O	|	|	|	|	3.53
7.417	0.00	0.27	0.998	O	|	|	|	|	3.52
7.500	0.00	0.27	0.996	O	|	|	|	|	3.52
7.583	0.00	0.27	0.994	O	|	|	|	|	3.52
7.667	0.00	0.27	0.992	O	|	|	|	|	3.51
7.750	0.00	0.27	0.990	O	|	|	|	|	3.51
7.833	0.00	0.27	0.988	O	|	|	|	|	3.51
7.917	0.00	0.27	0.987	O	|	|	|	|	3.50
8.000	0.00	0.27	0.985	O	|	|	|	|	3.50
8.083	0.00	0.27	0.983	O	|	|	|	|	3.50

8.167	0.00	0.27	0.981	O	|	|	|	|	3.49
8.250	0.00	0.27	0.979	O	|	|	|	|	3.49
8.333	0.00	0.27	0.977	O	|	|	|	|	3.49
8.417	0.00	0.27	0.975	O	|	|	|	|	3.48
8.500	0.00	0.27	0.974	O	|	|	|	|	3.48
8.583	0.00	0.27	0.972	O	|	|	|	|	3.48
8.667	0.00	0.27	0.970	O	|	|	|	|	3.47
8.750	0.00	0.27	0.968	O	|	|	|	|	3.47
8.833	0.00	0.27	0.966	O	|	|	|	|	3.47
8.917	0.00	0.27	0.964	O	|	|	|	|	3.46
9.000	0.00	0.27	0.962	O	|	|	|	|	3.46
9.083	0.00	0.27	0.961	O	|	|	|	|	3.46
9.167	0.00	0.27	0.959	O	|	|	|	|	3.45
9.250	0.00	0.27	0.957	O	|	|	|	|	3.45
9.333	0.00	0.27	0.955	O	|	|	|	|	3.45
9.417	0.00	0.27	0.953	O	|	|	|	|	3.44
9.500	0.00	0.27	0.951	O	|	|	|	|	3.44
9.583	0.00	0.27	0.949	O	|	|	|	|	3.44
9.667	0.00	0.27	0.948	O	|	|	|	|	3.43
9.750	0.00	0.27	0.946	O	|	|	|	|	3.43
9.833	0.00	0.27	0.944	O	|	|	|	|	3.43
9.917	0.00	0.27	0.942	O	|	|	|	|	3.42
10.000	0.00	0.27	0.940	O	|	|	|	|	3.42
10.083	0.00	0.27	0.938	O	|	|	|	|	3.42
10.167	0.00	0.27	0.936	O	|	|	|	|	3.41
10.250	0.00	0.27	0.935	O	|	|	|	|	3.41
10.333	0.00	0.27	0.933	O	|	|	|	|	3.41
10.417	0.00	0.27	0.931	O	|	|	|	|	3.40
10.500	0.00	0.27	0.929	O	|	|	|	|	3.40
10.583	0.00	0.27	0.927	O	|	|	|	|	3.40
10.667	0.00	0.27	0.925	O	|	|	|	|	3.39
10.750	0.00	0.27	0.924	O	|	|	|	|	3.39
10.833	0.00	0.27	0.922	O	|	|	|	|	3.39
10.917	0.00	0.27	0.920	O	|	|	|	|	3.38
11.000	0.00	0.27	0.918	O	|	|	|	|	3.38
11.083	0.00	0.27	0.916	O	|	|	|	|	3.38
11.167	0.00	0.27	0.914	O	|	|	|	|	3.37
11.250	0.00	0.27	0.912	O	|	|	|	|	3.37
11.333	0.00	0.27	0.911	O	|	|	|	|	3.37
11.417	0.00	0.27	0.909	O	|	|	|	|	3.36
11.500	0.00	0.27	0.907	O	|	|	|	|	3.36
11.583	0.00	0.27	0.905	O	|	|	|	|	3.36
11.667	0.00	0.27	0.903	O	|	|	|	|	3.35
11.750	0.00	0.27	0.901	O	|	|	|	|	3.35
11.833	0.00	0.27	0.900	O	|	|	|	|	3.35
11.917	0.00	0.27	0.898	O	|	|	|	|	3.34
12.000	0.00	0.27	0.896	O	|	|	|	|	3.34
12.083	0.00	0.27	0.894	O	|	|	|	|	3.34
12.167	0.00	0.27	0.892	O	|	|	|	|	3.33
12.250	0.00	0.26	0.891	O	|	|	|	|	3.33
12.333	0.00	0.26	0.889	O	|	|	|	|	3.33
12.417	0.00	0.26	0.887	O	|	|	|	|	3.32
12.500	0.00	0.26	0.885	O	|	|	|	|	3.32
12.583	0.00	0.26	0.883	O	|	|	|	|	3.32
12.667	0.00	0.26	0.881	O	|	|	|	|	3.31
12.750	0.00	0.26	0.880	O	|	|	|	|	3.31

12.833	0.00	0.26	0.878	O	|	|	|	|	3.31
12.917	0.00	0.26	0.876	O	|	|	|	|	3.30
13.000	0.00	0.26	0.874	O	|	|	|	|	3.30
13.083	0.00	0.26	0.872	O	|	|	|	|	3.30
13.167	0.00	0.26	0.871	O	|	|	|	|	3.29
13.250	0.00	0.26	0.869	O	|	|	|	|	3.29
13.333	0.00	0.26	0.867	O	|	|	|	|	3.29
13.417	0.00	0.26	0.865	O	|	|	|	|	3.28
13.500	0.00	0.26	0.863	O	|	|	|	|	3.28
13.583	0.00	0.26	0.861	O	|	|	|	|	3.28
13.667	0.00	0.26	0.860	O	|	|	|	|	3.27
13.750	0.00	0.26	0.858	O	|	|	|	|	3.27
13.833	0.00	0.26	0.856	O	|	|	|	|	3.27
13.917	0.00	0.26	0.854	O	|	|	|	|	3.26
14.000	0.00	0.26	0.852	O	|	|	|	|	3.26
14.083	0.00	0.26	0.851	O	|	|	|	|	3.26
14.167	0.00	0.26	0.849	O	|	|	|	|	3.26
14.250	0.00	0.26	0.847	O	|	|	|	|	3.25
14.333	0.00	0.26	0.845	O	|	|	|	|	3.25
14.417	0.00	0.26	0.843	O	|	|	|	|	3.25
14.500	0.00	0.26	0.842	O	|	|	|	|	3.24
14.583	0.00	0.26	0.840	O	|	|	|	|	3.24
14.667	0.00	0.26	0.838	O	|	|	|	|	3.24
14.750	0.00	0.26	0.836	O	|	|	|	|	3.23
14.833	0.00	0.26	0.834	O	|	|	|	|	3.23
14.917	0.00	0.26	0.833	O	|	|	|	|	3.23
15.000	0.00	0.26	0.831	O	|	|	|	|	3.22
15.083	0.00	0.26	0.829	O	|	|	|	|	3.22
15.167	0.00	0.26	0.827	O	|	|	|	|	3.22
15.250	0.00	0.26	0.825	O	|	|	|	|	3.21
15.333	0.00	0.26	0.824	O	|	|	|	|	3.21
15.417	0.00	0.26	0.822	O	|	|	|	|	3.21
15.500	0.00	0.26	0.820	O	|	|	|	|	3.20
15.583	0.00	0.26	0.818	O	|	|	|	|	3.20
15.667	0.00	0.26	0.816	O	|	|	|	|	3.20
15.750	0.00	0.26	0.815	O	|	|	|	|	3.19
15.833	0.00	0.26	0.813	O	|	|	|	|	3.19
15.917	0.00	0.26	0.811	O	|	|	|	|	3.19
16.000	0.00	0.26	0.809	O	|	|	|	|	3.18
16.083	0.00	0.26	0.808	O	|	|	|	|	3.18
16.167	0.00	0.26	0.806	O	|	|	|	|	3.18
16.250	0.00	0.26	0.804	O	|	|	|	|	3.17
16.333	0.00	0.26	0.802	O	|	|	|	|	3.17
16.417	0.00	0.26	0.800	O	|	|	|	|	3.17
16.500	0.00	0.26	0.799	O	|	|	|	|	3.16
16.583	0.00	0.26	0.797	O	|	|	|	|	3.16
16.667	0.00	0.26	0.795	O	|	|	|	|	3.16
16.750	0.00	0.26	0.793	O	|	|	|	|	3.16
16.833	0.00	0.26	0.792	O	|	|	|	|	3.15
16.917	0.00	0.26	0.790	O	|	|	|	|	3.15
17.000	0.00	0.26	0.788	O	|	|	|	|	3.15
17.083	0.00	0.26	0.786	O	|	|	|	|	3.14
17.167	0.00	0.26	0.784	O	|	|	|	|	3.14
17.250	0.00	0.26	0.783	O	|	|	|	|	3.14
17.333	0.00	0.26	0.781	O	|	|	|	|	3.13
17.417	0.00	0.26	0.779	O	|	|	|	|	3.13

17.500	0.00	0.26	0.777	O	|	|	|	|	3.13
17.583	0.00	0.26	0.776	O	|	|	|	|	3.12
17.667	0.00	0.26	0.774	O	|	|	|	|	3.12
17.750	0.00	0.26	0.772	O	|	|	|	|	3.12
17.833	0.00	0.26	0.770	O	|	|	|	|	3.11
17.917	0.00	0.26	0.768	O	|	|	|	|	3.11
18.000	0.00	0.26	0.767	O	|	|	|	|	3.11
18.083	0.00	0.26	0.765	O	|	|	|	|	3.10
18.167	0.00	0.26	0.763	O	|	|	|	|	3.10
18.250	0.00	0.26	0.761	O	|	|	|	|	3.10
18.333	0.00	0.26	0.760	O	|	|	|	|	3.09
18.417	0.00	0.26	0.758	O	|	|	|	|	3.09
18.500	0.00	0.26	0.756	O	|	|	|	|	3.09
18.583	0.00	0.26	0.754	O	|	|	|	|	3.09
18.667	0.00	0.26	0.753	O	|	|	|	|	3.08
18.750	0.00	0.26	0.751	O	|	|	|	|	3.08
18.833	0.00	0.25	0.749	O	|	|	|	|	3.08
18.917	0.00	0.25	0.747	O	|	|	|	|	3.07
19.000	0.00	0.25	0.746	O	|	|	|	|	3.07
19.083	0.00	0.25	0.744	O	|	|	|	|	3.07
19.167	0.00	0.25	0.742	O	|	|	|	|	3.06
19.250	0.00	0.25	0.740	O	|	|	|	|	3.06
19.333	0.00	0.25	0.739	O	|	|	|	|	3.06
19.417	0.00	0.25	0.737	O	|	|	|	|	3.05
19.500	0.00	0.25	0.735	O	|	|	|	|	3.05
19.583	0.00	0.25	0.733	O	|	|	|	|	3.05
19.667	0.00	0.25	0.732	O	|	|	|	|	3.04
19.750	0.00	0.25	0.730	O	|	|	|	|	3.04
19.833	0.00	0.25	0.728	O	|	|	|	|	3.04
19.917	0.00	0.25	0.726	O	|	|	|	|	3.03
20.000	0.00	0.25	0.725	O	|	|	|	|	3.03
20.083	0.00	0.25	0.723	O	|	|	|	|	3.03
20.167	0.00	0.25	0.721	O	|	|	|	|	3.03
20.250	0.00	0.25	0.719	O	|	|	|	|	3.02
20.333	0.00	0.25	0.718	O	|	|	|	|	3.02
20.417	0.00	0.25	0.716	O	|	|	|	|	3.02
20.500	0.00	0.25	0.714	O	|	|	|	|	3.01
20.583	0.00	0.25	0.712	O	|	|	|	|	3.01
20.667	0.00	0.25	0.711	O	|	|	|	|	3.01
20.750	0.00	0.25	0.709	O	|	|	|	|	3.00
20.833	0.00	0.25	0.707	O	|	|	|	|	3.00
20.917	0.00	0.25	0.705	O	|	|	|	|	3.00
21.000	0.00	0.25	0.704	O	|	|	|	|	2.99
21.083	0.00	0.25	0.702	O	|	|	|	|	2.99
21.167	0.00	0.25	0.700	O	|	|	|	|	2.99
21.250	0.00	0.25	0.699	O	|	|	|	|	2.98
21.333	0.00	0.25	0.697	O	|	|	|	|	2.98
21.417	0.00	0.25	0.695	O	|	|	|	|	2.98
21.500	0.00	0.25	0.693	O	|	|	|	|	2.98
21.583	0.00	0.25	0.692	O	|	|	|	|	2.97
21.667	0.00	0.25	0.690	O	|	|	|	|	2.97
21.750	0.00	0.25	0.688	O	|	|	|	|	2.97
21.833	0.00	0.25	0.686	O	|	|	|	|	2.96
21.917	0.00	0.25	0.685	O	|	|	|	|	2.96
22.000	0.00	0.25	0.683	O	|	|	|	|	2.96
22.083	0.00	0.25	0.681	O	|	|	|	|	2.95

22.167	0.00	0.25	0.680	O	|	|	|	|	2.95
22.250	0.00	0.25	0.678	O	|	|	|	|	2.95
22.333	0.00	0.25	0.676	O	|	|	|	|	2.94
22.417	0.00	0.25	0.674	O	|	|	|	|	2.94
22.500	0.00	0.25	0.673	O	|	|	|	|	2.94
22.583	0.00	0.25	0.671	O	|	|	|	|	2.94
22.667	0.00	0.25	0.669	O	|	|	|	|	2.93
22.750	0.00	0.25	0.668	O	|	|	|	|	2.93
22.833	0.00	0.25	0.666	O	|	|	|	|	2.93
22.917	0.00	0.25	0.664	O	|	|	|	|	2.92
23.000	0.00	0.25	0.662	O	|	|	|	|	2.92
23.083	0.00	0.25	0.661	O	|	|	|	|	2.92
23.167	0.00	0.25	0.659	O	|	|	|	|	2.91
23.250	0.00	0.25	0.657	O	|	|	|	|	2.91
23.333	0.00	0.25	0.656	O	|	|	|	|	2.91
23.417	0.00	0.25	0.654	O	|	|	|	|	2.90
23.500	0.00	0.25	0.652	O	|	|	|	|	2.90
23.583	0.00	0.25	0.650	O	|	|	|	|	2.90
23.667	0.00	0.25	0.649	O	|	|	|	|	2.90
23.750	0.00	0.25	0.647	O	|	|	|	|	2.89
23.833	0.00	0.25	0.645	O	|	|	|	|	2.89
23.917	0.00	0.25	0.644	O	|	|	|	|	2.89
24.000	0.00	0.25	0.642	O	|	|	|	|	2.88
24.083	0.00	0.25	0.640	O	|	|	|	|	2.88
24.167	0.00	0.25	0.639	O	|	|	|	|	2.88
24.250	0.00	0.25	0.637	O	|	|	|	|	2.87
24.333	0.00	0.25	0.635	O	|	|	|	|	2.87
24.417	0.00	0.25	0.633	O	|	|	|	|	2.87
24.500	0.00	0.25	0.632	O	|	|	|	|	2.86
24.583	0.00	0.25	0.630	O	|	|	|	|	2.86
24.667	0.00	0.25	0.628	O	|	|	|	|	2.86
24.750	0.00	0.25	0.627	O	|	|	|	|	2.86
24.833	0.00	0.25	0.625	O	|	|	|	|	2.85
24.917	0.00	0.25	0.623	O	|	|	|	|	2.85
25.000	0.00	0.25	0.622	O	|	|	|	|	2.85
25.083	0.00	0.25	0.620	O	|	|	|	|	2.84
25.167	0.00	0.25	0.618	O	|	|	|	|	2.84
25.250	0.00	0.25	0.617	O	|	|	|	|	2.84
25.333	0.00	0.24	0.615	O	|	|	|	|	2.83
25.417	0.00	0.24	0.613	O	|	|	|	|	2.83
25.500	0.00	0.24	0.611	O	|	|	|	|	2.83
25.583	0.00	0.24	0.610	O	|	|	|	|	2.83
25.667	0.00	0.24	0.608	O	|	|	|	|	2.82
25.750	0.00	0.24	0.606	O	|	|	|	|	2.82
25.833	0.00	0.24	0.605	O	|	|	|	|	2.82
25.917	0.00	0.24	0.603	O	|	|	|	|	2.81
26.000	0.00	0.24	0.601	O	|	|	|	|	2.81
26.083	0.00	0.24	0.600	O	|	|	|	|	2.81
26.167	0.00	0.24	0.598	O	|	|	|	|	2.80
26.250	0.00	0.24	0.596	O	|	|	|	|	2.80
26.333	0.00	0.24	0.595	O	|	|	|	|	2.80
26.417	0.00	0.24	0.593	O	|	|	|	|	2.79
26.500	0.00	0.24	0.591	O	|	|	|	|	2.79
26.583	0.00	0.24	0.590	O	|	|	|	|	2.79
26.667	0.00	0.24	0.588	O	|	|	|	|	2.79
26.750	0.00	0.24	0.586	O	|	|	|	|	2.78

26.833	0.00	0.24	0.585	O					2.78
26.917	0.00	0.24	0.583	O					2.78
27.000	0.00	0.24	0.581	O					2.77
27.083	0.00	0.24	0.580	O					2.77
27.167	0.00	0.24	0.578	O					2.77
27.250	0.00	0.24	0.576	O					2.76
27.333	0.00	0.24	0.575	O					2.76
27.417	0.00	0.24	0.573	O					2.76
27.500	0.00	0.24	0.571	O					2.76
27.583	0.00	0.24	0.570	O					2.75
27.667	0.00	0.24	0.568	O					2.75
27.750	0.00	0.24	0.566	O					2.75
27.833	0.00	0.24	0.565	O					2.74
27.917	0.00	0.24	0.563	O					2.74
28.000	0.00	0.24	0.561	O					2.74
28.083	0.00	0.24	0.560	O					2.73
28.167	0.00	0.24	0.558	O					2.73
28.250	0.00	0.24	0.556	O					2.73
28.333	0.00	0.24	0.555	O					2.73
28.417	0.00	0.24	0.553	O					2.72
28.500	0.00	0.24	0.551	O					2.72
28.583	0.00	0.24	0.550	O					2.72
28.667	0.00	0.24	0.548	O					2.71
28.750	0.00	0.24	0.546	O					2.71
28.833	0.00	0.24	0.545	O					2.71
28.917	0.00	0.24	0.543	O					2.71
29.000	0.00	0.24	0.541	O					2.70
29.083	0.00	0.24	0.540	O					2.70
29.167	0.00	0.24	0.538	O					2.70
29.250	0.00	0.24	0.536	O					2.69
29.333	0.00	0.24	0.535	O					2.69
29.417	0.00	0.24	0.533	O					2.69
29.500	0.00	0.24	0.532	O					2.68
29.583	0.00	0.24	0.530	O					2.68
29.667	0.00	0.24	0.528	O					2.68
29.750	0.00	0.24	0.527	O					2.68
29.833	0.00	0.24	0.525	O					2.67
29.917	0.00	0.24	0.523	O					2.67
30.000	0.00	0.24	0.522	O					2.67
30.083	0.00	0.24	0.520	O					2.66
30.167	0.00	0.24	0.518	O					2.66
30.250	0.00	0.24	0.517	O					2.66
30.333	0.00	0.24	0.515	O					2.65
30.417	0.00	0.24	0.514	O					2.65
30.500	0.00	0.24	0.512	O					2.65
30.583	0.00	0.24	0.510	O					2.65
30.667	0.00	0.24	0.509	O					2.64
30.750	0.00	0.24	0.507	O					2.64
30.833	0.00	0.24	0.505	O					2.64
30.917	0.00	0.24	0.504	O					2.63
31.000	0.00	0.24	0.502	O					2.63
31.083	0.00	0.24	0.500	O					2.63
31.167	0.00	0.24	0.499	O					2.63
31.250	0.00	0.24	0.497	O					2.62
31.333	0.00	0.24	0.496	O					2.62
31.417	0.00	0.24	0.494	O					2.62

31.500	0.00	0.24	0.492	O	|	|	|	|	2.61
31.583	0.00	0.24	0.491	O	|	|	|	|	2.61
31.667	0.00	0.24	0.489	O	|	|	|	|	2.61
31.750	0.00	0.24	0.488	O	|	|	|	|	2.61
31.833	0.00	0.24	0.486	O	|	|	|	|	2.60
31.917	0.00	0.23	0.484	O	|	|	|	|	2.60
32.000	0.00	0.23	0.483	O	|	|	|	|	2.60
32.083	0.00	0.23	0.481	O	|	|	|	|	2.59
32.167	0.00	0.23	0.479	O	|	|	|	|	2.59
32.250	0.00	0.23	0.478	O	|	|	|	|	2.59
32.333	0.00	0.23	0.476	O	|	|	|	|	2.58
32.417	0.00	0.23	0.475	O	|	|	|	|	2.58
32.500	0.00	0.23	0.473	O	|	|	|	|	2.58
32.583	0.00	0.23	0.471	O	|	|	|	|	2.58
32.667	0.00	0.23	0.470	O	|	|	|	|	2.57
32.750	0.00	0.23	0.468	O	|	|	|	|	2.57
32.833	0.00	0.23	0.467	O	|	|	|	|	2.57
32.917	0.00	0.23	0.465	O	|	|	|	|	2.56
33.000	0.00	0.23	0.463	O	|	|	|	|	2.56
33.083	0.00	0.23	0.462	O	|	|	|	|	2.56
33.167	0.00	0.23	0.460	O	|	|	|	|	2.56
33.250	0.00	0.23	0.458	O	|	|	|	|	2.55
33.333	0.00	0.23	0.457	O	|	|	|	|	2.55
33.417	0.00	0.23	0.455	O	|	|	|	|	2.55
33.500	0.00	0.23	0.454	O	|	|	|	|	2.54
33.583	0.00	0.23	0.452	O	|	|	|	|	2.54
33.667	0.00	0.23	0.450	O	|	|	|	|	2.54
33.750	0.00	0.23	0.449	O	|	|	|	|	2.54
33.833	0.00	0.23	0.447	O	|	|	|	|	2.53
33.917	0.00	0.23	0.446	O	|	|	|	|	2.53
34.000	0.00	0.23	0.444	O	|	|	|	|	2.53
34.083	0.00	0.23	0.442	O	|	|	|	|	2.52
34.167	0.00	0.23	0.441	O	|	|	|	|	2.52
34.250	0.00	0.23	0.439	O	|	|	|	|	2.52
34.333	0.00	0.23	0.438	O	|	|	|	|	2.52
34.417	0.00	0.23	0.436	O	|	|	|	|	2.51
34.500	0.00	0.23	0.435	O	|	|	|	|	2.51
34.583	0.00	0.23	0.433	O	|	|	|	|	2.51
34.667	0.00	0.23	0.431	O	|	|	|	|	2.50
34.750	0.00	0.23	0.430	O	|	|	|	|	2.50
34.833	0.00	0.23	0.428	O	|	|	|	|	2.50
34.917	0.00	0.23	0.427	O	|	|	|	|	2.50
35.000	0.00	0.23	0.425	O	|	|	|	|	2.49
35.083	0.00	0.23	0.423	O	|	|	|	|	2.49
35.167	0.00	0.23	0.422	O	|	|	|	|	2.49
35.250	0.00	0.23	0.420	O	|	|	|	|	2.48
35.333	0.00	0.23	0.419	O	|	|	|	|	2.48
35.417	0.00	0.23	0.417	O	|	|	|	|	2.48
35.500	0.00	0.23	0.415	O	|	|	|	|	2.48
35.583	0.00	0.23	0.414	O	|	|	|	|	2.47
35.667	0.00	0.23	0.412	O	|	|	|	|	2.47
35.750	0.00	0.23	0.411	O	|	|	|	|	2.47
35.833	0.00	0.23	0.409	O	|	|	|	|	2.46
35.917	0.00	0.23	0.408	O	|	|	|	|	2.46
36.000	0.00	0.23	0.406	O	|	|	|	|	2.46
36.083	0.00	0.23	0.404	O	|	|	|	|	2.46

36.167	0.00	0.23	0.403	O	|	|	|	|	2.45
36.250	0.00	0.23	0.401	O	|	|	|	|	2.45
36.333	0.00	0.23	0.400	O	|	|	|	|	2.45
36.417	0.00	0.23	0.398	O	|	|	|	|	2.44
36.500	0.00	0.23	0.397	O	|	|	|	|	2.44
36.583	0.00	0.23	0.395	O	|	|	|	|	2.44
36.667	0.00	0.23	0.393	O	|	|	|	|	2.44
36.750	0.00	0.23	0.392	O	|	|	|	|	2.43
36.833	0.00	0.23	0.390	O	|	|	|	|	2.43
36.917	0.00	0.23	0.389	O	|	|	|	|	2.43
37.000	0.00	0.23	0.387	O	|	|	|	|	2.42
37.083	0.00	0.23	0.386	O	|	|	|	|	2.42
37.167	0.00	0.23	0.384	O	|	|	|	|	2.42
37.250	0.00	0.23	0.382	O	|	|	|	|	2.42
37.333	0.00	0.23	0.381	O	|	|	|	|	2.41
37.417	0.00	0.23	0.379	O	|	|	|	|	2.41
37.500	0.00	0.23	0.378	O	|	|	|	|	2.41
37.583	0.00	0.23	0.376	O	|	|	|	|	2.40
37.667	0.00	0.23	0.375	O	|	|	|	|	2.40
37.750	0.00	0.23	0.373	O	|	|	|	|	2.40
37.833	0.00	0.23	0.372	O	|	|	|	|	2.40
37.917	0.00	0.23	0.370	O	|	|	|	|	2.39
38.000	0.00	0.23	0.368	O	|	|	|	|	2.39
38.083	0.00	0.23	0.367	O	|	|	|	|	2.39
38.167	0.00	0.23	0.365	O	|	|	|	|	2.39
38.250	0.00	0.23	0.364	O	|	|	|	|	2.38
38.333	0.00	0.23	0.362	O	|	|	|	|	2.38
38.417	0.00	0.23	0.361	O	|	|	|	|	2.38
38.500	0.00	0.22	0.359	O	|	|	|	|	2.37
38.583	0.00	0.22	0.358	O	|	|	|	|	2.37
38.667	0.00	0.22	0.356	O	|	|	|	|	2.37
38.750	0.00	0.22	0.354	O	|	|	|	|	2.37
38.833	0.00	0.22	0.353	O	|	|	|	|	2.36
38.917	0.00	0.22	0.351	O	|	|	|	|	2.36
39.000	0.00	0.22	0.350	O	|	|	|	|	2.36
39.083	0.00	0.22	0.348	O	|	|	|	|	2.35
39.167	0.00	0.22	0.347	O	|	|	|	|	2.35
39.250	0.00	0.22	0.345	O	|	|	|	|	2.35
39.333	0.00	0.22	0.344	O	|	|	|	|	2.35
39.417	0.00	0.22	0.342	O	|	|	|	|	2.34
39.500	0.00	0.22	0.341	O	|	|	|	|	2.34
39.583	0.00	0.22	0.339	O	|	|	|	|	2.34
39.667	0.00	0.22	0.338	O	|	|	|	|	2.33
39.750	0.00	0.22	0.336	O	|	|	|	|	2.33
39.833	0.00	0.22	0.334	O	|	|	|	|	2.33
39.917	0.00	0.22	0.333	O	|	|	|	|	2.33
40.000	0.00	0.22	0.331	O	|	|	|	|	2.32
40.083	0.00	0.22	0.330	O	|	|	|	|	2.32
40.167	0.00	0.22	0.328	O	|	|	|	|	2.32
40.250	0.00	0.22	0.327	O	|	|	|	|	2.32
40.333	0.00	0.22	0.325	O	|	|	|	|	2.31
40.417	0.00	0.22	0.324	O	|	|	|	|	2.31
40.500	0.00	0.22	0.322	O	|	|	|	|	2.31
40.583	0.00	0.22	0.321	O	|	|	|	|	2.30
40.667	0.00	0.22	0.319	O	|	|	|	|	2.30
40.750	0.00	0.22	0.318	O	|	|	|	|	2.30

40.833	0.00	0.22	0.316	O	|	|	|	|	2.30
40.917	0.00	0.22	0.315	O	|	|	|	|	2.29
41.000	0.00	0.22	0.313	O	|	|	|	|	2.29
41.083	0.00	0.22	0.312	O	|	|	|	|	2.29
41.167	0.00	0.22	0.310	O	|	|	|	|	2.29
41.250	0.00	0.22	0.308	O	|	|	|	|	2.28
41.333	0.00	0.22	0.307	O	|	|	|	|	2.28
41.417	0.00	0.22	0.305	O	|	|	|	|	2.28
41.500	0.00	0.22	0.304	O	|	|	|	|	2.27
41.583	0.00	0.22	0.302	O	|	|	|	|	2.27
41.667	0.00	0.22	0.301	O	|	|	|	|	2.27
41.750	0.00	0.22	0.299	O	|	|	|	|	2.27
41.833	0.00	0.22	0.298	O	|	|	|	|	2.26
41.917	0.00	0.22	0.296	O	|	|	|	|	2.26
42.000	0.00	0.22	0.295	O	|	|	|	|	2.26
42.083	0.00	0.22	0.293	O	|	|	|	|	2.26
42.167	0.00	0.22	0.292	O	|	|	|	|	2.25
42.250	0.00	0.22	0.290	O	|	|	|	|	2.25
42.333	0.00	0.22	0.289	O	|	|	|	|	2.25
42.417	0.00	0.22	0.287	O	|	|	|	|	2.24
42.500	0.00	0.22	0.286	O	|	|	|	|	2.24
42.583	0.00	0.22	0.284	O	|	|	|	|	2.24
42.667	0.00	0.22	0.283	O	|	|	|	|	2.24
42.750	0.00	0.22	0.281	O	|	|	|	|	2.23
42.833	0.00	0.22	0.280	O	|	|	|	|	2.23
42.917	0.00	0.22	0.278	O	|	|	|	|	2.23
43.000	0.00	0.22	0.277	O	|	|	|	|	2.23
43.083	0.00	0.22	0.275	O	|	|	|	|	2.22
43.167	0.00	0.22	0.274	O	|	|	|	|	2.22
43.250	0.00	0.22	0.272	O	|	|	|	|	2.22
43.333	0.00	0.22	0.271	O	|	|	|	|	2.21
43.417	0.00	0.22	0.269	O	|	|	|	|	2.21
43.500	0.00	0.22	0.268	O	|	|	|	|	2.21
43.583	0.00	0.22	0.266	O	|	|	|	|	2.21
43.667	0.00	0.22	0.265	O	|	|	|	|	2.20
43.750	0.00	0.22	0.263	O	|	|	|	|	2.20
43.833	0.00	0.22	0.262	O	|	|	|	|	2.20
43.917	0.00	0.22	0.260	O	|	|	|	|	2.20
44.000	0.00	0.22	0.259	O	|	|	|	|	2.19
44.083	0.00	0.22	0.257	O	|	|	|	|	2.19
44.167	0.00	0.22	0.256	O	|	|	|	|	2.19
44.250	0.00	0.22	0.254	O	|	|	|	|	2.18
44.333	0.00	0.22	0.253	O	|	|	|	|	2.18
44.417	0.00	0.22	0.251	O	|	|	|	|	2.18
44.500	0.00	0.22	0.250	O	|	|	|	|	2.18
44.583	0.00	0.22	0.248	O	|	|	|	|	2.17
44.667	0.00	0.22	0.247	O	|	|	|	|	2.17
44.750	0.00	0.22	0.245	O	|	|	|	|	2.17
44.833	0.00	0.22	0.244	O	|	|	|	|	2.17
44.917	0.00	0.22	0.242	O	|	|	|	|	2.16
45.000	0.00	0.21	0.241	O	|	|	|	|	2.16
45.083	0.00	0.21	0.240	O	|	|	|	|	2.16
45.167	0.00	0.21	0.238	O	|	|	|	|	2.16
45.250	0.00	0.21	0.237	O	|	|	|	|	2.15
45.333	0.00	0.21	0.235	O	|	|	|	|	2.15
45.417	0.00	0.21	0.234	O	|	|	|	|	2.15

45.500	0.00	0.21	0.232	O	|	|	|	|	2.14
45.583	0.00	0.21	0.231	O	|	|	|	|	2.14
45.667	0.00	0.21	0.229	O	|	|	|	|	2.14
45.750	0.00	0.21	0.228	O	|	|	|	|	2.14
45.833	0.00	0.21	0.226	O	|	|	|	|	2.13
45.917	0.00	0.21	0.225	O	|	|	|	|	2.13
46.000	0.00	0.21	0.223	O	|	|	|	|	2.13
46.083	0.00	0.21	0.222	O	|	|	|	|	2.13
46.167	0.00	0.21	0.220	O	|	|	|	|	2.12
46.250	0.00	0.21	0.219	O	|	|	|	|	2.12
46.333	0.00	0.21	0.217	O	|	|	|	|	2.12
46.417	0.00	0.21	0.216	O	|	|	|	|	2.12
46.500	0.00	0.21	0.215	O	|	|	|	|	2.11
46.583	0.00	0.21	0.213	O	|	|	|	|	2.11
46.667	0.00	0.21	0.212	O	|	|	|	|	2.11
46.750	0.00	0.21	0.210	O	|	|	|	|	2.10
46.833	0.00	0.21	0.209	O	|	|	|	|	2.10
46.917	0.00	0.21	0.207	O	|	|	|	|	2.10
47.000	0.00	0.21	0.206	O	|	|	|	|	2.10
47.083	0.00	0.21	0.204	O	|	|	|	|	2.09
47.167	0.00	0.21	0.203	O	|	|	|	|	2.09
47.250	0.00	0.21	0.201	O	|	|	|	|	2.09
47.333	0.00	0.21	0.200	O	|	|	|	|	2.09
47.417	0.00	0.21	0.198	O	|	|	|	|	2.08
47.500	0.00	0.21	0.197	O	|	|	|	|	2.08
47.583	0.00	0.21	0.196	O	|	|	|	|	2.08
47.667	0.00	0.21	0.194	O	|	|	|	|	2.08
47.750	0.00	0.21	0.193	O	|	|	|	|	2.07
47.833	0.00	0.21	0.191	O	|	|	|	|	2.07
47.917	0.00	0.21	0.190	O	|	|	|	|	2.07
48.000	0.00	0.21	0.188	O	|	|	|	|	2.07
48.083	0.00	0.21	0.187	O	|	|	|	|	2.06
48.167	0.00	0.21	0.185	O	|	|	|	|	2.06
48.250	0.00	0.21	0.184	O	|	|	|	|	2.06
48.333	0.00	0.21	0.182	O	|	|	|	|	2.06
48.417	0.00	0.21	0.181	O	|	|	|	|	2.05
48.500	0.00	0.21	0.180	O	|	|	|	|	2.05
48.583	0.00	0.21	0.178	O	|	|	|	|	2.05
48.667	0.00	0.21	0.177	O	|	|	|	|	2.04
48.750	0.00	0.21	0.175	O	|	|	|	|	2.04
48.833	0.00	0.21	0.174	O	|	|	|	|	2.04
48.917	0.00	0.21	0.172	O	|	|	|	|	2.04
49.000	0.00	0.21	0.171	O	|	|	|	|	2.03
49.083	0.00	0.21	0.170	O	|	|	|	|	2.03
49.167	0.00	0.21	0.168	O	|	|	|	|	2.03
49.250	0.00	0.21	0.167	O	|	|	|	|	2.03
49.333	0.00	0.21	0.165	O	|	|	|	|	2.02
49.417	0.00	0.21	0.164	O	|	|	|	|	2.02
49.500	0.00	0.21	0.162	O	|	|	|	|	2.02
49.583	0.00	0.21	0.161	O	|	|	|	|	2.02
49.667	0.00	0.21	0.159	O	|	|	|	|	2.01
49.750	0.00	0.21	0.158	O	|	|	|	|	2.01
49.833	0.00	0.21	0.157	O	|	|	|	|	2.01
49.917	0.00	0.21	0.155	O	|	|	|	|	2.01
50.000	0.00	0.21	0.154	O	|	|	|	|	2.00
50.083	0.00	0.21	0.152	O	|	|	|	|	2.00

50.167	0.00	0.21	0.151	O	|	|	|	|	1.99
50.250	0.00	0.21	0.149	O	|	|	|	|	1.97
50.333	0.00	0.20	0.148	O	|	|	|	|	1.95
50.417	0.00	0.20	0.147	O	|	|	|	|	1.93
50.500	0.00	0.20	0.145	O	|	|	|	|	1.91
50.583	0.00	0.20	0.144	O	|	|	|	|	1.89
50.667	0.00	0.20	0.142	O	|	|	|	|	1.87
50.750	0.00	0.20	0.141	O	|	|	|	|	1.86
50.833	0.00	0.20	0.140	O	|	|	|	|	1.84
50.917	0.00	0.20	0.138	O	|	|	|	|	1.82
51.000	0.00	0.20	0.137	O	|	|	|	|	1.80
51.083	0.00	0.20	0.136	O	|	|	|	|	1.78
51.167	0.00	0.20	0.134	O	|	|	|	|	1.77
51.250	0.00	0.19	0.133	O	|	|	|	|	1.75
51.333	0.00	0.19	0.132	O	|	|	|	|	1.73
51.417	0.00	0.19	0.130	O	|	|	|	|	1.71
51.500	0.00	0.19	0.129	O	|	|	|	|	1.70
51.583	0.00	0.19	0.128	O	|	|	|	|	1.68
51.667	0.00	0.19	0.126	O	|	|	|	|	1.66
51.750	0.00	0.19	0.125	O	|	|	|	|	1.65
51.833	0.00	0.19	0.124	O	|	|	|	|	1.63
51.917	0.00	0.19	0.122	O	|	|	|	|	1.61
52.000	0.00	0.19	0.121	O	|	|	|	|	1.59
52.083	0.00	0.19	0.120	O	|	|	|	|	1.58
52.167	0.00	0.18	0.119	O	|	|	|	|	1.56
52.250	0.00	0.18	0.117	O	|	|	|	|	1.54
52.333	0.00	0.18	0.116	O	|	|	|	|	1.53
52.417	0.00	0.18	0.115	O	|	|	|	|	1.51
52.500	0.00	0.18	0.114	O	|	|	|	|	1.49
52.583	0.00	0.18	0.112	O	|	|	|	|	1.48
52.667	0.00	0.18	0.111	O	|	|	|	|	1.46
52.750	0.00	0.18	0.110	O	|	|	|	|	1.45
52.833	0.00	0.18	0.109	O	|	|	|	|	1.43
52.917	0.00	0.18	0.107	O	|	|	|	|	1.41
53.000	0.00	0.17	0.106	O	|	|	|	|	1.40
53.083	0.00	0.17	0.105	O	|	|	|	|	1.38
53.167	0.00	0.17	0.104	O	|	|	|	|	1.37
53.250	0.00	0.17	0.103	O	|	|	|	|	1.35
53.333	0.00	0.17	0.101	O	|	|	|	|	1.34
53.417	0.00	0.17	0.100	O	|	|	|	|	1.32
53.500	0.00	0.17	0.099	O	|	|	|	|	1.30
53.583	0.00	0.17	0.098	O	|	|	|	|	1.29
53.667	0.00	0.17	0.097	O	|	|	|	|	1.27
53.750	0.00	0.17	0.096	O	|	|	|	|	1.26
53.833	0.00	0.17	0.095	O	|	|	|	|	1.24
53.917	0.00	0.16	0.093	O	|	|	|	|	1.23
54.000	0.00	0.16	0.092	O	|	|	|	|	1.21
54.083	0.00	0.16	0.091	O	|	|	|	|	1.20
54.167	0.00	0.16	0.090	O	|	|	|	|	1.18
54.250	0.00	0.16	0.089	O	|	|	|	|	1.17
54.333	0.00	0.16	0.088	O	|	|	|	|	1.16
54.417	0.00	0.16	0.087	O	|	|	|	|	1.14
54.500	0.00	0.16	0.086	O	|	|	|	|	1.13
54.583	0.00	0.16	0.085	O	|	|	|	|	1.11
54.667	0.00	0.16	0.083	O	|	|	|	|	1.10
54.750	0.00	0.16	0.082	O	|	|	|	|	1.08

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54.833  0.00  0.15  0.081  O    |    |    |    |    1.07
54.917  0.00  0.15  0.080  O    |    |    |    |    1.06
55.000  0.00  0.15  0.079  O    |    |    |    |    1.04
55.083  0.00  0.15  0.078  O    |    |    |    |    1.03
55.167  0.00  0.15  0.077  O    |    |    |    |    1.01
55.250  0.00  0.15  0.076  O    |    |    |    |    1.00
55.333  0.00  0.15  0.075  O    |    |    |    |    0.99
55.417  0.00  0.15  0.074  O    |    |    |    |    0.97
55.500  0.00  0.15  0.073  O    |    |    |    |    0.96
55.583  0.00  0.15  0.072  O    |    |    |    |    0.95
55.667  0.00  0.14  0.071  O    |    |    |    |    0.93
55.750  0.00  0.14  0.070  O    |    |    |    |    0.92
55.833  0.00  0.14  0.069  O    |    |    |    |    0.91
55.917  0.00  0.14  0.068  O    |    |    |    |    0.90
56.000  0.00  0.14  0.067  O    |    |    |    |    0.88
56.083  0.00  0.14  0.066  O    |    |    |    |    0.87
56.167  0.00  0.14  0.065  O    |    |    |    |    0.86
56.250  0.00  0.14  0.064  O    |    |    |    |    0.84
56.333  0.00  0.14  0.063  O    |    |    |    |    0.83
56.417  0.00  0.14  0.062  O    |    |    |    |    0.82
56.500  0.00  0.14  0.061  O    |    |    |    |    0.81
56.583  0.00  0.13  0.060  O    |    |    |    |    0.80
56.667  0.00  0.13  0.060  O    |    |    |    |    0.78
56.750  0.00  0.13  0.059  O    |    |    |    |    0.77
56.833  0.00  0.13  0.058  O    |    |    |    |    0.76
56.917  0.00  0.13  0.057  O    |    |    |    |    0.75
57.000  0.00  0.13  0.056  O    |    |    |    |    0.74
57.083  0.00  0.13  0.055  O    |    |    |    |    0.72
57.167  0.00  0.13  0.054  O    |    |    |    |    0.71
57.250  0.00  0.13  0.053  O    |    |    |    |    0.70
57.333  0.00  0.13  0.052  O    |    |    |    |    0.69
57.417  0.00  0.12  0.052  O    |    |    |    |    0.68
57.500  0.00  0.12  0.051  O    |    |    |    |    0.67
57.583  0.00  0.12  0.050  O    |    |    |    |    0.66
57.667  0.00  0.12  0.049  O    |    |    |    |    0.64
57.750  0.00  0.12  0.048  O    |    |    |    |    0.63
57.833  0.00  0.12  0.047  O    |    |    |    |    0.62
57.917  0.00  0.12  0.046  O    |    |    |    |    0.61
58.000  0.00  0.12  0.046  O    |    |    |    |    0.60
58.083  0.00  0.12  0.045  O    |    |    |    |    0.59
58.167  0.00  0.12  0.044  O    |    |    |    |    0.58
58.250  0.00  0.12  0.043  O    |    |    |    |    0.57
58.333  0.00  0.12  0.042  O    |    |    |    |    0.56
58.417  0.00  0.11  0.042  O    |    |    |    |    0.55
58.500  0.00  0.11  0.041  O    |    |    |    |    0.54
58.583  0.00  0.11  0.040  O    |    |    |    |    0.53
58.667  0.00  0.11  0.039  O    |    |    |    |    0.52
58.750  0.00  0.11  0.039  O    |    |    |    |    0.51
58.833  0.00  0.11  0.038  O    |    |    |    |    0.50
58.917  0.00  0.11  0.037  O    |    |    |    |    0.49
59.000  0.00  0.11  0.036  O    |    |    |    |    0.48
59.083  0.00  0.10  0.036  O    |    |    |    |    0.47
59.167  0.00  0.10  0.035  O    |    |    |    |    0.46
59.250  0.00  0.10  0.034  O    |    |    |    |    0.45
```

Remaining water in basin = 0.03 (Ac.Ft)

****************************HYDROGRAPH DATA****************************

Number of intervals = 711

Time interval = 5.0 (Min.)

Maximum/Peak flow rate = 0.283 (CFS)

Total volume = 1.133 (Ac.Ft)

Status of hydrographs being held in storage

	Stream 1	Stream 2	Stream 3	Stream 4	Stream 5
Peak (CFS)	0.000	0.000	0.000	0.000	0.000
Vol (Ac.Ft)	0.000	0.000	0.000	0.000	0.000

****

Appendix B
Stormwater Quality Best Management Practice
Design Handbook

Filter Strip Example

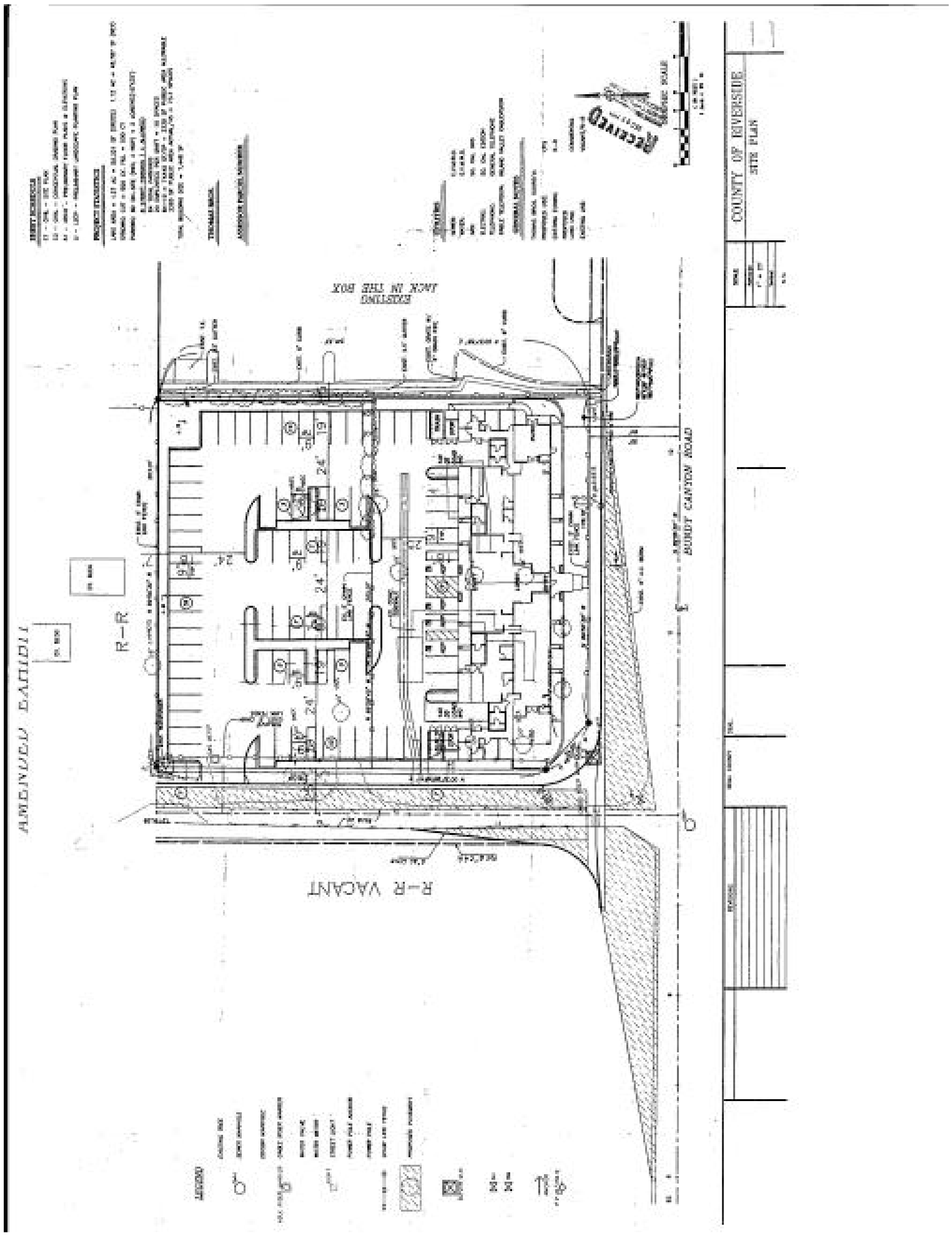

COUNTY OF RIVERSIDE
SITE PLAN
BUNDY CANYON ROAD
EXISTING JACK IN THE BOX
R-R
R-R VACANT
RECEIVED

Table 4. Runoff Coefficients for an Intensity = 0.2 $^{in}/_{hr}$ for Urban Soil Types*

Impervious %	A Soil RI =32	B Soil RI =56	C Soil RI =69	D Soil RI =75
0 (Natural)	0.06	0.15	0.24	0.31
5	0.10	0.18	0.28	0.35
10	0.15	0.23	0.33	0.40
15	0.19	0.27	0.37	0.44
20 (1-Acre)	0.24	0.29	0.38	0.41
25	0.27	0.35	0.43	0.49
30	0.32	0.38	0.46	0.51
35	0.35	0.41	0.47	0.51
40 (1/2-Acre)	0.40	0.45	0.50	0.53
45	0.44	0.48	0.52	0.55
50 (1/4-Acre)	0.49	0.53	0.55	0.59
55	0.53	0.57	0.58	0.62
60	0.57	0.61	0.62	0.66
65 (Condominiums)	0.61	0.65	0.65	0.77
70	0.65	0.69	0.70	0.76
75 (Mobilehomes)	0.69	0.71	0.73	0.75
80 (Apartments)	0.74	0.75	0.77	0.78
85	0.77	0.78	0.79	0.81
90 (Commercial)	0.82	0.83	0.83	0.84
95	0.86	0.86	0.87	0.88
100	0.90	0.90	0.90	0.90

*Complete District's standards can be found in the Riverside County Flood Control Hydrology Manual

Worksheet 2

Design Procedure Form for Design Flow

Uniform Intensity Design Flow

Designer: **Benjie Cho**
Company: **Riverside County Flood Control and Water Conservation District**
Date: **5/24/04**
Project: **BMP Example**
Location:

1. Determine Impervious Percentage				
a. Determine total tributary area	A_{total} =	**1.27**	acres	***(1)***
b. Determine Impervious %	i =	**90**	%	***(2)***
2. Determine Runoff Coefficient Values Use **Table 2** and impervious % found in step 1				
a. A Soil Runoff Coefficient	C_a =	**.82**		***(3)***
b. B Soil Runoff Coefficient	C_b =	**.83**		***(4)***
c. C Soil Runoff Coefficient	C_c =			***(5)***
d. D Soil Runoff Coefficient	C_d =			***(6)***
3. Determine the Area decimal fraction of each soil type in tributary area				
a. Area of A Soil / ***(1)*** =	A_a =	**0.5**		***(7)***
b. Area of B Soil / ***(1)*** =	A_b =	**0.5**		***(8)***
c. Area of C Soil / ***(1)*** =	A_c =			***(9)***
d. Area of D Soil / ***(1)*** =	A_d =			***(10)***
4. Determine Runoff Coefficient				
a. C = ***(3)***x***(7)*** + ***(4)***x***(8)*** + ***(5)***x***(9)*** + ***(6)***x***(10)*** **=**	C =	**.83**		***(11)***
5. Determine BMP Design flow				
a. Q_{BMP} = C x I x A = ***(11)*** x 0.2 x ***(1)***	Q_{BMP} =	**0.21**	$\frac{ft^3}{s}$	***(12)***

Datasheet

Site Conditions:

A_{total} = 1.27 acres (from worksheet 2)
Q_{BMP} = 0.21 cfs (from worksheet 2)

Design Assumptions:

1. **Design Flow**
   Q_{BMP} = 0.211 cfs

2. **Minimum Width**
   Calculate minimum width of the grass strip filter (W_m) normal to flow direction:
   $W_m = (Q_{BMP})/0.005$ cfs/ft (minimum) = 42.2 ft

3. **Minimum Length**
   Length of the grass strip filter (Lm) in the direction of flow shall not be less than 15 feet.
   L_m = 15 feet (minimum)

4. **Slope Requirement**
   Slope = 4%

5. **Flow Distribution**
   Level spreader of similar concept.

6. **Vegetation**
   3” Grass

7. **Outflow Collection**
   Street gutter

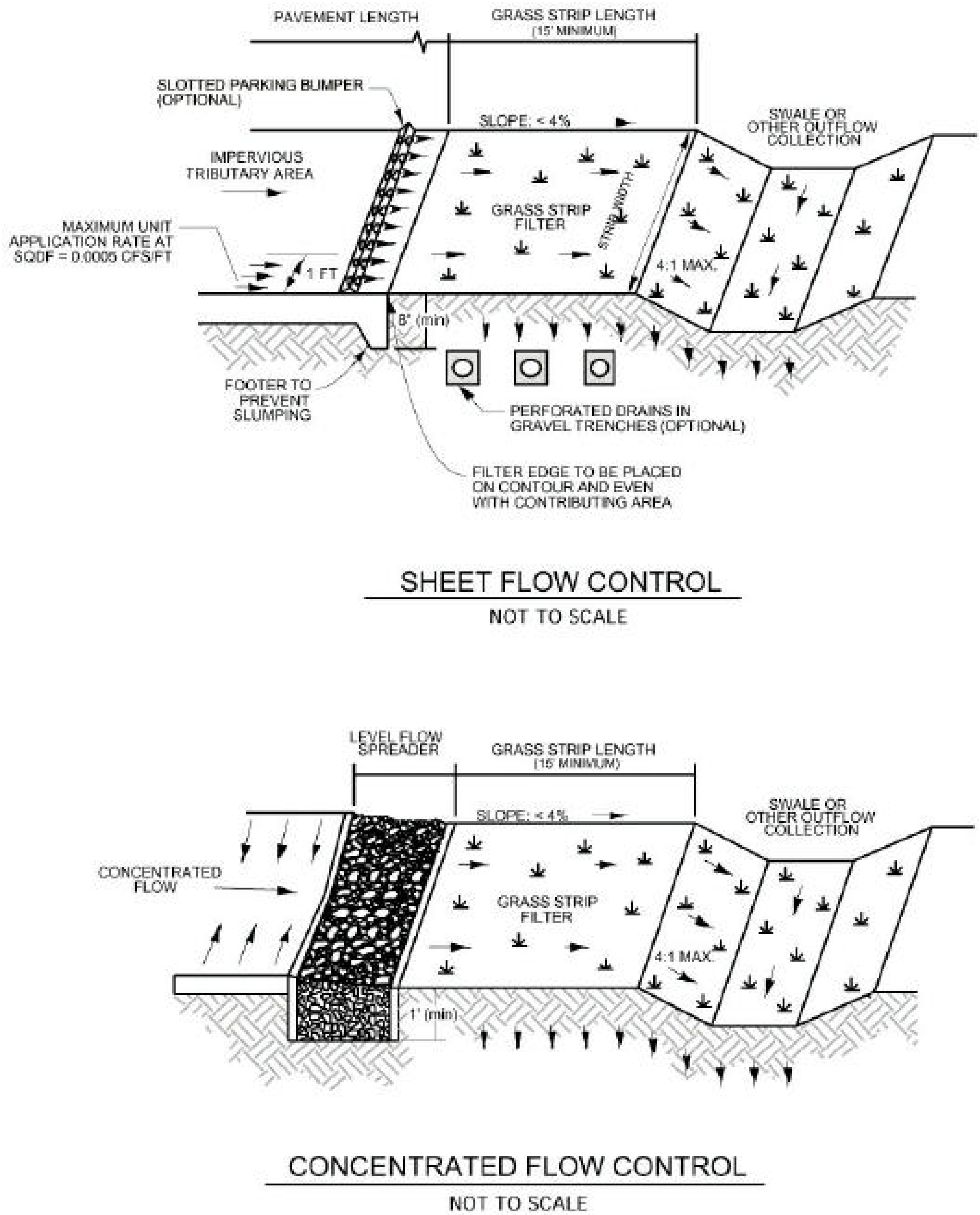


Figure 12: Grass Filter Strip

Source: Ventura County Guidance Manual

Worksheet 10

Design Procedure Form for Filter Strip

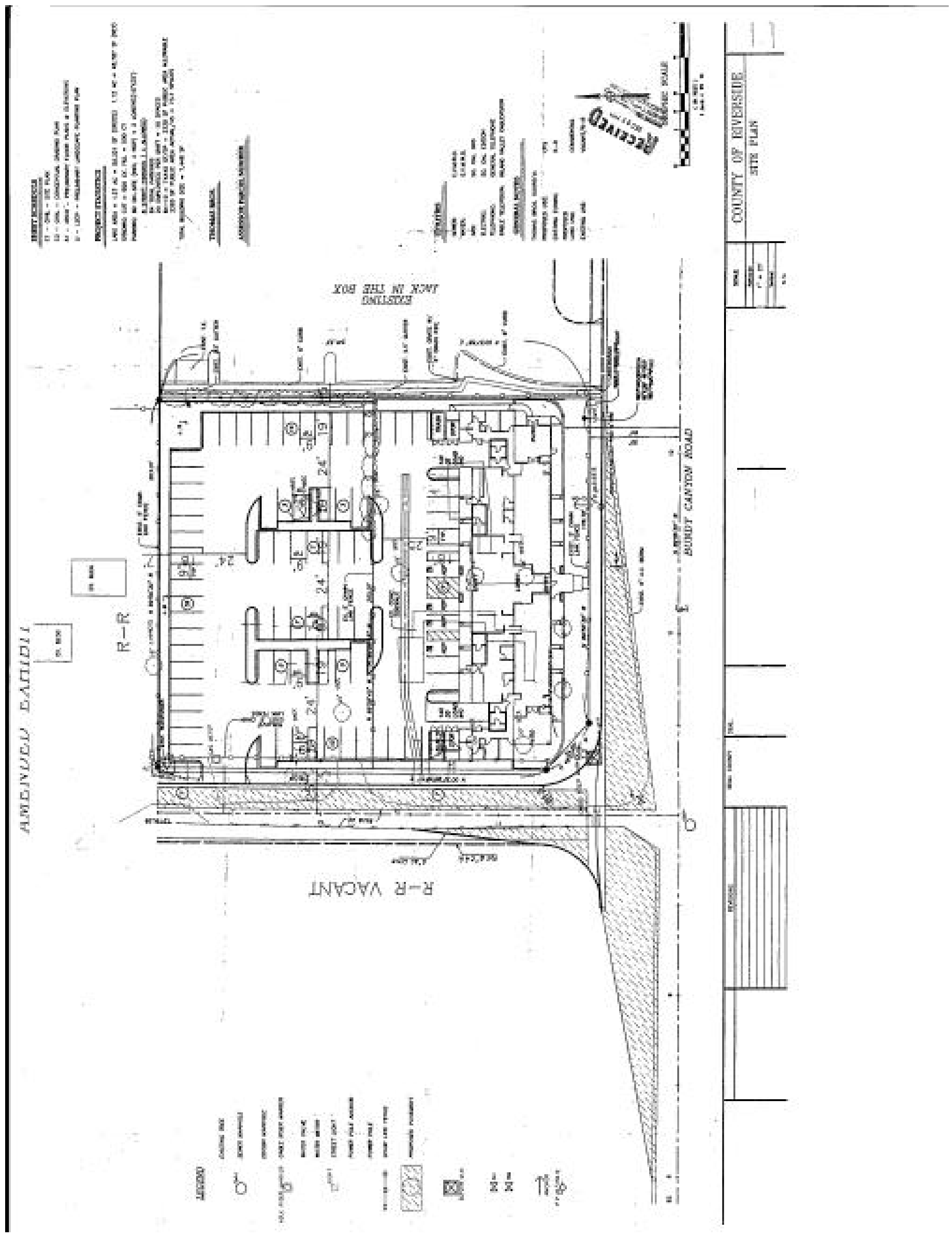
Designer: Benjie Cho
Company: Riverside County Flood Control
Date: 5/20/04
Project: BMP Example
Location: Township 6 South & Range 4 West Section 22

1. Determine Design Flow (Use Worksheet 2)	Q_{BMP} = **.211** cfs
2. Design Width $W_m = (Q_{BMP})/0.005$ cfs/ft	W_m = **42.2** ft
3. Design Length (15 ft minimum)	L_m = 15 ft
4. Design Slope (4 % maximum)	S_D = 4 %
5. Flow Distribution (check type used or describe "other")	___ slotted curbing ___ Modular Block Porous Pavement _X_ Level Spreader ___other______
6. Vegetation (describe)	3" grass
5. Outflow Collection (check type used or describe "other")	___ Grass Swale _X_ Street Gutter ___ Storm Drain ___ Underdrain ___ Other______

Notes:

Appendix B
Stormwater Quality Best Management Practice
Design Handbook

Infiltration Basin Example


COUNTY OF RIVERSIDE
SITE PLAN
BUNDY CANYON ROAD
R-R VACANT
R-R
EXISTING
JACK IN THE BOX
LEGEND

Worksheet 1

Design Procedure for BMP Design Volume

85th percentile runoff event

Designer:	**Benjie Cho**
Company:	**Riverside County Flood Control and Water Conservation District**
Date:	**3/1/04**
Project:	**BMP Example**
Location:	**Township 6 South & Range 4 West Section 22**

1. Create Unit Storage Volume Graph a. Site location (Township, Range and Section)		T **6S** &R **4W** Section **22**	*(1)*
b. Slope value from the Design Volume Curve in **Appendix A**.	Slope =	**1.148**	*(2)*
c. Plot this value on the Unit Storage Volume Graph shown on **Figure 2**. d. Draw a straight line form this point to the origin, to create the graph	Is this graph attached?	Yes ☒ No ☐	
2. Determine Runoff Coefficient a. Determine total impervious area	$A_{impervious}$ =	**1.143** acres	*(5)*
b. Determine total tributary area	A_{total} =	**1.27** acres	*(6)*
c. Determine Impervious fraction i = ***(5)*** / ***(6)***	i =	**.90**	*(7)*
d. Use ***(7)*** in **Figure 1** to find Runoff OR $C = .858i^3 - .78i^2 + .774i + .04$	C =	**.73**	*(8)*
3. Determine 85% Unit Storage Volume a. Use ***(8)*** in **Figure 1** Draw a Vertical line from ***(8)*** to the graph, then a Horizontal line to the desired V_u value.	V_u =	**0.88** in-acre / acre	*(9)*
4. Determine Design Storage Volume a. V_{BMP} = ***(9)*** x ***(6)*** [in- acres]	V_{BMP} =	**1.13** in-acre	*(10)*
b. V_{BMP} = ***(10)*** / 12 [ft- acres]	V_{BMP} =	**0.0942** ft-acre	*(11)*
c. V_{BMP} = ***(11)*** x 43560 [ft^3]	V_{BMP} =	**4103** ft^3	*(12)*

Notes:

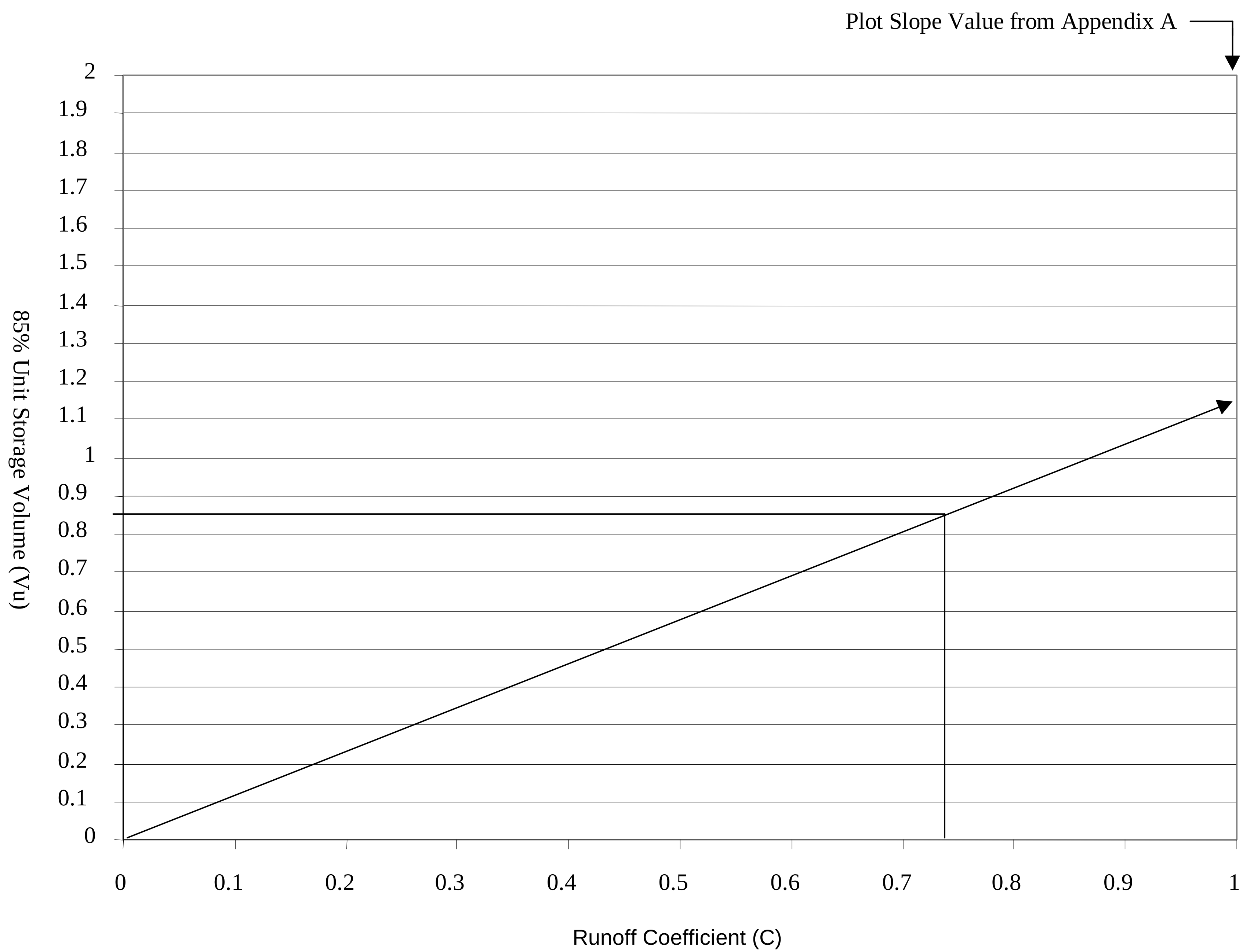


Figure 2 Unit Storage Volume Graph

Datasheet

Site Conditions

A_{total} = 1.27 acres
Land Use = Commercial
Impervious Cover = 90%

Design Assumptions

1. Design Storage Volume
   V_{BMP} = 4103 ft^3 (from worksheet 1)

2. Trench Water Depth
   Maximum depth should not exceed 8 feet
   Calculate the maximum allowable depth of water in the trench, Dm, in feet using the following equation:

$$D_m = [(t) \times (I)] / 12s$$

Where I = site infiltration rate (in/hr)
s = safety factor
t = minimum draw down time (48 hours)

Step#1: For urban cover with B type soil the District uses a RI value of 56
Step#2: Using Plate E-6.2, Fp (infiltration rate) = 0.517 in/hr (for an AMC II)
Step#3: Assuming a safety factor of 3, **D_m = 0.689 feet**

3. Trench Surface Area
   Calculate the minimum surface area of the trench bottom will the following equation:

$$A_m = V_{BMP} / D_m$$

A_m = 5952 feet = 0.1366 Acres

Where A_m = minimum area required (ft^2)
V_{BMP} = volume of the infiltration basin (ft^3)
D_m = maximum allowable depth (ft)

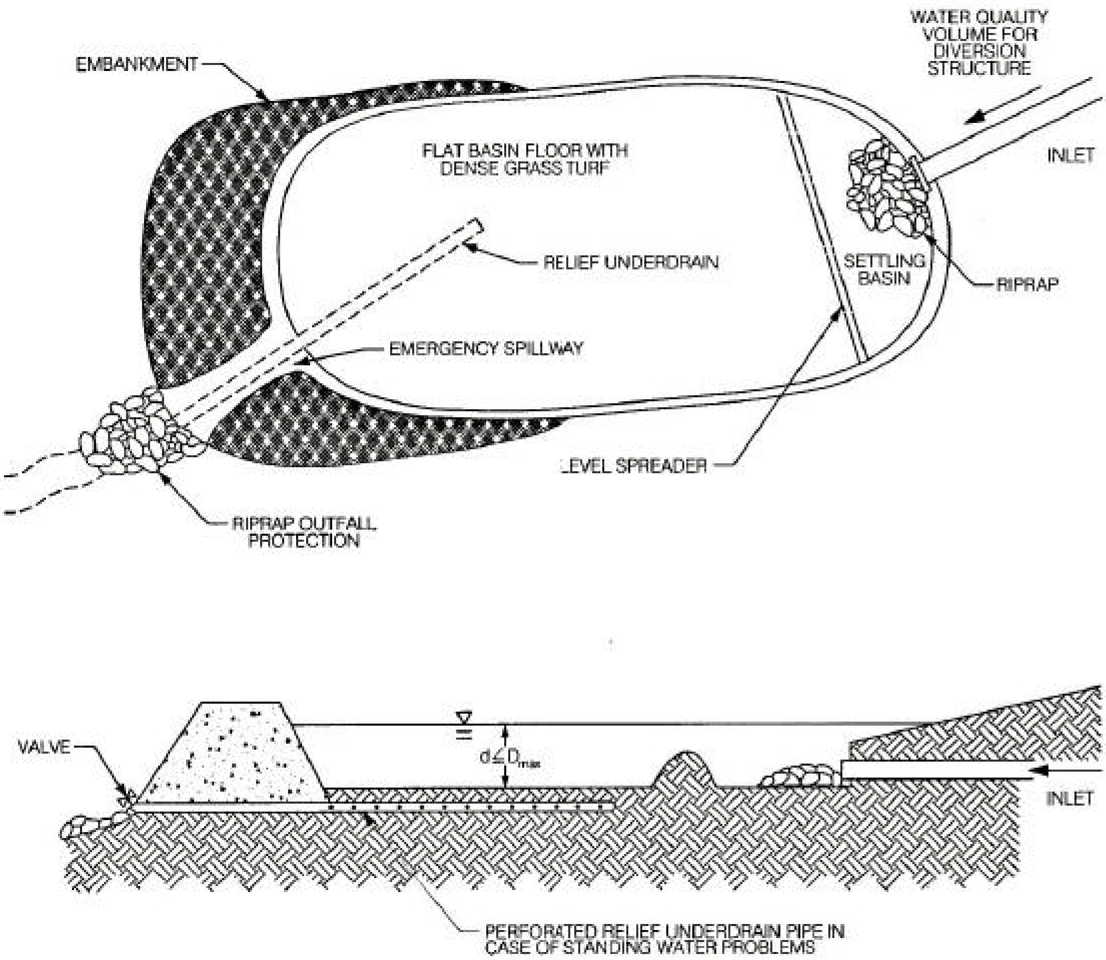


Figure 6: INFILTRATION BASIN

Source: City of Modesto Guidance Manual

Worksheet 4

Design Procedure Form for Infiltration Basin

Designer: Benjie Cho
Company: Riverside County Flood Control
Date: 5/24/04
Project: Example
Location: Township 6 South & Range 4 West Section 22

1. Determine Design Storage Volume (Use Worksheet 1) a. Total Tributary Area (maximum 50) b. Design Storage Volume, V_{BMP}	A_{total} = 1.27 acres V_{BMP} = 4103 ft^3
2. Maximum Allowable Depth (D_m) a. Site infiltration rate (I) b. Minimum drawdown time (48 hrs) c. Safety factor (s) d. $D_m = [(t) \times (I)]/[12s]$	I = 0.517 in/hr t = 48 hrs s = 3 D_m = 0.689 ft
3. Basin Surface Area $A_m = V_{BMP} / D_m$	A_m = 5952 ft^2
4. Vegetation (check type used or describe "other")	____ Native Grasses _X_ Irrigated Turf Grass ____ Other

Notes:

Exhibit D

SMR WQMP Applicability Checklist

2014 Santa Margarita Region WQMP – Exhibit D

Checklist for Identifying Projects Requiring a Project-Specific WQMP within the Santa Margarita Region

Project File No.:	
Project Name:	
Project Location:	
Project Description:	

Proposed Project Consists of or Includes:	Yes	No
New Development. The creation of 10,000 square feet or more of impervious surfaces (collectively over the entire project site) including commercial, industrial, residential, mixed-use, and public projects.		
Redevelopment. The creation, addition or replacement of at least 5,000 square feet of impervious surfaces on an already developed site and the existing development and/or the redevelopment project falls under the project categories or locations listed below in this table. Where redevelopment results in an increase of less than 50% of the impervious surfaces of previously existing development, and the existing development was not subject to WQMP requirements, the numeric sizing criteria [MS4 Permit requirement F.1.d. (6)] applies only to the addition or replacement, and not to the entire development. [Note: Where redevelopment results in an increase of more than 50% of the impervious surfaces of a previously existing development, the numeric sizing criteria applies to the entire development.]		
Automotive repair shops. A facility that is categorized in any one of the following Standard Industrial Classification (SIC) Codes 5013–Motor vehicle supplies or parts, 5014–Tires & Tubes, 5541–Gasoline Service Stations, 7532–Top, Body & Upholstery Repair Shops and Paint Shops, 7533–Automotive Exhaust System Repair Shops, 7534–Tire Retreading and Repair Shops, 7536–Automotive Glass Replacement Shops, 7537–Automotive Transmission Repair Shops, 7538–General Automotive Repair Shops, 7539–Automotive Repair Shops, not elsewhere classified)		
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 (SIC code 5812), where the land area for development is greater than 5,000 square feet. Restaurants where land development is less than 5,000 square feet must meet all WQMP requirements except for structural treatment BMP and numeric sizing criteria requirement F.1.d.(6) and hydromodification requirement F.1.h.		
All Hillside development greater than 5,000 square feet. Any development that creates greater than 5,000 square feet of impervious surface which is located in an area with known erosive soil conditions, where the development will include grading on any natural slope that is 25% or greater.		
Environmentally Sensitive Areas (ESAs)[1]. All development located within or directly adjacent to or discharging directly to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage conveyance system that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flows from adjacent lands.		
Parking lot. Impervious parking lots 5,000 sq. ft. or more and potentially exposed to runoff. Parking lot is defined as a land area or facility for the temporary parking or storage of motor vehicles used personally for business or commerce.		
Streets, roads, highways, and freeways. Includes any paved impervious surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles, and other vehicles.		
Retail Gasoline Outlets (RGOs). Includes RGOs that meet the following criteria: (a) 5,000 square feet or more, or (b) a projected Average Daily Traffic (ADT) of 100 or more vehicles per day.		
Pollutant Generating projects disturbing over 1 acre. Development projects that disturb over one acre of land, where the post-construction use of the site generate pollutants at levels greater than natural background levels.		

1 Land area is based on acreage disturbed
2 Descriptions of SIC codes can be found at http://www.osha.gov/pls/imis/sicsearch.html.

DETERMININATION: Circle appropriate determination

<u>Any</u> questions answered "YES" → Project requires a project-specific WQMP.
<u>All</u> questions are answered "NO" → Project requires incorporation of Site Design and Source Control BMPs imposed through Conditions of Approval or permit conditions.

Exhibit E

Project Specific SMR WQMP Review Checklist

Water Quality Management Plan Review Checklist

The purpose of this checklist is to provide a format for uniform, comprehensive, and well-documented reviews of the Water Quality Management Plans (WQMPs) submitted by project applicants. The completed checklist should be transmitted to the project applicant with the project WQMP. A copy of the completed checklist should be retained with the project planning/permitting file.

Planning Project/Design Review Number: ______________________

Project Name: ______________________

Project Address: ______________________

____

First Review

WQMP Received on: ______________

Review Completed on: ______________

Second Review

WQMP Received on: ______________

Review Completed on: ______________

Third Review

WQMP Received on: ______________

Review Completed on: ______________

Signature of Reviewer: ______________________ Date: ______________

WQMP REQUIREMENT	Requirement Satisfied? Yes	No	N/A
Title Page			
The Title Page includes the following:			
Project Title			
Development No. (Tract, Parcel, or Use number)			
Design Review/Case number			
Prepared for: (Owner/Developer name and contact information)			
Prepared by: (Consulting/Engineering firm that prepared WQMP with contact person, title and information)			
Date WQMP was prepared and appropriate revision date(s)			
Preliminary or Final box checked			
Owner's Certification			
Includes a fully completed and signed certification statement, in which the project owner acknowledges and accepts the provisions of the WQMP, follows the title page. *Note: Original signature and notarization certification for the project owner will be required for each approval document(s).*			
Includes a fully completed and signed certification statement, in which the preparer acknowledges that the WQMP meets the requirements of Regional Water Quality Control Board Order No. R9-2010-0016, follows the title page.			
Table of Contents			
Includes a fully completed Table of Contents, list of figures, and appendices, as applicable.			
SECTION A: PROJECT AND SITE INSPECTION			
Includes an accurate description of project information, project location, project characteristics, and existing site characteristics.			
Section A.1: Maps and Site Plans			
Includes a WQMP site plan • Refer to Appendix 1 for specific WQMP site plan information to be provided.			
Section A.2: Identify Receiving Waters			
Includes fully completed Table A.1: Identification of Receiving Waters - All receiving waters that the project site is tributary to, are listed in order of upstream to downstream.			
Section A.3: Drainage System Susceptibility to Hydromodification			
Includes fully completed Table A.3: Identification of Susceptibility to Hydromodification			
Section A.4: Additional Permits/Approvals required for the Project:			
Includes fully completed Table A.2: Other Applicable Permits - Identifies additional permits/approvals required for the project: • State Department of Fish and Wildlife, 1602 Streambed Alteration Agreement. • State Water Resources Control Board, Clean Water Act (CWA) section 401 Water Quality Certification. • US Army Corps of Engineers, CWA section 404 permit. • US Fish and Wildlife, Endangered Species Act section 7 biological opinion. • Statewide Construction General Permit Coverage. • Statewide Industrial General Permit Coverage. • Western Riverside MSHCP Consistency Approval (e.g. JPR, DBESP). • Other.			

WQMP REQUIREMENT	Requirement Satisfied? Yes	No	N/A
SECTION B: OPTIMIZE SITE UTILIZATION (LID PRINCIPLES)			
Includes narrative describing approach to identifying and preserving existing drainage patterns.			
Includes narrative describing approach to identifying and protecting existing vegetation.			
Includes narrative describing approach to identifying and preserving natural infiltration capacity.			
Includes narrative describing approach to identifying and minimizing impervious area.			
Includes narrative describing approach to identifying and dispersing runoff to adjacent pervious areas.			
SECTION C: DELINEATE DRAINAGE MANAGEMENT AREAS (DMA'S)			
Includes fully completed Table C.1: DMA Classifications. • Drainage Management Areas (DMAs) and surface type (e.g. landscaping, pervious paving, or roofs). • The total project site area should total the sum of all DMAs, plus the area of any stormwater BMPs.			
Includes fully completed Table C.2: Type 'A' Self-Treating Areas.			
Includes fully completed Table C.3: Type 'B' Self-Retaining Areas.			
Includes fully completed Table C.4: Type 'C' Areas that Drain to Self-Retaining Areas.			
Includes fully completed Table C.5: Type 'D' Areas draining to BMPs. • Where possible, site drainage should be designed so that only impervious roofs and pavement drain to LID BMPs. This yields a simpler, more efficient design and minimizes the potential for clogging by sediment.			
SECTION D: IMPLEMENT LID BMPS			
Section D.1: Infiltration Applicability			
Indicates if Harvest and Use BMPs will be implemented to address the DCV for all DMA or if there is an approved downstream 'Highest and Best Use' for stormwater runoff. • If Yes, Infiltration BMPs shall not be used for the site, and the Highest and Best Use is documented in the WQMP. • If No, a project site-specific evaluation of the feasibility of Infiltration BMPs shall be performed and is included with the WQMP. • Existence of an approved 'Highest and Best Use' should be verified with Copermittee.			
Indicates if the project meets criteria for classification as a 'small project' consistent with the requirements of Chapter 2 of the WQMP Guidance Document by providing supporting evidence that the project meets the following criteria: • Project must not be larger than size criteria listed on Page 27 of the 2014 WQMP Guidance Document. • Project must be underlain with hydrologic soils group (HSG) "D" soils only, according to available regional soils maps. • No data should be available that conflicts with the above HSG "D" designation.			
Includes fully completed Table D.1 Infiltration Feasibility, listing any affected DMAs.			
Section D.2: Harvest and Use Assessment			
Indicates if reclaimed water will be used for the non-potable water demands for the project.			
Indicates if downstream water rights may be impacted by Harvest and Use, as approved by the Regional Board.			
Indicates if the Design Capture Volume (DCV) will be addressed using Infiltration Only BMPs.			
Irrigation Use Feasibility			
Step 1: Identifies the total area of irrigated landscape (Acres).			
Step 1: Identifies the type of landscaping – Conservation Design or Active Turf.			
Step 2: Identifies total area of impervious surfaces (Acres).			
Step 3: Identifies the minimum area of *Effective Irrigated Area per Tributary Impervious Area* (EIATIA factor).			
Step 4: Identifies minimum required irrigated area (Acres).			
Step 5: Determines if harvesting stormwater runoff for irrigation use is feasible.			

WQMP REQUIREMENT	Requirement Satisfied? Yes	No	N/A
Toilet Use Feasibility			
Step 1: Identifies the total number of daily toilet users and the project type (Residential, Commercial, Industrial or School).			
Step 2: Identifies total area of impervious surfaces (Acres).			
Step 3: Identifies minimum number of *toilet users per tributary impervious acre* (TUTIA) Factor.			
Step 4: Identifies minimum number of toilet users.			
Step 5: Determines if harvesting stormwater runoff for toilet use is feasible.			
Other Non-Potable Use Feasibility			
Provided narrative description of other non-potable uses for stormwater runoff.			
Step 1: Identifies average daily demand: Projected average daily use in (GPD).			
Step 2: Identifies total area of impervious surfaces (Acres).			
Step 3: Identifies minimum demand for non-potable uses per tributary impervious acre (see Table 2-5 of the WQMP Guidance Document).			
Step 4: Identifies minimum number of gallons per day of non-potable use that would be required.			
Step 5: Determines if harvesting stormwater runoff for other non-potable use is feasible.			
Section D.3: Bioretention and Biotreatment Assessment			
Lists LID Bioretention/Biotreatment BMPs that will be used for some or all DMAs of the Project.			
If LID BMPs are infeasible throughout the site, a site-specific technical infeasibility analysis is included in Appendix 5.			
Section D.4: Other Limiting Geotechnical Conditions			
Indicates if onsite retention is not feasible due to specific geotechnical concerns identified in Geotechnical Report			
Provides brief narrative describing why onsite retention is not feasible.			
Section D.5: Feasibility Assessment Summaries			
Includes fully completed Table D.3 Feasibility Assessment Summary Table			
Provides brief narrative describing all DMAs where LID BMPs are not feasible for implementation.			
Section D.6: LID BMP Sizing			
Provides a completed Table D.4: DCV Calculations for LID BMPs			
Provides a completed Table D.5: LID BMP Sizing			
Indicates if LID BMPs will be used.			
SECTION E: IMPLEMENT HYDROLOGIC CONTROL BMPs AND SEDIMENT SUPPLY BMPs			
Section E.1: Onsite Feasibility of Hydrologic Control BMPs			
Indicates Yes or No that onsite Hydrologic Control BMPs are feasible or infeasible.			
Indicates that infeasibility has been approved by Copermittee.			
Section E.2: Meeting the HMP Performance Standard for Small Project Sites			
Indicates that the project is either greater or less than 1 acre.			
Provides a Simplified Technical Feasibility Study in Appendix 7.			
Indicates if onsite Hydrologic Control BMPs are feasible or not feasible .			
Section E.3: Hydrologic Control BMP Selection			
Includes fully completed Table E.1: LID & Hydromodification BMP Location.			
Section E.4: Hydrologic Control BMP Sizing			

WQMP REQUIREMENT	Requirement Satisfied?		
	Yes	No	N/A
Includes fully completed Table E.2: Hydrologic Control BMP Sizing			
Section E.5: Implement Sediment Supply BMPs			
Completed Step 1: Identify if site is a Significant Source of Bed Sediment Supply			
• Step 1.A: Identifies bed sediment similarity as…High, Medium or Low. • Results from geotechnical report attached in Appendix 7			
• Step 1.B: Identifies onsite streams capable of delivering bed sediment to receiving channel as…High, Medium or Low. • Results from analysis attached in Appendix 7			
• Step 1.C: Identifies if receiving channel will adversely respond to change in Bed Sediment Load as…High, Medium or Low. • Results from in-stream analysis provided in Appendix 7			
• Step 1.D: Provides summary of Step 1 in Table E.3: Triad Assessment Summary			
Completed Step 2: Preservation of identified onsite channels			
- Indicates whether site design will or will not avoid onsite channels that are identified as Significant Source of Bed Sediment…Yes or No.			
- Provides map identifying all onsite channels that are Significant Source of Bed Sediment in Appendix 7			
Completed Step 3: By-Pass of Upstream Drainage(s)			
- Indicates if site design avoids or doesn't avoid all onsite channels			
- Provides a site map identifying all upstream channels that are Significant Source of Bed Sediment in Appendix 7			
SECTION F: ALTERNATIVE COMPLIANCE			
Indicates if LID Principles and LID BMPs have been incorporated into the site design to fully address all DMAs. If checked, no alternative compliance measures are required for this project and thus, Section F is not required to be completed. Preparer may skip to Section E.			
Indicates that some project DMAs are unable to be addressed using LID & Hydrologic Control BMPs. • Includes site-specific infeasibility analysis, approved by the Copermittee, in Appendix 5. • Indicates that no downstream regional and/or sub-regional LID & Hydrologic Control BMPs exist or are available for use by the project. • Includes list of DMAs that are unable to be addressed using LID & Hydrologic Control BMPs.			
Section F.1: Identify Pollutants of Concern			
Includes fully completed Table E.1: Potential Pollutants by Land Use Type. • Indicates all applicable project categories. • Identifies the project's Pollutants of Concern by comparing general pollutant categories to those listed as impairments in the project's receiving waters.			
Section F.2: Stormwater Credits			
Includes fully completed Table E.2: Water Quality Credits – Provides credit reduction percentage of DCV.			
Section F.3: Sizing Criteria			
Includes fully completed Table E.3: Treatment Control BMP Sizing – Includes appropriate V_{BMP} or Q_{BMP} calculations and are analyzed using method described in Section 2.3.1 of the Guidance Document.			
Section F.4: Treatment Control BMP Selection			

WQMP REQUIREMENT	Requirement Satisfied? Yes	No	N/A
Includes fully completed Table F.4: Treatment Control BMP Selection. • Lists proposed treatment control BMP. • List project's priority pollutants of concern. • List removal efficiency percentage, as documented in Copermittee approved study. Include study in Appendix 6.			
Section F.5: Hydrologic Performance Standard – Alternative Compliance Approach			
Provides an Technical Feasibility Study or Simplified Technical Feasibility Study in Appendix 7 • Written approval from Copermittee has been given prior to development of study			
Indicates if offsite hydrologic control management within the same channel system will be pursued.			
Provides a completed Table F.5: Offsite Hydrologic Control BMP Sizing			
Indicates if in-stream restoration project is being pursued			
Provides a technical report detailing in-stream restoration option in Appendix 7			
Section F.6: Sediment Supply Performance Standard – Alternative Compliance			
Copermittee has given approval to investigate alternative Bed Sediment Supply options and the approval document is provided in the WQMP			
Provides narrative of alternative Bed Sediment Supply approach in Appendix 7 • Includes long-term monitoring program • Includes findings of the numerical modeling			
SECTION G: SOURCE CONTROL BMPS			
Includes completed Table G.1: Structural and Operational Source Control BMP – Table is consistent with Stormwater Pollutant Sources/Source Control Checklist located in Appendix 8 for the following: • Potential sources of runoff pollutants. • Structural source control BMPs. • Operational source control BMPs.			
SECTION H: CONSTRUCTION PLAN CHECKLIST			
Includes completed Table H.1: Construction Plan Cross-reference: • For Final WQMP only. • Reference tool to be used for easy reference of related construction plans.			
SECTION I. OPERATION, MAINTENANCE AND FUNDING			
Describes Maintenance Mechanism that is included in Appendix 9.			
Indicates if proposed BMPs will be maintained by a Home Owners' Association (HOA) or Property Owners Association (POA)			
APPENDICES			
Appendix 1: Maps and Site Plans			
Includes an accurate project location Map.			
Includes a fully complete and labeled map of all project identified receiving waters.			

WQMP REQUIREMENT	Requirement Satisfied?		
	Yes	No	N/A
Includes WQMP Site Plan that provides the following: • DMAs and drainage paths. • Proposed structural LID BMPs and design details. • Drainage infrastructure, inlets, and overflows. • Source Control BMPs consistent with those specified in Appendix 8. • Buildings, roof lines, and downspouts. • Impervious, pervious and total project site areas. • Area made available for LID BMPs (Effective Area) – include floor area ratio in calculation as described in Table 2-6 of the WQMP Guidance Document. • Standard drawing labeling.			
Appendix 2: Construction Plans			
Includes grading, drainage, landscape/plant palette and other pertinent construction plans.			
Appendix 3: Soil Information			
Includes Geotechnical Study.			
Includes infiltration testing data.			
Appendix 4: Historical Site Conditions			
Includes Phase 1 Environmental Site Assessment and/or other information on past site use.			
Appendix 5: LID infeasibility			
Includes LID Technical Infeasibility Analysis. • Analysis should be approved by Copermittee.			
Appendix 6: BMP Design Details			
Includes Design procedure sheets for LID BMPs. • Includes separate calculations for each DMAs draining to an LID BMP. • Includes calculations of V_{BMP} for each DMA using worksheets from Appendix F of the *LID BMP Design Handbook.* • Sizing of the LID BMP is performed using worksheets found in the *LID BMP Design Handbook* or other approved method by the Copermittee, and all worksheets are included. • Calculation values are consistent with those provided in Table D.3.			
Appendix 7: Hydromodification			
Includes supporting documentation for exemption of receiving waters that were not evaluated in the SMR HMP			
Includes Simplified Technical Feasibility Study			
Includes SMRHM summary reports			
Includes sieve analysis from Geotechnical Report, including soil erodibility factor.			
Includes analysis of sediment delivery potential to receiving channel			
Includes in-stream analysis			
Includes a site map identifying all onsite/upstream channels that are a significant source of bed sediment supply			
Includes site specific Technical Infeasibility Study of Hydrologic Control and Sediment Supply BMPs, including, but not limited to: • Modeling analysis • Long-term monitoring program • Potential corrective actions • SMRHM summary reports for alternative approach BMPs			
Includes supporting documentation for alternative compliance option for offsite/in-stream restoration			

WQMP REQUIREMENT	Requirement Satisfied?		
	Yes	No	N/A
Includes analysis of sediment delivery potential to receiving channel.			
Includes full design plans for in-stream restoration project that has been approved by Copermittee.			
Appendix 8: Source Control			
Includes Pollutant Sources/Source Control Checklist. • Checklist is consistent with Table G.1: Structural and Operational Source Control BMP • Checklist is consistent with the WQMP Site Plan.			
Appendix 9: O&M			
Includes a mean to finance and implement facility maintenance in perpetuity, including replacement cost.			
Includes acceptance of responsibility for maintenance from the time the BMPs are constructed until the responsibility for operation and maintenance is legally transferred.			
Includes an outline of general maintenance requirements for the Stormwater BMPs selected.			
Includes figures delineating and designating pervious and impervious areas, location, and type of Stormwater BMP, and tables of pervious and impervious areas served by each facility. Geo-locating the BMPs using a coordinate system of latitude and longitude is recommended to help facilitate a future statewide database system.			
Includes a separate list and location of self-retaining areas, or areas addressed by LID Principles, that do not require specialized O&M or inspections, but will require typical landscape maintenance as noted in Chapter 5, in the WQMP Guidance. Includes a brief description of typical landscape maintenance for these areas.			
Includes Maintenance and Recording Mechanisms			
Appendix 10: Educational Materials			
Includes BMP Fact Sheets			
Includes Maintenance Guidelines			
Includes Other End-User BMP Information			

WQMP REVIEW COMMENTS

The following is a summary of major comments and/or questions relative to this project-specific WQMP:

2010 SMR MS4 Permit	Order No. R9-2010-0016, an NPDES Permit issued by the San Diego Regional Water Quality Control Board.
Applicant	Public or private entity seeking the discretionary approval of new or replaced improvements from the Copermittee with jurisdiction over the project site. The Applicant has overall responsibility for the implementation and the approval of a Priority Development Project. The WQMP uses consistently the term "user" to refer to the applicant such as developer or project proponent. The WQMP employs also the designation "user" to identify the Registered Professional Civil Engineer responsible for submitting the Project-Specific WQMP, and designing the required BMPs.
Bed Sediment	Term to define the coarse-grained portion of the sediment load
Bed Sediment Load	The Bed Sediment (material that moves along the bed by sliding or saltating) and part of the suspended sediment load including particle size fractions in the channel Bed Sediments.
Best Management Practice (BMP)	Defined in 40 CFR 122.2 as schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. In the case of municipal storm water permits, BMPs are typically used in place of numeric effluent limits.
BMP Fact Sheets	BMP Fact Sheets are available in the LID BMP Design Handbook. Individual BMP Fact Sheets include sitting considerations, and design and sizing guidelines for seven types of structural BMPs (infiltration basin, infiltration trench, permeable pavement, harvest-and-use, bioretention, extended detention basin, and sand filter).
California Stormwater Quality Association (CASQA)	Publisher of the California Stormwater Best Management Practices Handbooks, available at: www.cabmphandbooks.com.
CEQA	California Environmental Quality Act - a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.
CIMIS	California Irrigation Management Information System - an integrated network of 118 automated active weather stations all over California managed by the California Department of Water Resources.

Comprehensive Regional BMP	Regional runoff management systems that address water quality, hydrologic, and fluvial geomorphologic requirements for PDPs larger than 100 acres.
Conventional Treatment Control BMP	A type of BMP that provides treatment of stormwater runoff. Conventional treatment control BMPs, while designed to treat particular Pollutants, typically do not provide the same level of volume reduction as LID BMPs, and commonly require more specialized maintenance than LID BMPs. As such, the 2010 SMR MS4 Permit and this WQMP require the use of LID BMPs wherever feasible, before Conventional Treatment BMPs can be considered or implemented.
Copermittees	The 2010 SMR MS4 Permit identifies the Cities of Murrieta, Temecula, and Wildomar, the County, and the District, as Copermittees for the SMR.
County	The abbreviation refers to the County of Riverside in this document.
Critical Shear Stress	Threshold above which motion of bed sediment is initiated.
CWA	Clean Water Act - is the primary federal law governing water pollution. Passed in 1972, the CWA established the goals of eliminating releases of high amounts of toxic substances into water, eliminating additional water pollution by 1985, and ensuring that surface waters would meet standards necessary for human sports and recreation by 1983. CWA Section 402(p) is the federal statute requiring NPDES permits for discharges from MS4s.
CWA Section 303(d) Waterbody	Impaired water in which water quality does not meet applicable water quality standards and/or is not expected to meet water quality standards, even after the application of technology based pollution controls required by the CWA. The discharge of urban runoff to these water bodies by the Copermittees is significant because these discharges can cause or contribute to violations of applicable water quality standards.
DCIA	Directly Connected Impervious Areas - those impervious areas that are hydraulically connected to the MS4 (i.e. street curbs, catch basins, storm drains, etc.) and thence to the structural BMP without flowing over pervious areas.
DCV	Design Capture Volume (DCV) is the volume of runoff produced from the Design Storm to be mitigated through LID Retention BMPs, Other LID BMPs and Volume Based Conventional Treatment BMPs, as appropriate.
Design Flow Rate	The design flow rate represents the minimum flow rate capacity that flow-based conventional treatment control BMPs should treat to the MEP, when considered.

Design Storm	The 2010 SMR MS4 Permit has established the 85th percentile, 24-hour storm event as the "Design Storm". The applicant may refer to Exhibit A to identify the applicable Design Storm Depth (D85) to the project.
Discretionary Approval	A decision in which a Copermittee uses its judgment in deciding whether and how to carry out or approve a project.
District	Riverside County Flood Control and Water Conservation District.
DMA	A Drainage Management Area - a delineated portion of a project site that is hydraulically connected to a common structural BMP or conveyance point. The Applicant may refer to Section 3.3 for further guidelines on how to delineate DMAs.
Drawdown Time	Refers to the amount of time the design volume takes to pass through the BMP. The specified or incorporated drawdown times are to ensure that adequate contact or detention time has occurred for treatment, while not creating vector or other nuisance issues. It is important to abide by the drawdown time requirements stated in the fact sheet for each specific BMP.
Effective Area	Area which 1) is suitable for a BMP (for example, if infiltration is potentially feasible for the site based on infeasibility criteria, infiltration must be allowed over this area) and 2) receives runoff from impervious areas.
Ep	stream erosion potential
Erosion	The process by which soil and rock are removed from the Earth's surface by exogenic processes such as wind or water flow, and then transported and deposited in other locations
ESA	An Environmental Sensitive Area (ESA) designates an area "in which plants or animals life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which would be easily disturbed or degraded by human activities and developments". (Reference: California Public Resources Code § 30107.5).
ET	Evapotranspiration (ET) is the loss of water to the atmosphere by the combined processes of evaporation (from soil and plant surfaces) and transpiration (from plant tissues). It is also an indicator of how much water crops, lawn, garden, and trees need for healthy growth and productivity
FAR	The Floor Area Ratio (FAR) is the total square feet of a building divided by the total square feet of the lot the building is located on.
Flow-Based BMP	Flow-based BMPs are conventional treatment control BMPs that are sized to treat the design flow rate.

FPPP	Facility Pollution Prevention Plan
GIS	Geographical Information System
HCOC	Hydrologic Condition of Concern - Exists when the alteration of a site's hydrologic regime caused by development would cause significant impacts on downstream channels and aquatic habitats, alone or in conjunction with impacts of other projects.
HMP	Hydromodification Management Plan – Plan defining Performance Standards for PDPs to manage increases in runoff discharge rates and durations.
HMP Performance Standard	The Hydrologic Performance and Sediment Supply Performance Standards
HRU/GLU Analysis	Hydrologic Response Units/Geomorphic Landscape Units
HSG	Hydrologic Soil Groups – soil classification to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSGs are A (very low runoff potential/high infiltration rate), B, C, and D (high runoff potential/very low infiltration rate)
HSPF	Hydrologic Simulation Program FORTRAN, distributed by USEPA
Hydrologic Control BMPs	A technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff
Hydrologic Performance Standard	The Hydrologic Performance Standard, or HMP Performance Standard consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event).
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, 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.
IMP	Integrated Management Practices

JRMP	A separate Jurisdictional Runoff Management Plan (JRMP) has been developed by each Copermittee and identifies the local programs and activities that the Copermittee is implementing to meet the 2010 SMR MS4 Permit requirements.
K	Soil erosion factor
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development (LID) is a site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques. LID site design BMPs help preserve and restore the natural hydrologic cycle of the site, allowing for filtration and infiltration which can greatly reduce the volume, peak flow rate, velocity, and pollutant loads of storm water runoff.
LID Bioretention BMP	LID Bioretention BMPs are bioretention areas are vegetated (i.e., landscaped) shallow depressions that provide storage, infiltration, and evapotranspiration, and provide for pollutant removal (e.g., filtration, adsorption, nutrient uptake) by filtering stormwater through the vegetation and soils. In bioretention areas, pore spaces and organic material in the soils help to retain water in the form of soil moisture and to promote the adsorption of pollutants (e.g., dissolved metals and petroleum hydrocarbons) into the soil matrix. Plants use soil moisture and promote the drying of the soil through transpiration. The 2010 SMR MS4 Permit defines "retain" as to keep or hold in a particular place, condition, or position without discharge to surface waters.
LID Biotreatment BMP	BMPs that reduce stormwater pollutant discharges by intercepting rainfall on vegetative canopy, and through incidental infiltration and/or evapotranspiration, and filtration, and other biological and chemical processes. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, biodegraded, and sequestered by the soil and plants, and collected through an underdrain.
LID BMP	A type of stormwater BMP that is based upon Low Impact Development concepts. LID BMPs not only provide highly effective treatment of stormwater runoff, but also yield potentially significant reductions in runoff volume – helping to mimic the pre-project hydrologic regime, and also require less ongoing maintenance than Treatment Control BMPs. The applicant may refer to Chapter 2.

LID BMP Design Handbook	The LID BMP Design Handbook was developed by the Copermitees to provide guidance for the planning, design and maintenance of LID BMPs which may be used to mitigate the water quality impacts of PDPs within the County.
LID Harvest and Reuse BMP	BMPs used to facilitate capturing Stormwater Runoff for later use without negatively impacting downstream water rights or other Beneficial Uses.
LID Infiltration BMP	BMPs to reduce stormwater runoff by capturing and infiltrating the runoff into in-situ soils or amended onsite soils. Typical LID Infiltration BMPs include infiltration basins, infiltration trenches and pervious pavements.
LID Principles	Site design concepts that prevent or minimize the causes (or drivers) of post-construction impacts, and help mimic the pre-development hydrologic regime.
LID Retention BMP	BMPs to ensure full onsite retention without runoff of the DCV such as infiltration basins, bioretention, chambers, trenches, permeable pavement and pavers, harvest and reuse.
Management Bank	A Bank consisting of regional HMP management projects where PDPs can buy HMP management credits if it is determined that implementing onsite Hydrologic Control BMPs is infeasible.
MEP	Maximum Extent Practicable - standard established by the 1987 amendments to the CWA for the reduction of Pollutant discharges from MS4s. Refer to Attachment C of the 2010 SMR MS4 Permit for a complete definition of MEP.
MF	Multi-family – zoning classification for parcels having 2 or more living residential units.
MS4	Municipal Separate Storm Sewer System (MS4) is 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 CWA 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 (POTW) as defined at 40 CFR 122.26.

MSHCP	Western Riverside County Multi-Species Habitat Conservation Plan
MUSLE	Modified Universal Soil Loss Equation. A mathematical model that describes soil erosion processes
New Development Project	Defined by the 2010 MS4 permit as 'Priority Development Projects' if the project, or a component of the project meets the categories and thresholds described in Section 1.1.1.
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System - Federal 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 CWA.
NRCS	Natural Resource Conservation Service
PDP	Priority Development Project - Includes New Development and Redevelopment project categories listed in Section F.1.d(2) of Order No. R9-2009-0002.
Priority Pollutants of Concern	Pollutants expected to be present on the project site and for which a downstream water body is also listed as Impaired under the CWA Section 303(d) list or by a TMDL.
Project-Specific WQMP	A plan specifying and documenting permanent LID Principles and Stormwater BMPs to control post-construction Pollutants and stormwater runoff for the life of the PDP, and the plans for operation and maintenance of those BMPs for the life of the project.
Q or Qw	Flow
Qcp	Geomorphically critical flow – 10% of the 2-year flow
Qcrit - Qc	Critical flow
Receiving Waters	Waters of the United States.
Redevelopment Project	The creation, addition, and or replacement of impervious surface on an already developed site. Examples include the expansion of a building footprint, road widening, the addition to or replacement of a structure, and creation or addition of impervious surfaces. Replacement of impervious surfaces includes any activity that is not part of a routine maintenance activity where impervious material(s) are removed, exposing underlying soil during construction. Redevelopment does not include trenching and resurfacing associated with utility work; resurfacing existing roadways; new sidewalk construction, pedestrian ramps, or bikelane on existing roads; and routine replacement of damaged pavement, such as pothole repair. Project that meets the criteria described in Section 1.

RGO	Retail Gasoline Outlets: A category 2 PDP less than one acre that uses BMPs to reduce or eliminate pollution
Runoff Fund	Runoff Funds have not been established by the Copermittees and are not available to the Applicant. If established, a Runoff Fund will develop regional mitigation projects where PDPs will be able to buy mitigation credits if it is determined that implementing onsite controls is infeasible.
RWQCB	Regional Water Quality Control Board
San Diego Regional Board	San Diego Regional Water Quality Control Board - The term "Regional Board", as defined in Water Code section 13050(b), is intended to refer to the California Regional Water Quality Control Board for the San Diego Region as specified in Water Code Section 13200. State agency responsible for managing and regulating water quality in the SMR.
SCCWRP	Southern California Coastal Water Research Project
SDRWQCB	San Diego California Regional Water Quality Control Board
Sediment Supply BMP	Site design principles to preserve onsite first-order or higher order streams that have been identified as significant contributors of bed sediment load.
Sediment Supply Performance Standard	Consists of maintaining the pre-project bed sediment supply to the downstream channel reach.
SF	Parcels with a zoning classification for a single residential unit.
Site Design BMP	Site design BMPs prevent or minimize the causes (or drivers) of post-construction impacts, and help mimic the pre-development hydrologic regime.
SMC	Southern California Stormwater Monitoring Coalition
SMR	The Santa Margarita Region (SMR) represents the portion of the Santa Margarita Watershed that is included within the County of Riverside.
SMR	Santa Margarita Region
SMRHM	Santa Margarita Region Hydrology Model
SOHM	South Orange Hydrology Model
Source Control BMP	Source Control BMPs land use or site planning practices, or structural or nonstructural measures that aim to prevent runoff pollution by reducing the potential for contamination at the source of pollution. Source control BMPs minimize the contact between Pollutants and runoff.

Stormwater Credit	Stormwater Credit can be claimed by an Applicant if certain development practices that provide broad-scale environmental benefits to communities are incorporated into the project design. Refer to Section 3.5.4 for additional information on Stormwater Credits.
Structural BMP	Structures designed to remove pollutants from stormwater runoff and mitigate hydromodification impacts.
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
Tentative Tract Map	Tentative Tract Maps are required for all subdivision creating five (5) or more parcels, five (5) or more condominiums as defined in Section 783 of the California Civil Code, a community apartment project containing five (5) or more parcels, or for the conversion of a dwelling to a stock cooperative containing five (5) or more dwelling units.
TMDL	Total Maximum Daily Load - the maximum amount of a Pollutant that can be discharged into a waterbody from all sources (point and non-point) and still maintain Water Quality Standards. Under CWA Section 303(d), TMDLs must be developed for all waterbodies that do not meet Water Quality Standards after application of technology-based controls.
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USEPA	United States Environmental Protection Agency
User	The person using this guidance document to prepare analyze a projects and preparea WQMP
USGS	United States Geological Survey
Volume-Based BMP	Volume-Based BMPs applies to BMPs where the primary mode of pollutant removal depends upon the volumetric capacity such as detention, retention, and infiltration systems.
Wash Load	The portion of the total sediment load carried continuously in suspension by the flow, and generally consists of the finest particles.
Wet Season	The 2010 SMR MS4 Permit defines the wet season from October 1 through April 30.
WQMP	Water Quality Management Plan