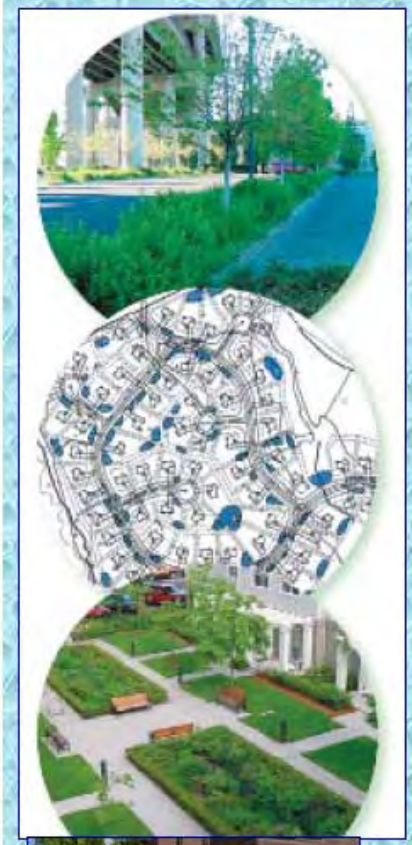

City of Salinas Development Standards Plan

Low Impact Development Designs and Practices for Urban Storm Drainage Management

July 2007

California Environmental Protection Agency
CENTRAL COAST REGIONAL
WATER QUALITY CONTROL BOARD

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Section 1: Introduction

1.0 Purpose and Organization

The purpose of the City of Salinas Development Standards Plan (Salinas DSP) is to present Low Impact Development (LID) planning policies, procedures and design standards that will effectively reduce the volume, rate, and pollutant loading of urban runoff from new development and significant redevelopment in the City and throughout the central coast region. The LID practices presented in the Salinas DSP have been carefully selected to provide a variety of design concepts applicable to the various land uses and climatic zones of the region. The Central Coast Regional Water Quality Control Board (RWQCB) facilitated and funded the development of the Salinas DSP under National Fish and Wildlife Foundation Contract No. 98-289-21. The development and implementation of the Salinas DSP is a requirement of Attachment 4 to RWQCB Order R3-2004-0135 (National Pollutant Discharge Elimination System (NPDES) Permit No. CA0049981) dated 4 February 2005, hereinafter referred to as the Salinas NPDES Permit.

The Salinas DSP is intended to assist planners, developers, engineers, architects, landscape professionals, City staff (development planning, permitting, engineering, parks, and maintenance), City planning commissioners, and others with the selection, siting, design, operation and long-term maintenance of LID practices and structural treatment controls for improving the quality and reducing the quantity of urban runoff and storm water discharges to local creeks, wetlands and rivers. As discussed in the following sections, LID practices and structural treatment controls are storm water Best Management Practices (BMPs) designed to treat and/or infiltrate the amount of runoff produced by the most frequently occurring, relatively small storm events. Therefore, conventional storm drainage facilities must also be included in development projects for the purpose of conveying the larger quantities of runoff that occur from larger storms to prevent flooding.

In addition, the Salinas DSP provides guidance on the policies and procedures that have been developed to meet the Salinas NPDES Permit requirements. Emphasis is placed on design of features and practices that mimic natural hydrologic functions (e.g. LID practices). These include design practices that minimize and disconnect impervious surfaces and facilities that filter runoff through vegetation, soils and organic matter. LID practices capture, slow, and cleanse urban runoff, enhance evapotranspiration, allow biodegradation of pollutants by soil bacteria. Additionally, in locations where existing site soils permit, LID practices can increase infiltration and groundwater recharge. Conventional development and storm drain system designs typically inhibit natural hydrologic functions by creating large areas of impermeable surfaces that prevent infiltration and recharge, increase runoff, provide surfaces for pollutants to accumulate and include pipelines that quickly transport pollutants to streams, rivers, lakes, wetlands and the ocean (e.g. the Monterey Bay National Marine Sanctuary).

LID designs and practices can be applied to most areas of residential, commercial, industrial, and municipal development. LID practices such as vegetated swales and bioretention systems can be incorporated anywhere landscaping occurs in urban development. If designed correctly, these LID practices can be a key amenity for the property, providing both aesthetic qualities and functional storm water management benefits. There are numerous variations of LID designs

that can be incorporated into development and redevelopment projects. Therefore, planning and design professionals and City staff should seek additional training and reference additional guidance documents and sources of information, such as those provided in the Salinas DSP. They should share their design and construction experiences with others in the local development community to improve the success and effectiveness of future projects.

Most LID practices should involve landscape architects and these professionals should be involved in all phases of project planning and design, especially during the conceptual design phase. LID cannot be effectively implemented into development projects if landscape architects are only involved during the final design phase (which is often the case). Landscape architects can be particularly important in redevelopment projects because they are trained not only in the science and aesthetics of plants in urban areas, but they are one of the few professions that can create functional landscaping (e.g. LID) in areas with numerous physical constraints.

Community participation in the planning and construction of LID practices, particularly at redevelopment projects, can also greatly add to the long-term success of a project and increase public awareness of the need to effectively manage storm water quantity and quality. In addition, art installations, public education signs and placards at LID demonstration project sites can also provide additional benefits. A simple art installation designed to capture and convey storm water to a LID treatment system can help the public understand that runoff can be a beneficial resource that can be used to help reduce dependence on potable water for irrigation (in addition to reducing untreated urban runoff from entering the conventional storm drain system and discharging to a nearby stream).

The Salinas DSP is organized as follows:

- Section 1 provides the purpose and organization of the Salinas DSP, its development history, related NPDES permit regulations, the new Salinas development review process, the Salinas DSP program area, documents related to the Salinas DSP, and the process to update and revise the Salinas DSP and provide comments to the City.

- Section 2 provides a general discussion on Low Impact Development (LID) and identifies LID policies and practices that meet the Maximum Extent Practicable (MEP) definition, and those that do not. This section also discusses the benefits and advantages of LID and several key storm water management/LID concepts such as the definition of BMPs, MS4 and MEP, what constitutes Impervious Surfaces, and what are Storm Water Quality Design Storms, Infiltration, Percolation, Amended and Engineered Soils.

- Section 3 presents several LID planning techniques that must be considered in the preliminary design phase of new development projects. This section also provides design information and examples of the techniques that can be used to minimize and disconnect impervious surfaces. Detailed information is also provided on the siting, design, inspection and maintenance requirements of LID practices such as vegetated swales, bioretention systems, permeable pavements and other techniques. Several examples of the experiences other communities have had implementing similar LID practices are also provided.

- Section 4 presents information on LID design considerations such as identifying common pollutant sources in urban development, understanding general shallow soil and groundwater conditions in the Salinas area and the associated design constraints that should be considered when infiltrating urban runoff. Tools are provided to assist with the design and selection of LID practices and structural treatment control BMPs, including an LID planting guide and the NPDES permit required numeric sizing criteria that must be applied to flow and volume-based LID practices and structural treatment control BMPs. Design guidance is also provided for diversion structures that can be applied to LID practices and structural treatment control BMPs to divert urban runoff for treatment and bypass high flows from relatively large storm events. In addition, examples of the LID practices that can be applied to Prority Project Categories are provided. Additional information is also presented regarding design considerations to prevent groundwater contamination, storm water in crawl spaces, mosquito breeding, and slope failures.

- Section 5 presents general information on related source and structural treatment control BMPs for new development and significant redevelopment. This section primarily discusses the related public domain structural treatment control BMPs that can be used with LID practices to meet the NPDES permit required MEP standard. A brief discussion about manufactured (patented) structural treatment control BMPs is also included. However, when used alone, most manufactured systems do not meet the MEP standard.

- Section 6 presents a compilation of the references and additional resource information provided throughout the Salinas DSP. To ensure the success and widespread implementation of LID, planning and design professionals and City staff should seek additional training and reference additional guidance documents and sources of information during the planning, design, construction and maintenance of development projects.

- Appendix A provides a copy of the section of the Salinas NPDES Permit that provides storm water requirements for new development and significant redevelopment in the City (Attachment 4 to RWQCB Order R3-2004-0135).

- Appendix B provides a Model LID Ordinance for Salinas and the Central Coast.

- Appendix C provides a Glossary of the technical/regulatory terms used in the Salinas DSP.

- Appendix D provides a List of Acronyms for the commonly used acronyms in the document.

1.1 State Water Board's LID Policy

On January 20, 2005, the State Water Resources Control Board (SWRCB) adopted sustainability as a core value for all activities and programs of California's nine RWQCBs. The SWRCB also directed the California RWQCBs' staff to consider sustainability in all future policies, guidelines, and regulatory actions.

Per the SWRCB, 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. LID has been a proven approach in other parts of the country and is seen in California as an alternative to conventional storm water management. The RWQCBs are advancing LID in California in various ways:

- Regulation through site-specific and general permits;
- Providing advocacy and outreach to local governments through the RWQCBs' Training Academy and regional workshops;
- Researching how to incorporate LID language into Standard Urban Storm Water Mitigation Plan (SUSMP) requirements;
- Funding LID related projects through the consolidated grants program; and
- Funding through CWA 319 funds to provide for further researching applicability of Impervious Surface Analysis Tool (ISAT) for land use planners and for the California Water and Land Use partnership (CaWaLUP) Center at U.C. Davis.

The SWRCB and the RWQCBs are key partners of the CaWaLUP (http://cawalup.usc.edu/), a collaborative effort made up of representative staff from government agencies, non profits, and academia, which aims to improve how water resource implications of land use are considered in California's local government decisions.

1.2 NPDES Storm Water Permit Regulations

Implementation of National Pollutant Discharge Elimination System (NPDES) Storm Water Permit regulations is mandated under both federal and state regulations (the U.S. EPA, the SWRCB, and the RWQCB). In 1987, Congress amended the Federal Water Pollution Control Act (also known as the Clean Water Act) in order to protect receiving water bodies from the impacts of urban runoff. The amendments established a framework for regulating municipal and industrial storm water discharges under the NPDES. According to the Clean Water Act mandate, municipalities regulated under the NPDES must reduce pollutant loadings in municipal separate storm sewer systems (MS4s) to the "maximum extent practicable" (MEP) and must effectively prohibit non-storm water discharges through their MS4s as a first step toward achieving pollutant loading reductions consistent with applicable water quality standards (U.S. EPA, 1997). Widespread implementation of storm water best management practices (BMPs) is required to meet the MEP standard. Detailed definitions of what constitutes an MS4, the various types of storm water BMPs, and the MEP standard are provided in Section 2.5 of the Salinas DSP.

The Central Coast RWQCB is the lead state agency responsible for protecting water quality in the Central Coast Region of California. The RWQCB has the authority to enforce regulatory policies and statutes under the Clean Water Act, the California Porter-Cologne Water Quality Control Act and the Central Coast Regional Water Quality Control Plan.

The following discussion presents a summary of Attachment 4 to the Salinas NPDES Permit (presented in Appendix A). For convenience, simplified explanations of some of the regulatory/statutory text provided in the permit have been provided. In the event of a conflict, the text and definitions found in the Salinas NPDES Permit take precedence.

The primary requirement of the Salinas NPDES Permit is the effective reduction in the volume, rate and pollutant loading of urban runoff draining to the City's municipal storm drain system (MS4) and discharging to receiving water bodies. With respect to new development and significant redevelopment in the City, Attachment 4 to the Salinas NPDES Permit requires that short and long-term water quality impacts on receiving waters be minimized through the City's review and update of its existing planning and development program. Per Attachment 4 the City is required to implement the following measures:

1. Require developers to analyze pre-and post-project pollutant loads and peak flow rates, and identify the Best Management Practices (BMPs) to be implemented;

2. Describe the BMPs that can be used in a Development Standards Plan (DSP);

3. Review and condition for compliance all "Priority Project Categories" and require the incorporation of structural treatment control BMPs and non-structural BMPs (source controls) as necessary to mitigate the projected increases in pollutant loads and peak flow rates;

4. Minimize the amount and direct connection of impervious surfaces;

5. Infiltrate runoff on-site where appropriate soil conditions exist and where infiltration of storm water will not pose a potential threat to groundwater quality;

6. Implement pollution prevention and source control measures as a first line of defense;

7. Preserve, create or restore riparian corridors, wetlands and buffer zones;

8. Implement structural treatment controls where necessary and where pollution prevention and source control measures are not sufficient to protect receiving water quality.

<u>Priority Project Categories</u>

Per Section III of Attachment 4 to the Salinas NPDES Permit (Appendix A), the City of Salinas is required to implement practices and policies that minimize the short and long-term impacts on receiving water quality from new development and significant redevelopment (defined as the creation or addition of at least 5,000 square feet of impervious surfaces on an already developed site). Specifically the City must review and condition for compliance the following Priority Project Categories:

1. Residential developments with 10 or more units;

2. Commercial developments that create 100,000 ft^2 or more impervious land area;

3. Automotive repair shops (≥ 5,000 ft^2);

4. Restaurants (≥ 5,000 ft^2);

5. Hillside developments (≥ 5,000 ft^2);

6. Parking lots (≥ 5,000 ft^2);

7. Streets, roads, highways, and freeways that create 5 or more acres of pavement; and,

8. Retail gasoline outlets (≥ 5,000 ft^2)

As noted above, these Priority Project Categories are required to incorporate structural treatment control BMPs and non-structural BMPs (source controls) as necessary to mitigate the projected increases in urban runoff pollutant loads, flow rates and volumes.

For additional details on Priority Project Categories, please reference the Salinas NPDES Permit in Appendix A.

Numeric Sizing Criteria

The Salinas NPDES permit requires the application of numeric sizing criteria to the volume- and flow-based treatment control BMPs proposed for any of the above Priority Project Categories. The required numeric sizing criteria is discussed in detail in Section 4.4 of the Salinas DSP.

Pollutants of Concern

When selecting structural treatment control BMPs, planners and designers of Priority Project Categories must consider the following:

1. Target pollutants;

2. Pollutants associated with different land uses;

3. Post-development changes in runoff volumes and flow rates; and

4. Sensitivity of receiving waters to changes in runoff volumes and flow rates and the potential for downstream erosion and stream habitat degradation.

Local pollutants of concern include:

- Fecal Coliform and Nitrate (per 303(d) list);

- TDS, Cl, CO_4, B and Na (per Water Quality Objectives for the Salinas River and the Gabilan Tributary, Central Coast Regional Water Quality Control Plan, 1994); and,

- Sediment from construction sites

General urban pollutants of concern that may be contained in storm water include heavy metals; pathogens; petroleum hydrocarbons; polycyclic aromatic hydrocarbons (PAHs), trash, pesticides, herbicides, and nutrients that cause or contribute to the depletion of dissolved

oxygen and/or impaired conditions in receiving water quality. Increased flows from urban development may cause or contribute to downstream erosion and/or excessive sediment discharge and deposition in receiving waters. Additional information about common sources of urban storm water pollutants and estimating pollutant loads is presented in Section 4.0 of the Salinas DSP.

Potential Impacts on Groundwater Quality

Planners and designers of Priority Project Categories must also consider potential impacts on groundwater quality if direct or indirect storm water infiltration facilities are proposed. Restrictions on these structural treatment control BMPs include the following:

- Storm water infiltration practices must not to be used in drainage areas that include industrial or commercial sites with outdoor storage of materials and/or chemicals;
- Existing site soil infiltration rates must be tested and yield percolation rates of at least 0.5 inches/hour, but not be greater than 3.0 inches/hour (120 to 20 minutes/inch).
- There must be a minimum separation of 5 feet between the bottom of a proposed storm water infiltration practice and the seasonally high groundwater level.
- Storm water infiltration practices must be located at least 100 feet from drinking water supply wells; and,
- Storm water infiltration practices must be located at least 500 feet from underground storage tanks (UST's) and areas of known groundwater contamination, such as the Leaking Underground Fuel Tank (LUFT) sites.

Additional design criteria and potential setback exemptions for storm water infiltration practices are presented in Sections 4.2, 4.4, and 4.8 of the Salinas DSP.

Maintenance Agreements

Priority Project developers and land owners must also establish maintenance agreements for post-construction structural treatment control BMPs and ensure the transfer of maintenance responsibilities occurs when land ownership changes occur. The City of Salinas shall require verification of maintenance provisions for structural treatment control BMPs by implementing the following measures:

1. Developers must sign a statement accepting responsibility for maintenance until the maintenance responsibility is legally transferred to another party; or
2. Written conditions must be included in the sales or lease agreement that require the recipient to assume responsibility for maintenance; or
3. Written text must be included in project conditions, covenants and restrictions (CC&R's) for residential developments that assign maintenance responsibilities to a home owner's association (HOA), or another appropriate group, for the maintenance of structural treatment control BMPs; or

4. Implementation of any other legally enforceable agreement that assigns responsibility for maintenance of structural treatment control BMPs.

The City of Salinas will utilize Maintenance Assessment Districts to ensure the long-term regular maintenance of structural treatment control BMPs located on private property. Maintenance Assessment Districts are currently used by private property owners to fund storm drain system maintenance, including detention/retention ponds.

Waiver Program & Regional Storm Water Mitigation Fund

The City will propose a waiver program and/or a regional storm water mitigation fund with the approval of the RWQCB. The waiver program could potentially allow for a project to be waived from requirements to implement LID practices and structural treatment control BMPs if infeasibility can be established. A regional or sub-regional storm water mitigation program could potentially substitute in part or wholly for the Development Standard requirements noted above. The RWQCB may consider for approval such a program if its implementation will:

1. Improve storm water quality and protect stream habitat;
2. Promote cooperative problem-solving by diverse interests;
3. Be fiscally sustainable via secured funding; and,
4. Be completed in five years, including the construction and start-up of treatment facilities.

Additional details and requirements for establishing a Waiver Program and a Regional Storm Water Mitigation Fund are presented in Sections III d. and e. of Attachment 4 (Appendix A).

1.3 Salinas Development History

The City has experienced significant new development in the past several years. There are several large developments planned for the northern and eastern areas of the City. These large developments pose both water quality challenges and opportunities with respect to LID. Current agricultural land uses can negatively impact water quality through soil loss, fertilizer use, and pesticide/herbicide application. Conversion to urban land uses has the potential to improve some of these water quality concerns such as a reduction in soil erosion. However, urban land uses can pose different water quality challenges. As discussed in Section 4.0 of the Salinas DSP, a wide variety of pollutants can be deposited on manmade impervious surfaces and incorporated into urban runoff that enters the storm drain system and discharges into local waterways. Through the use of LID techniques, it is intended that net water quality impacts from these new development areas are reduced.

As noted above, the RWQCB is the lead state agency responsible for protecting the water quality of the Central Coast Region. To protect the receiving waters of the Salinas area, the RWQCB has required the City to develop and submit for public review and comment, and RWQCB approval, the Salinas DSP. This document is intended to describe the source control and structural treatment control BMPs that are to be implemented at all new development and significant redevelopment projects in the City that fall under the Priority Project Categories noted above. LID designs and practices can serve as both source and structural treatment control

BMPs. Section 2.5 of the Salinas DSP provides a detailed discussion about the concept of BMPs and the range of BMPs that must be implemented to meet the required MEP standard.

Development of the Salinas DSP began in May 2006. Kennedy/Jenks Consultants met with RWQCB and City staff to exchange information and develop an approach and schedule to complete the Salinas DSP. Technical memoranda were developed and public workshops were presented to facilitate public education and participation. Draft and final technical memoranda were developed on the following subjects:

1. Review of City of Salinas Policies and Procedures for Conformance with LID Principles and NPDES Permit Requirements;

2. Review of Surface Soil and Shallow Groundwater Conditions and the Feasibility of Infiltrating Urban Runoff in the Salinas Area; and,

3. Model Low Impact Development (LID) Ordinance for Salinas and the Central Coast.

The final technical memoranda formed the basis for the development of the Salinas DSP. The workshop presentations have been posted on the RWQCB's website (http://www.swrcb.ca.gov/rwqcb3/SWNEW/PhaseI/Municipal/index.htm).

1.4 Model Development Review Process

The Salinas NPDES Permit requires the Priority Project Categories (listed in Section 1.2) to meet specific standards. These include the incorporation of storm water BMPs to protect receiving water bodies from increased pollutant loads and increases in the rate and volume of runoff from new development and redevelopment projects. The development review process for storm water BMPs relates to project design, environmental review, permit conditions, and construction management. The type and location of storm water BMPs are site and project specific; therefore, they will vary based upon the project's design and the potential impact to urban runoff and receiving water quality.

Since the conditions of the Salinas NPDES Permit may be used as a model and applied to other areas of the Central Coast, the following presents the Model Development Review Process for Priority Project Categories in the City of Salinas and other areas.

Step 1 – Conceptual Project Development Process: Development processing begins with land use review by applicable City/County agency planning staff. For relatively large or complex projects, and for applicants new to the process, a pre-application meeting is an advisable first step. As NPDES storm water management requirements and BMPs such as LID practices are new to City/County staff and the public, a pre-application meeting is recommended for all Priority Project Categories until procedures are well established. Staff should review proposed land uses, discuss site constraints, opportunities, and necessary BMPs (as well as other requirements) and potential design options. Additional information should be provided to applicants as needed. The pre-application meeting affords early dialogue about project opportunities and constraints, and can avoid unnecessary delays.

The submittal of a draft Storm Water Control Plan may be required as part of the initial step for planning and zoning review. In addition to presenting design concepts and BMPs to reduce the

volume, rate and pollutant loading of runoff from the proposed development, the benefits of submitting a draft Storm Water Control Plan during planning and zoning review potentially include:

- Reduced overall project costs;
- Expedited project review;
- Improved site design;
- A cost effective approach to achieving the required MEP standard; and,
- Avoiding unnecessary site redesign and project delays.

Applicants proposing to construct vegetated LID practices (e.g. vegetated swales, bioretention systems, storm water ponds and wetlands) should consider involvement of landscape design professionals during the conceptual design phase as well as later phases of the project. Landscape architects can assist with the siting and preliminary design of vegetated LID practices which are most effective when considered early in the development process.

Step 2 – Planning Permit Process: Once the project application is deemed complete, City/County planning staff should review the proposed development for conformity with local codes, ordinances, and standards, and related state and federal requirements. They should solicit comments from other municipal departments such as fire, police, water resources, and others. Comments from these various municipal disciplines should be considered and selected projects should be discussed at a Design Review Committee (DRC) meeting. DRC recommendations may result in project amendments or Conditions of Approval (COA's). Projects requiring post-construction structural treatment control BMPs may be recommended for approval only after all applicable requirements have been satisfactorily incorporated in project plans (including the draft Storm Water Control Plan), specifications and permit conditions. Applicable projects should be required to include the environmental review procedure prescribed under the California Environmental Quality Act (CEQA). City/County planners should review the applicant's draft Storm Water Control Plan as part of the CEQA environmental review process.

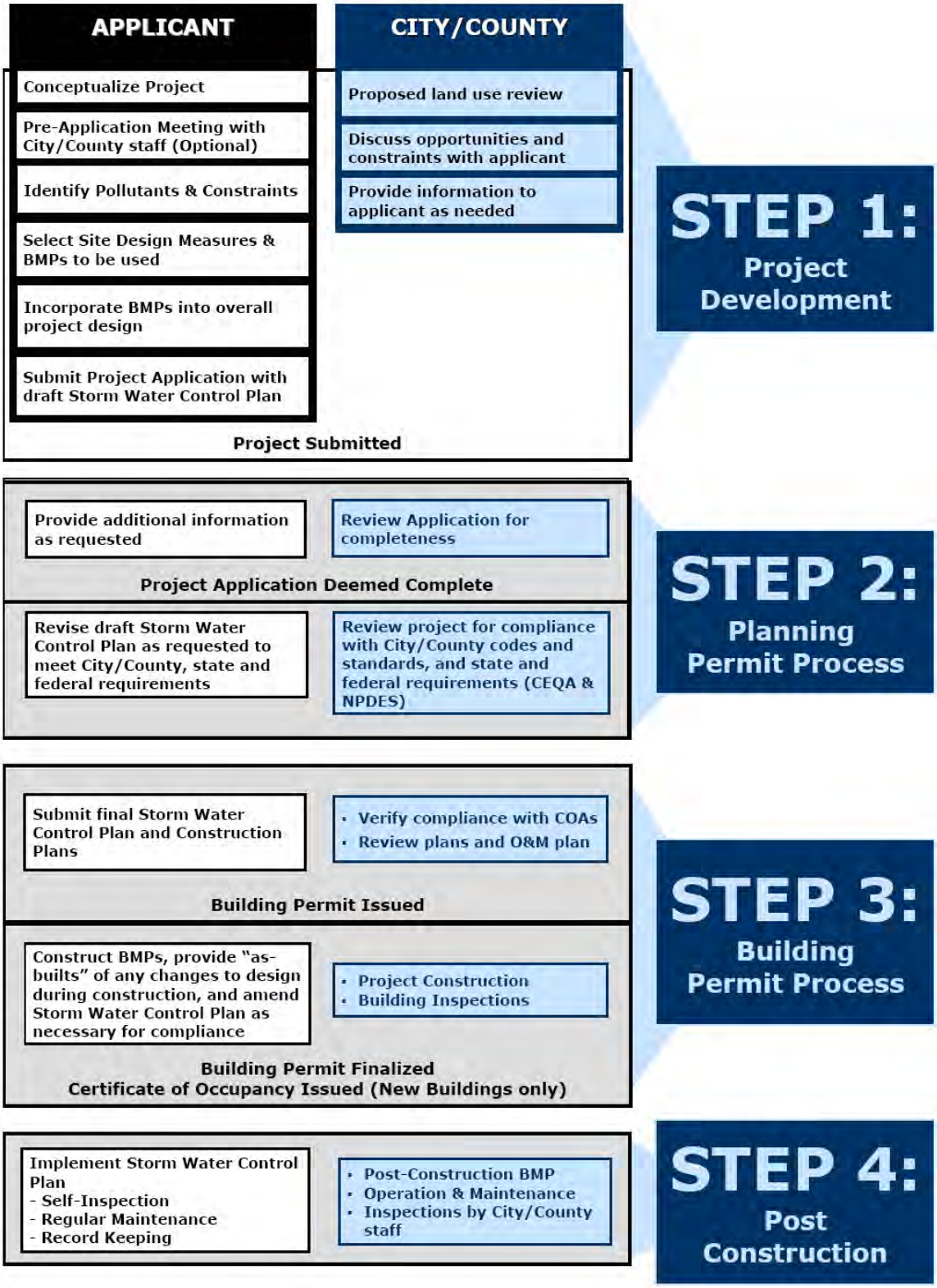
Requirements to implement BMPs should be based upon a determination of the potential for significant adverse impacts to: 1) water quality and 2) ambient flow volumes and velocities to downstream beneficial uses, or municipal/county storm drain systems. When City/County planners determine that potentially significant impacts are present, they should require that mitigations, and project conditions including BMPs to reduce impacts to "acceptable levels" be added. "Acceptable levels" are defined as levels that conform to the Salinas General Plan, the Water Quality Control Plan, the Central Coast Region (Basin Plan), the NPDES Permit, and the jurisdictions Storm Water Management Plan. If potential significant impacts are present and can not be easily mitigated; City/County staff may require preparation of an Environmental Impact Report (EIR) per CEQA regulations.

Step 3 – Building Permit Process: During the building plan, construction permit, and plan check process, City/County staff should review non-discretionary and previously approved discretionary projects for adequacy of land planning and development (post-construction) BMPs. City/County staff should ensure that storm water BMPs included under planning review are carried forth and incorporated into construction drawings/plans, specifications and

conditions (and the final Storm Water Control Plan). In addition, City/County staff should identify needs and add other storm water BMPs as needed to meet erosion control, engineering, or other NPDES Permit requirements. Changes to the project post-discretionary approval should also be reviewed. During this phase of the project, long-term post-construction BMP inspection, operation and maintenance policies and procedures should be established. Maintenance methods and responsibilities must be identified in writing and approved as part of permit conditions prior to permit issuance. In addition, the mechanism(s) necessary to assure the maintenance of construction and/or post-construction BMPs must be fully executed prior to the commencement of construction.

Step 4 – Post Construction: Project applicants should assure the adequacy of the inspection, operation and maintenance of permanent storm water BMPs during construction and throughout life of project. Maintenance of structural treatment controls and other storm water controls should be the responsibility of the property owner, unless an alternative agreement is formally approved by the City/County. The City/County may consider in-lieu maintenance provisions, such as payment of a perpetual fee in an amount sufficient to cover full maintenance cost. Such transfer requests shall include an itemized cost analysis signed by the applicant (or their agent). Full cost recovery should include an escalation provision to reflect inflationary effects. Adequacy of assurance should be determined by staff and may include the posting of performance bonds, construction details, site management BMPs and/or other means.

Where post-construction storm water BMPs are not maintained and they can become a public health and safety hazard and/or a source of storm water pollution. Therefore the City/County should consider enforcement and penalty procedures such as fines and/or referral to the County Health Department and the RWQCB. The City/County may also conduct the necessary corrective actions and take legal actions against the property owner to recover the costs.


APPLICANT
CITY/COUNTY
Conceptualize Project
Pre-Application Meeting with City/County staff (Optional)
Identify Pollutants & Constraints
Select Site Design Measures & BMPs to be used
Incorporate BMPs into overall project design
Submit Project Application with draft Storm Water Control Plan
Proposed land use review
Discuss opportunities and constraints with applicant
Provide information to applicant as needed
Project Submitted
STEP 1: Project Development
Provide additional information as requested
Review Application for completeness
Project Application Deemed Complete
Revise draft Storm Water Control Plan as requested to meet City/County, state and federal requirements
Review project for compliance with City/County codes and standards, and state and federal requirements (CEQA & NPDES)
STEP 2: Planning Permit Process
Submit final Storm Water Control Plan and Construction Plans
• Verify compliance with COAs
• Review plans and O&M plan
Building Permit Issued
Construct BMPs, provide "as-builts" of any changes to design during construction, and amend Storm Water Control Plan as necessary for compliance
• Project Construction
• Building Inspections
Building Permit Finalized
Certificate of Occupancy Issued (New Buildings only)
STEP 3: Building Permit Process
Implement Storm Water Control Plan
- Self-Inspection
- Regular Maintenance
- Record Keeping
• Post-Construction BMP
• Operation & Maintenance
• Inspections by City/County staff
STEP 4: Post Construction

1.5 Salinas DSP Program Area

The Salinas DSP applies to areas of new development and redevelopment within the City of Salinas that fall under the Priority Project Categories noted in Section 1.1 above. Per the Salinas NPDES Permit, the receiving waters subject to municipal storm water discharges in the City include Santa Rita Creek, Gabilan Creek, Natividad Creek, Alisal Creek and their tributaries. Alisal Creek is renamed the Reclamation Ditch within the City. These receiving waters discharge to Espinosa and Tembladero Sloughs which in turn discharge to the Old Salinas River. Storm water from the southernmost portion of the City discharges to the main Salinas River channel, via a lift station. The main Salinas River, Espinosa and Tembladero Sloughs, discharge into the Old Salinas River channel in the summer, which discharges to Monterey Bay. The main Salinas River discharges directly into Monterey Bay in the winter.

1.6 Documents Related to the Salinas DSP

The Salinas DSP is intended to be used during the planning and design phase of new development and redevelopment projects in the City of Salinas. It should also be used as a general guidance document to assist owners with understanding the proper operation and long-term maintenance of their LID practices and structural treatment control BMPs. During the design of these facilities, the designer should cross-reference the City's current drainage design manual to ensure consistent technical approaches and related policies and procedures are applied. This information is currently contained in the following document:

- The City of Salinas Standard Specifications, Design Standards and Standard Plans

The other relevant documents that relate to the design and permitting of development and redevelopment projects, and associated drainage, flood control and storm water management facilities in the City of Salinas include the following:

- The City of Salinas Storm Water Ordinance
- The City of Salinas Zoning Code
- The City of Salinas Grading Ordinance
- The Salinas General Plan
- The City of Salinas Storm Water Management Plan

1.7 Updates and Revisions

The RWQCB requires the City to implement LID practices and structural treatment control BMPs that effectively reduce the volume, rate, and pollutant loading of urban runoff to the Maximum Extent Practicable (MEP). Since the science and technology of LID and structural treatment control BMPs is evolving and new and innovative BMPs continue to be developed, the City is required in its NPDES permit to periodically review and approve new or innovative BMPs to meet the MEP standard. New approved BMPs may be periodically added to the City's website (http://www.ci.salinas.ca.us/index.html). In addition, the City will review and update the Salinas DSP a minimum of once every five years. This schedule will ensure that the review and update process occurs at least once during each five-year NPDES storm water permit cycle.

The review process must consist of two tasks; a technical review of the new LID practices and structural treatment control BMPs used locally, by other communities and recommended by the RWQCB and the U.S. EPA; and a procedural review of how well the Salinas DSP is being implemented in the City. Developers, planners, design engineers and contractors, as well as agency plan review, permitting, engineering and inspection staff should be consulted to determine potential deficiencies and suggested improvements.

1.8 Comments and Distribution

Comments and questions on the Salinas DSP may be directed to:

City Engineer
200 Lincoln Avenue
Salinas, CA 93901-2639
Phone: (831) 758-7432
Fax: (831) 758-7241

1.9 Disclaimer

The City of Salinas Development Standards Plan (Salinas DSP) has been developed and reviewed in accordance with the standard of professional care for civil engineers for identification of errors, omissions, and other related issues, but do not expect perfection. As with the release of any new publication, it is likely that some nonconformities, errors or omissions will be discovered. The developers of the Salinas DSP welcome user feedback in helping to identify any problems so that improvements can be made to future releases. The user should refer to Section 1.7 above and check the City of Salinas website (http://www.ci.salinas.ca.us/index.html) for contact information to supply user feedback and information on updates and revisions to the Salinas DSP.

The Salinas DSP is intended to assist with the consistent design and review of Low Impact Development (LID) practices and structural treatment control BMPs to reduce pollutant loadings and the volume and rate of urban runoff to receiving waters such as Santa Rita Creek, Gabilan Creek, Natividad Creek, and Alisal Creek/Reclamation Ditch. The details and design standards provided in the Salinas DSP are intended to show design concepts. Preparation of final design plans, addressing details of structural adequacy, public safety, hydraulic functionality, maintainability, plant and soils specifications, and aesthetics, remain the sole responsibility of the designer. To be effective, it is recommended that LID practices and structural treatment control BMPs are planned and designed concurrently with conventional storm drainage and flood control facilities. Engineers and landscape architects are also encouraged to work together in the design of LID practices and structural treatment control BMPs that include soil amendments and vegetation (e.g. buffer strips, swales and bioretention basins) to effectively reduce the rate, volume and pollutant loading of urban runoff and that can serve to convey flows from large runoff events.

By use of the Salinas DSP the user agrees to the following:

1. The City of Salinas, its contractors, advisors, reviewers, and Kennedy/Jenks Consultants do not warrant that the Salinas DSP will meet the users requirements, or that the Salinas DSP will be free from errors or omissions.

2. To the maximum extent permitted by applicable law, in no event shall the City of Salinas, its staff, consultants, contractors, advisors, reviewers, or Kennedy/Jenks Consultants be liable for any damages whatsoever, whether, general, incidental, special, punitive, exemplary, or consequential (including, without limitation, damages for any liabilities, losses, claims, actions or proceedings, reasonable attorneys' fees, loss of business profits, business interruption, loss of business information or other pecuniary loss) arising out of the use or inability to use the Salinas DSP.

Section 2: Low Impact Development (LID)

2.0 What is LID?

Low Impact Development (LID) represents the storm drainage component of sustainable development. It is an innovative storm water management approach with the basic principle that is modeled after nature: manage runoff from rainfall and urban use of water at the source using uniformly distributed decentralized small scale controls, also known as integrated management practices (IMPs). IMPs are small on-lot treatment control BMPs that are integrated into the site layout, landscaping and drainage design of urban development. LID was pioneered in Prince Georges County, Maryland in the 1980's and has been applied successfully across the country and in Europe and Australia. Village Homes in Davis is one of the older examples of a residential LID design in California. The primary goal of LID is to mimic a site's pre-development hydrology by using design practices and techniques that effectively capture, filter, detain, infiltrate, and evaporate runoff close to its source. Pre-development hydrology is defined as the rate, volume and quality of runoff that would have occurred from the land surface prior to any land disturbing human activities such as agriculture or urban development. LID practices that mimic a site's predevelopment hydrology can be accomplished by implementing the following basic principles:

1. Protect natural drainageways, areas of native vegetation and high value open space, and direct runoff to soils that support infiltration;
2. Reduce the amount of compacted soil and continuously connected hard surfaces in site designs;
3. Create site design features that direct runoff to vegetated areas with engineered soils; and,
4. Educate staff, designers, and landowners about the function of LID practices and the need to maintain the viability of these practices so that they continue to function as designed.

This order mirrors the order of events that a developer/designer would undergo to apply LID and the actions that municipal and regulatory agency staff must apply to ensure the successful long term performance of LID practices.

Protecting natural drainage features and incorporating them into the site design is highly desirable in LID designs. Since natural drainage features such as swales and drainage coursers often have developed soil structures that formed over long periods of time, they can be utilized in the design of LID practices such as vegetated swales and often function much more efficiently than vegetated swales installed on imported fill materials. Conventional development techniques often remove native vegetation, reduce open space and fill natural drainage features; therefore LID strives to preserve particularly high value open space areas such as wetlands, natural riparian corridors and soils with good groundwater recharge potential. LID also strives to minimize the amount of land disturbance to only those areas necessary for construction of structures (often referred to as site fingerprinting).

Figure 2-1 presents a comparison between the way urban runoff is typically managed in a conventional residential development and an LID landscaping approach. In the conventional

development model, impervious surfaces (roofs, driveways, sidewalks, and compacted soils), and elevated (convex) landscaped areas that drain to impervious surfaces, increase runoff and pollutant discharges to the storm drain system. This approach typically results in an inefficient use of water resources and a system that drains water and other resources (e.g. topsoil and fertilizers) away and into local waterways. In the LID approach, runoff from impervious surfaces drains to depressed (concave) landscaped areas with amended soils and only runoff from relatively large storm events discharges to the storm drain system. With the LID landscaping approach, the rate, volume and pollutant loading of urban runoff can be reduced to pre-development levels and the biological and physical integrity of local waterways can be preserved and maintained.

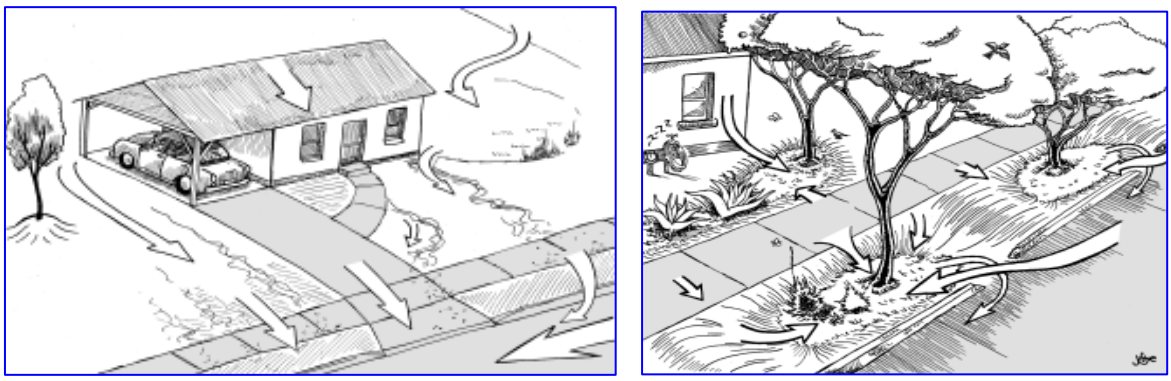
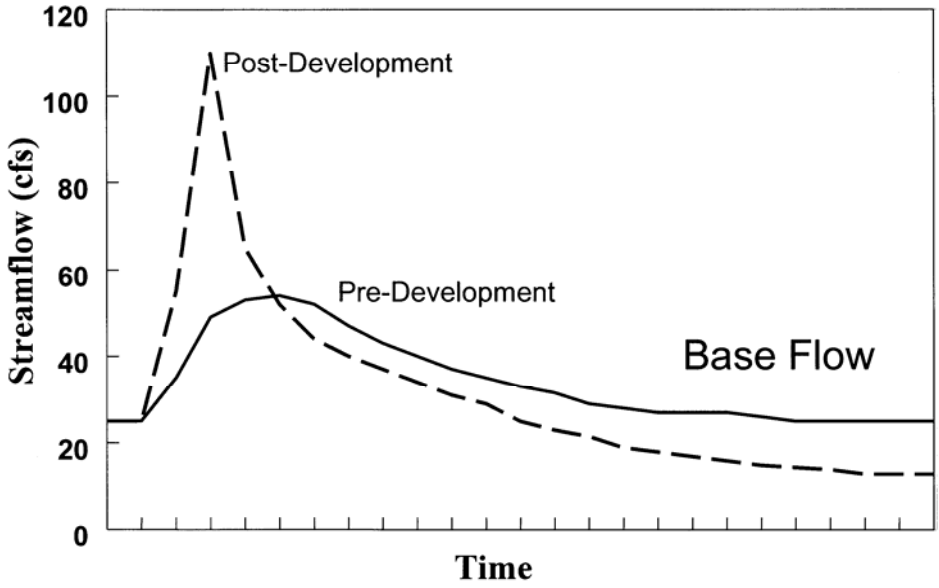


Figure 2-1: Comparison of urban runoff from a conventional development and an LID approach. Graphics source: www.harvestingrainwater.com

Although the term LID is relatively new, the concept of incorporating design features into structures and the landscape for the purpose of capturing rainfall and runoff for beneficial purposes is very old, dating back to the beginnings of agriculture. This concept is often referred to as “Rainwater Harvesting” and includes the use of rain barrels and cisterns to capture, store and reuse roof runoff; and the creation of berms and depressed areas to divert and capture runoff to reduce the need for supplemental irrigation and improve plant health and crop yields. Several Cities in the arid southwest U.S. are rediscovering and encouraging the use rainwater harvesting techniques as a method to conserve water. Cities such as Tucson, AZ and Albuquerque, NM have an extensive amount of information available online about harvesting rainwater for landscape use.

As noted previously, conventional development and storm drainage system designs typically increase the rate, volume and pollutant loading of urban runoff, which often results in negative environmental impacts to local surface water resources. This occurs because man made impervious surfaces such as roofs, driveways, sidewalks, and compacted soils are often directly connected to each other. Runoff from directly connected impervious surfaces often drains to impervious curb and gutter systems, which then drain to storm drain inlets and a network of impervious underground pipes that discharge directly local waterways untreated. Conventional storm drain systems are designed as storm water disposal systems which efficiently drain urbanized areas and rapidly transport storm water to receiving waters. However, they also increase peak flow rates and volumes, rapidly transport pollutants, and cause downstream erosion and stream habitat degradation.

Figure 2-2 provides an example of the response of stream flow to urbanization and conventional storm drain system design within a hypothetical watershed. A watershed is defined as all the land area that contributes runoff to a particular point along a waterway. Figure 2-2 is a hydrograph, which is a graph of runoff flow rate plotted as a function of time. As can be seen on the hydrograph, runoff from conventional development typically increases the peak flow rates of urban area streams, which increases erosion. The volume of runoff, which is represented by the area under the curve, also increases and is typically not mitigated by conventional flood control structures such as detention basins. Development also leads to a reduction in natural land surfaces that previously infiltrated a portion of the annual rainfall into pervious soils. This water recharged groundwater and slowly discharged to streams and rivers. The result is that streams in urban areas with conventional development tend to dry up between storm events, but experience higher flows during storm events, further increasing erosion, changes to stream channel morphology, and loss of stream habitat. Figure 2-2 also demonstrates the typical decline in stream base flows that often occurs in response to urbanization and decreased recharge. Although the model for conventional development and storm drain system design has been in place in the U.S. for at least the last 50 years, the U.S. EPA, the SWRCB and the RWQCB are now requiring a different model to mitigate the effects of urbanization and increased impervious surfaces.



Source: Center for Watershed Protection

Figure 2-2: Streamflow response to conventional urbanization within a hypothetical watershed.

LID practices are based on the premise that storm water management should not be seen as merely storm water disposal. Instead of conveying the majority of runoff into underground pipes and managing and treating storm water in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses urban runoff through small, cost-effective landscape features located at the lot level. Although not technically considered LID, redundant semi-regional or regional facilities such as relatively large LID practices and/or the structural

treatment control BMPs presented in Section 5 can also be incorporated into site designs to provide additional storm water management benefits. These facilities can provide additional treatment (e.g. a treatment train) and offset lot level practices that may not be maintained or are modified by private landowners, such as an on-lot bioretention system or a vegetated swale that has been filled in by a homeowner. Redundant semi-regional or regional facilities can also be designed to function as flood control facilities. Examples of semi-regional or regional facilities include, but are not limited to, a bioretention basin for a residential neighborhood block located in the City ROW or subsurface storm water wetland cells in a flood control detention basin. Maintenance of semi-regional and regional facilities can often be more effectively controlled and secured by municipalities. In the City of Salinas, semi-regional or regional facilities located on private property will be maintained by Maintenance Assessment Districts supervised by the City.

Almost all components of the urban environment have the potential to serve as LID practices. This includes the rooftops, streetscapes, parking lots, driveways, sidewalks, medians and the open spaces of residential, commercial, industrial, civic, and municipal land uses. Anywhere landscaping can be applied also presents an opportunity for implementation of LID practices. LID is a versatile approach that can be applied equally well to new development, urban retrofits, redevelopment, and revitalization projects. Local hydrologic and geotechnical conditions, land uses and regulatory requirements must be considered in the design of LID practices.

LID is one of several new urban planning techniques. It differs from other techniques such as “Smart Growth” and “Sustainable Development” in that LID is primarily focused on alternative storm drainage techniques. Smart Growth is a term that describes the efforts of communities across the country to manage and direct growth in a way that minimizes damage to the environment and builds livable and economically sustainable towns and cities. Livability suggests, among other things, that the quality of our built environment and how well we preserve the adjacent natural environment directly affects our quality of life. Smart Growth calls for the investment of time, attention, and resources in central cities and older suburbs to restore community and vitality. It advocates patterns for newly developing areas that promote both a balanced mix of land uses and a transportation system that accommodates pedestrians, bicycles, transit and automobiles.

Sustainable Development is a term that grew out of the conservation/environmental movement of the 1970's. While the conservation/environmental movement asked questions about preserving the Earth's resources, Sustainable Development includes questions about how human decisions affect the Earth's environment. A sustainable community preserves and enhances the quality of life of residents both within and between communities, while minimizing local impacts on the natural environment. By recognizing the interdependent relationships between the natural, social, and economic parameters of a community, Sustainable Development creates conditions that strengthen the health of all. Dependent on partnerships between governments, researchers, businesses, and community members, Sustainable Development involves an inclusive and expansive decision-making process that considers long-term economic, ecological, and social prosperity.

LID addresses the drainage component of new development and redevelopment projects by implementing practices that mitigate the increased volume, rate, and pollutant loading of urban runoff. LID practices mimic natural hydrologic functions by filtering urban runoff through vegetation, soils and organic matter, allowing evapotranspiration by vegetation, biodegradation

of pollutants by soil bacteria, infiltration and groundwater recharge. LID practices that mimic natural hydrologic functions include green roofs, vegetated swales, bioretention basins and permeable pavements. With the exception of green roofs, these LID practices can indirectly infiltrate urban runoff into underlying soils and eventually reach groundwater. Protection of groundwater quality is of utmost importance when designing storm water infiltration systems. However, the potential to contaminate groundwater by infiltrating urban runoff in properly designed and constructed treatment control BMPs with proper pretreatment is low[1]. In addition, surface soils are typically very effective at urban runoff pollutant removal and retention because a multitude of natural processes occur, including physical filtering, ion exchange, adsorption, biological processing, conversion, and uptake. In addition to providing water quality benefits and increasing groundwater recharge, LID practices can also reduce flooding potential and assist with water conservation. The RWQCB supports the use of LID practices because they meet the "maximum extent practicable" (MEP) definition for management of storm water quality and have been proven to be effective, feasible and economically practicable in other communities.

The way we design and build urban developments has a direct effect on the hydrology and water quality of a watershed and its natural water systems. The RWQCB supports the use of LID practices because they have been proven to be effective at reducing the rate, volume and pollutant loading of urban runoff in other communities and are economically feasible. LID practices also meet the RWQCB's definition of MEP, discussed in Section 2.5 below.

Community participation in the planning and construction of LID practices, particularly at redevelopment projects, can greatly add to the long-term success of a project and increase public awareness of the need to effectively manage storm water quantity and quality. Public education signs and placards installed at LID project sites also provide additional benefits.

2.1 What is Not LID?

Conventional urban development and storm drainage system design is not LID because it typically increases the rate, volume and pollutant loading of urban runoff. Conventional storm drainage systems typically consist of impervious streets, parking lots, sidewalks, driveways, and roofs that are directly interconnected to drain to impervious curb and gutter systems and discharge to storm drain inlets and a network of impervious underground pipes. Conventional flood control detention basins are also not LID because they are typically designed to only reduce the peak flow rates of runoff from the relatively large storm events (e.g. the 25, 50, or 100-year storm event). They typically do not reduce pollutants in urban runoff, and unless sited on permeable soils that have not been compacted, conventional flood control detention basins typically do not allow significant infiltration and groundwater recharge (therefore they typically do not significantly reduce the volume of runoff from developed areas). In addition, conventional landscaping that consists of mounded areas that drain onto impervious surfaces is not LID. To be considered LID, landscaping must be depressed and below the grade of adjacent impervious surfaces. LID landscaping must also be designed with amended or engineered soils that provide sufficient infiltration and pollutant removal characteristics.

[1] Pitt et al., 1994. Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration, U.S. Environmental Protection Agency's Risk Reduction Engineering Laboratory, May 1994. EPA/600/SR-94/051.

Some public domain, and most manufactured (proprietary), structural treatment control BMPs (presented in Section 5) are also typically not considered LID practices because most do not meet the MEP definition. When these devices are constructed of concrete enclosures, such that they do not allow infiltration through soils and/or water uptake by soils and plants, they typically do not significantly reduce the volume of runoff. In addition, devices such as underground treatment vaults and hydrodynamic or vortex separators are typically only effective at removing relatively coarse sediment, trash, debris and some oil and grease from urban runoff. They typically do not remove fine sediment, suspended sediment or dissolved pollutants, which are the primary pollutants of concern in the Salinas area and in many other areas of the nation. A number of manufactured structural treatment control BMPs also require relatively frequent maintenance and/or specialized equipment. Because they are typically underground, they can easily become "out of sight and out of mind" and are easily forgotten (i.e. not maintained). They can hold standing water permanently and can be susceptible to mosquito breeding. Therefore, they do not meet the MEP standard when used alone. However, public domain and manufactured structural treatment control BMPs can be used for pretreatment and removal of coarse sediment, trash and debris prior to further treatment by a downstream LID practice, such as a bioretention basin.

Managing and treating urban runoff with a conventional storm drainage system and costly end-of-pipe structural treatment control BMPs located at the bottom of a relatively large drainage area in also not LID. As noted above, LID addresses urban runoff through small, cost-effective landscape features located at the lot- or neighborhood-level. However, the science and technology of storm water treatment control BMPs is new and evolving. Innovative public domain and manufactured structural treatment control BMPs are constantly being developed to meet NPDES permit requirements. Therefore the City of Salinas should periodically review and consider approval of new structural treatment control BMPs <u>if</u> they meet the MEP standard discussed in Section 2.5 below.

2.2 LID Site Planning Principles

As noted previously, LID storm water management techniques can restore and maintain pre-development hydrology and water quality in new development and redevelopment projects to predevelopment levels. As shown on Figure 2-3, when implemented in the planning phase of new and redevelopment projects, LID can have the greatest relative impact on reducing the rate, volume and pollutant loading of urban runoff. This is particularly true in relatively large development projects.

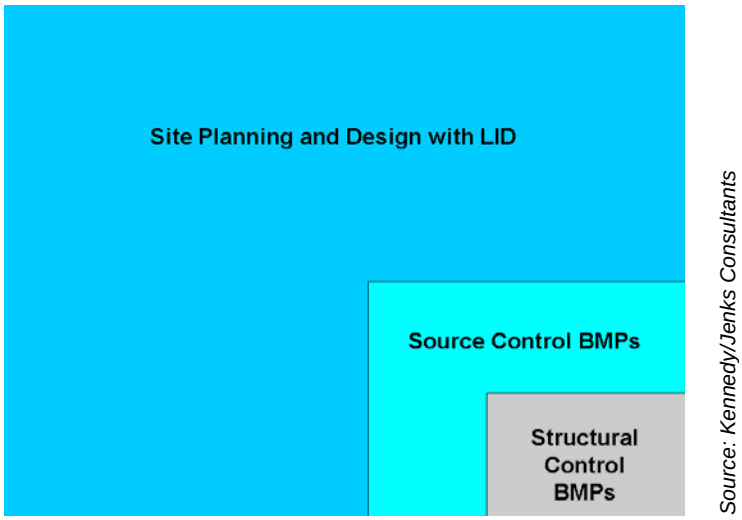


Figure 2-3: The relative effectiveness of methods to reduce the rate, volume and pollutant loading of urban runoff.

LID discourages mass grading and leaving large disturbed areas unprotected for extended periods of time. This practice is also not allowed under the State Water Resources Control Board (SWRCB) General Permit for Construction Activity (Water Quality Order 99-08-DWQ) which states that "the most efficient way to address erosion control is to preserve existing vegetation where feasible, to limit disturbance, and to stabilize and revegetate disturbed areas as soon as possible after grading or construction. Particular attention must be paid to large mass-graded sites where the potential for soil exposure to the erosive effects of rainfall and wind is great."

2.3 Integrating New Urbanism and LID

As noted in the City of Salinas General Plan (2002), development in Future Growth Area will be based on the principles of New Urbanism. Therefore, it will be important to understand how LID can be incorporated into the new developments planned for this area. New Urbanism is an urban design movement which has risen to prominence since it's beginnings in the early 1980s. It aims to reform all aspects of real estate development and urban planning, including everything from urban retrofits, to suburban infill. The movement is particularly associated with the USA, with its "rediscovery" of urban patterns, which have had greater continuity in Europe. The New Urbanism movement incorporates the following planning principles:

- Walkability
- Connectivity
- Mixed-Use & Diversity
- Mixed Housing
- Quality Architecture & Urban Design
- Traditional Neighborhood Structure
- Increased Density

- Smart Transportation
- Sustainability
- Quality of Life

As the movement has been embraced by designers, architects, planners and the associated industries, new innovations have followed. This allows the guiding principles to be increasingly applied to projects at the full range of scales, from a single building to an entire community.

As a storm water planning approach, LID represents a narrower set of planning principles. However, the goals of LID are compatible with New Urbanism, especially with the sustainability and quality of life planning principles. Though New Urbanist developments are dense, they do not preclude the use Integrated Management Practices (IMPs), which are the small scale decentralized storm water management techniques of LID. Design innovation and thoughtful planning can integrate LID storm water management techniques into small spaces with IMPs such as infiltration planters, tree box filters, vegetated swales, and green roofs. Parks and shared green spaces at housing complexes can be planned to function as planted infiltration areas. Disconnected and porous pavements can also be incorporated into most developments. Designers, engineers, and planners need to thoughtfully integrate LID techniques into compact New Urbanist developments. Policy, research funding, and the market will need to support these efforts.

2.4 LID and Green Building Credits

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System offers a number of credits for LID practices. These include credits for erosion control and site selection, and site designs that protect or restore habitat, maximize open space, control the quantity and quality of storm water, and utilize roofs that reduce the heat island effect (e.g. green roofs). The LEED system also provides credits for water efficient landscaping and water use reduction. Because vegetated LID practices such as bioretention systems and vegetated swales harvest rainwater and can be designed with native low water use plants, they may also apply for green building credits. In addition to sustainable site design and water efficiency, the LEED Green Building Rating System also applies credits for projects that improve energy efficiency and air quality, utilize recycled and locally manufactured materials, reuse materials and reduce construction waste. Additional information about LEED standards can be obtained from the U.S. Green Building Council (www.usgbc.org)

Significant benefits can be realized by projects that obtain LEED certification. In addition, new legislative measures that provide significant economic benefits are being passed throughout the nation to support the implementation of green buildings. For example, in 2006, Nevada Assembly Bill 3 (AB3) was passed and now mandates LEED green building standards to be applied to all new state public buildings. The bill also provides significant tax abatements for new and existing commercial buildings that meet the same LEED standards of up to 50% savings in property taxes for 10 years. These tax abatements provide significant incentives to the current and future owners of commercial buildings to build or retrofit them to LEED standards. California will likely follow Nevada's lead in developing similar incentives.

2.5 BMPs, MS4 and MEP

The Salinas NPDES Permit requires the City to implement Best Management Practices (BMPs) and reduce the discharge of pollutant loads to and from the municipal separate storm sewer system (MS4) to the "maximum extent practicable" (MEP). The following section provides a description of each of these storm water management terms.

Best Management Practices (BMPs)

A Best Management Practice (BMP) refers to any kind of procedure or device designed to minimize the quantity of pollutants that enter the municipal storm drain system (e.g. the MS4). Since the beginning of the NPDES storm water program in 1990, a rough taxonomy of BMPs has emerged. BMPs can be classified in three general ways; temporary construction BMPs, source control BMPs and structural treatment control BMPs. Source control BMPs can be further subdivided into operational BMPs and integrated management practices, or IMPs.

Temporary Construction BMPs are intended to control erosion and sediment transport during the construction phase of new development and redevelopment projects (e.g. tracking and mulching are typical erosion control BMPs and silt fences and fiber rolls are typical sediment controls. Temporary Construction BMPs are also intended to control and contain the discharge of chemicals and materials from construction equipment and stockpiled supplies. Once construction is complete, excess supplies and debris are removed and bare soil areas are stabilized (e.g. revegetated), these BMPs and are to be removed. Some construction BMPs can also later serve as permanent Structural Treatment Control BMPs (e.g. a sediment retention basin designed to serve as an extended detention basin after construction is complete). Additional information about Construction BMPs is presented in Section 5.1.

Source Control BMPs (also known as **source control measures** or **non-structural BMPs**) aim to stop pollutants from entering storm water at their source. All **Operational BMPs** (described below) are for source control, but source control BMPs can also be site design features that prevent rain water from contacting a potential pollutant source (e.g. a roof over a storage area). Since the objective of LID is to control and treat urban runoff as close to the source as possible, many LID design practices can be considered source control BMPs. LID practices integrated into the landscape design and distributed throughout the site are known as Integrated Management Practices, or IMPs), which are another form of source control. Additional information about post-construction Source Control BMPs is presented in Section 5.2.

Structural Treatment Control BMPs are built devices or facilities that remove pollutants that have already become suspended or dissolved in storm water. When designed by an engineer based on public design guidance manuals, they are considered **Public Domain Structural Treatment Control BMPs**. When pre-manufactured devices are purchased from a supplier they are considered **Manufactured (Proprietary) Structural Treatment Control BMPs**. A sand filter or a sedimentation basin designed to treat runoff from an urban drainage area that includes a number of impervious surfaces is considered a public domain structural treatment control BMP. Both IMPs and most public domain structural treatment control BMPs can be designed to also reduce the volume, rate and duration of urban runoff. Therefore, they can be designed to meet the MEP standard of the Salinas NPDES permit. They can also be designed to part of the flood control system that must be incorporated into urban development to safely convey runoff from the infrequent large storm events. However, most manufactured structural

treatment control BMPs do not reduce the volume, rate and duration of urban runoff. Therefore, when used alone, they typically do not meet the MEP standard. Structural Treatment Control BMPs are discussed in detail in sections 5.3 and 5.4.

Operational BMPs are practices or procedures that prevent pollutants from entering storm water. Activities such as dumping wash water in an indoor sink rather than the gutter, sweeping outside work areas daily, and conducting routine maintenance activities to ensure structural treatment controls function as designed are considered operational BMPs.

Municipal Separate Storm Sewer System (MS4)

The Municipal Separate Storm Sewer System (MS4) is the conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, county, city, town, district, association, or other public body (created by or pursuant to state law) having jurisdiction over the disposal of sewage, industrial wastes, storm water, or other wastes, that discharges to waters of the United States. [40 CFR 122.26(b)(8)]. Therefore the MS4 within a City typically includes the public roadways, curb and gutter systems, storm drain inlets and catch basins, underground storm drain pipes, man-made channels, and detention basins.

Maximum Extent Practicable

Per the Salinas NPDES permit, the Maximum Extent Practicable (MEP) standard is defined as "the emphasis of pollution prevention and source control BMPs as the first lines of defense in combination with structural and treatment methods where appropriate serving as additional lines of defense. The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility." The Salinas NPDES permit further states that "the RWQCB will determine compliance with MEP standards based on the terms of the Permit, including Attachment 4; and SWRCB decisions or guidance, EPA regulations and guidance and applicable case law defining MEP." In addition, the December 22, 2005 RWQCB letter to the City of Salinas indicates that LID techniques implemented in new development meet the MEP definition.

MEP, as described by the SWRCB includes the following. "The federal Clean Water Act (CWA) provides that NPDES permits for Municipal Separate Storm Sewer Systems (MS4) must require municipalities to reduce pollutants in their storm water discharges to the MEP (CWA §402(p)(3)(B)). MS4 permits shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods."

The MEP standard involves applying best management practices (BMPs) that are effective in reducing the discharge of pollutants in storm water runoff. In discussing the MEP standard, the SWRCB has said the following: "There must be a serious attempt to comply, and practical solutions may not be lightly rejected. If, from the list of BMPs, a permittee chooses only a few of the least expensive methods, it is likely that MEP has not been met. On the other hand, if a permittee employs all applicable BMPs, except those where it can show that they are not technically feasible in the locality, or whose cost would exceed any benefit to be derived, it would have met the standard. MEP requires permittees to choose effective BMPs, and to reject applicable BMPs only where other effective BMPs will serve the same purpose, the BMPs would

not be technically feasible, or the cost would be prohibitive." (Order No. WQ 2000-11, at p.20.) MEP is the result of the cumulative effect of implementing, continuously evaluating, and making corresponding changes to a variety of technically and economically feasible BMPs that ensure the most appropriate controls are implemented in the most effective manner. This process of implementing, evaluating, revising, or adding new BMPs is commonly referred to as the iterative approach. For Small MS4s, EPA has stated that pollutant reductions to the MEP will be realized by implementing BMPs through the six minimum measures described in the permit. (64 Federal Register 68753.) http://www.waterboards.c.gov/stormwtr/smallms4faq.html

2.6 Impervious Surfaces

Imperviousness is the characteristic of a material, which allows or prevents the effective passage of water through it (e.g. no effective infiltration). Impervious surfaces are hard surfaces that prevent or retard the entry of water into the soil mantle and causes water to run off the surface in greater quantities or at a greater rate of flow than under natural pre-developed conditions. Impervious surfaces include, but are not limited to, building rooftops, roads, streets, driveways, parking lots, rooftops, patios, sidewalks and compacted soils. Gravel pavement over sandy soils is highly permeable and is not considered an impervious surface. However gravel pavement over clay soils is considered an impervious surface. Open, uncovered retention or detention facilities are not considered impervious surfaces.

The aerial extent and direct connection of impervious surfaces should be considered the "unifying theme" for the efforts of planners, engineers, landscape architects, scientists, and local officials concerned with urban watershed protection (Schueler, 1995). As noted previously impervious surfaces in urban land development and conventional storm drain system design are often directly linked to the degradation of aquatic ecosystems. However, when imperviousness is quantified, managed, and controlled (e.g. minimized and disconnected) during land development planning and design, impacts can be significantly reduced. Imperviousness has long been understood as the key variable in urban hydrology and conventional storm drain system design. Peak runoff flow and total runoff volume from relatively small urban drainage areas can be calculated as a function of the ratio of impervious area to total area using the empirically derived Rational Method. The Rational Method correlates peak flow to the runoff coefficient "C", where the maximum value is 1.0 and the minimum value is 0.01. Relatively high C values are assigned to impervious surfaces such as roadway pavement (e.g. C = 0.9), whereas relatively pervious surfaces such as sandy soils are typically assigned relatively low values (e.g. C = 0.05). The appropriate C values to be used with the Rational Method in the City are presented in the City of Salinas Standard Specifications, Design Standards and Standard Plans.

Increased flows resulting from urban development tend to increase the frequency of flooding downstream. Imperviousness links urban land development to degradation of aquatic ecosystems in two principal ways. First, the combination of paved surfaces and piped runoff efficiently collects urban pollutants and transports them, in suspended or dissolved form, to surface waters. These pollutants may originate as airborne dust, be washed from the atmosphere during rains, or may be generated by automobiles and outdoor work activities.

Second, increased peak flows and runoff durations typically cause erosion of stream banks and beds, transport of fine sediments, and the degradation of aquatic habitats. Measures taken to

control stream erosion, such as hardening banks with riprap or concrete, may permanently eliminate habitat. As shown on Figure 2-2 previously, increased imperviousness often reduces infiltration and groundwater recharge, which may also reduce dry-weather stream flows (e.g. base flows). Imperviousness has two major components: rooftops and transportation corridors (including streets, highways, and parking areas). The transportation component is usually larger and is more likely to be directly connected to the storm drain system.

The effects of imperviousness can be mitigated by disconnecting impervious areas from the drainage system and by making drainage less efficient (e.g. by encouraging detention and retention of runoff in IMPs and LID practices located near the point where it is generated). Extended detention and retention basins also reduce peak flows and volumes and allow pollutants to settle out or adhere to soils before they can be transported downstream. These storm water management practices can also be sized to reduce peak flows generated by the infrequently occurring large storm events (e.g. the 25, 50, or 100-year storm event).

2.7 Storm Water Quality Design Storms

Engineers and hydrologists have been using statistically derived design storms to calculate the required size of storm drainage facilities that convey, detain and store urban runoff for many years. These facilities are typically based on statistics of relatively large storm events to protect public safety and prevent flooding. Because small storms occur relatively frequently throughout the course of a year, it stands to reason that these relatively frequently occurring storm events wash urban surfaces most frequently and transport the largest pollutant loads. Studies, such as the Nationwide Urban Runoff Program (NURP) study (U.S. EPA, 1983) have shown that the relatively frequent small storm events and the first 15 to 30 minutes of runoff from all storms, known as the “first flush”, contain the highest concentrations of pollutants in urban runoff. Therefore, certain LID practices and structural treatment control BMPs should be designed to treat the rate and volume of urban runoff produced by the locally occurring relatively small storm events. The National Water Quality Inventory: 2000 Report to Congress identified urban runoff as one of the leading sources of water quality impairment in surface waters. Under the NPDES program, it is now a nationwide requirement to treat the rate and volume of urban runoff produced by the relatively small storm events that occur locally.

Since no two rainstorms are exactly alike and new storms provide new data, hydrologists periodically sort and analyze rain gauge records to find long-term patterns of rainfall intensity and duration. They then apply engineering calculations and other methods to estimate runoff flow rates and volumes. These methods are based on patterns of rainfall intensity and duration, the size, topography, soils, the land uses within a particular watershed, and the runoff travel time in its drainage areas. Different design storms apply to different purposes. Design storms for the design of conventional storm drain systems typically target the relatively large storm events. For example, large flood control channels are typically designed to convey runoff from storms with a one-in-one-hundred (1%) probability of occurring in any particular year, commonly called the 100-year storm event. Conventional flood-control detention basins are often designed to capture and reduce flows from storms that have a 4% or 10% of probability of occurring each year (a 25-year or 10-year storm, respectively). Although these conventional storm drain system designs can be effective at reducing potential flooding, they can increase downstream risks and typically fail to reduce the increased volume and pollutant loading of

urban runoff from conventional development. Therefore, design techniques such as LID are necessary to offset these additional impacts of urban runoff.

Rather than specifying a design storm, NPDES storm water permit design criteria for certain LID practices (e.g. bioretention systems and vegetated swales) and structural treatment control BMPs typically target the treatment of 80 to 85% of the volume or rate of average annual runoff. This value was derived from studies such as the NURP study discussed above. To achieve treatment of 80% to 85% of the volume or rate of average annual runoff, treatment control BMPs should be sized based on a statistical analysis of local rainfall data. As with all NPDES storm water permits, the Salinas NPDES Permit requires numeric sizing criteria for both volume- and flow-based treatment control BMPs. As discussed in Section 4.5, volume-based treatment control BMPs should be designed to treat the volume produced by the 24-hour 85th percentile storm event, based on local rainfall records. Whereas flow-based treatment control BMPs should be designed to infiltrate or treat the maximum flow rate produced by a rain event equal to two times the 85th percentile hourly rainfall intensity. As noted previously, facilities designed to treat these smaller relatively frequent storms are typically considerably smaller than flood control facilities.

A statistical analysis of rainfall data was conducted for the Salinas area. Figure 2-4 indicates that the majority of storms in the Salinas area produce 0.50 inches or less of rainfall. Figure 2-5 shows that in the Salinas area, the majority of storm rainfall intensities are at a rate of 0.10 inches/hour or less. The Salinas Permit requires volume-based BMPs to infiltrate or treat the volume of runoff produced from a 24-hour 85th percentile storm. As discussed in Section 4.5, the rainfall depth associated with the 24-hour 85th percentile storm event is 0.60 inches. The Salinas Permit requires flow-based BMPs to infiltrate or treat two times the 24-hour 85th percentile storm. The rainfall intensity associated with the 24-hour 85th percentile storm in the Salinas area is 0.11 inches/hour; therefore flow-based BMPs must infiltrate or treat 0.22 inches/hour. These are the values that should be used to size volume- and flow-based treatment control BMPs in the Salinas area. The Salinas numeric sizing criteria for volume- and flow-based treatment control BMPs is discussed in detail Section 4.5.

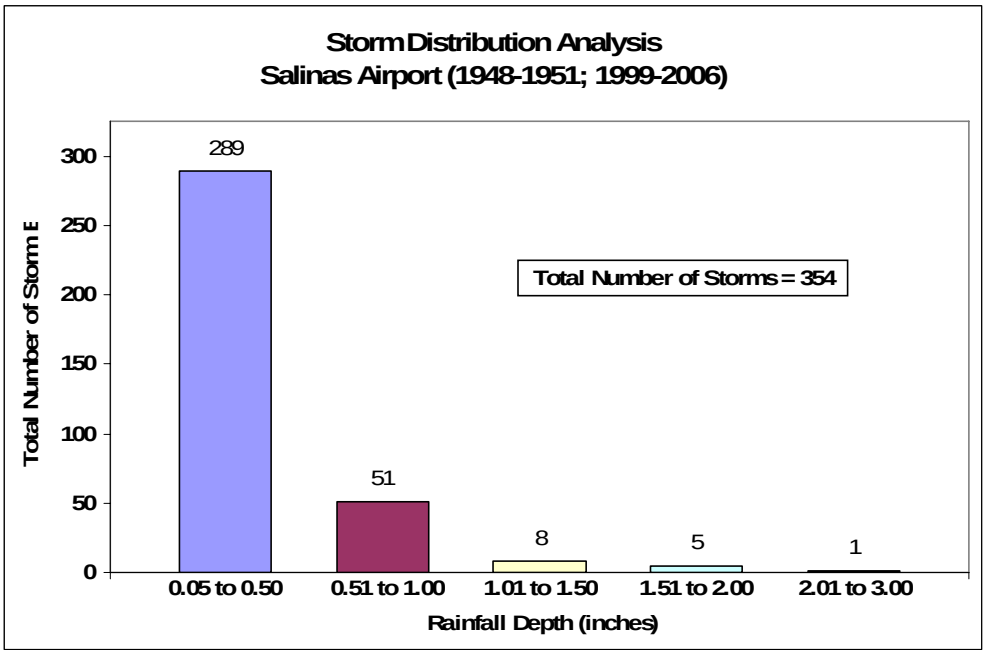


Figure 2-4: Storm distribution analysis for the Salinas area. (Source: Kennedy/Jenks Consultants)

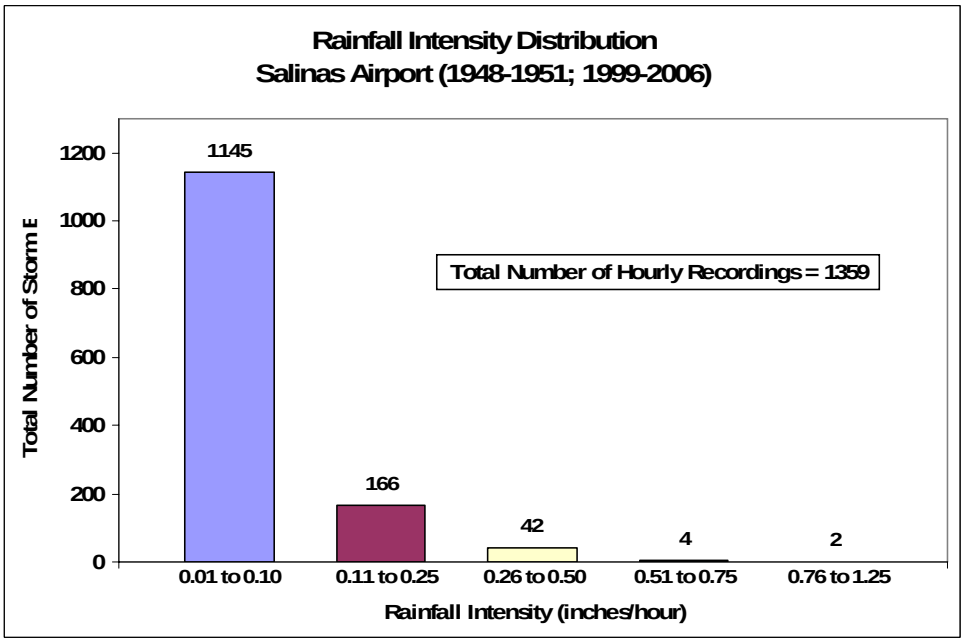


Figure 2-5: Rainfall intensity distribution analysis for the Salinas area. (Source: Kennedy/Jenks Consultants)

2.8 Infiltration and Percolation

As a storm water management/LID method, the term infiltration refers to practices that retain or detain urban runoff within permeable soils. Depending on: a) the amount of runoff, b) the design of the storm water infiltration practice and, c) the soil permeability[2] in existing site soils, a portion of the runoff that enters the device can infiltrate into underlying soils and recharge groundwater. Infiltration is the primary mechanism in LID practices for reducing the rate, volume, and pollutant loading of urban runoff. Soil amendments are typically required to increase the permeability and pollutant removal effectiveness of existing site soils, particularly in areas with clayey soils. The following presents several important concepts with respect to the infiltration of storm water and LID.

Infiltration Rate – means the rate at which water percolates into the subsoil measured in inches per hour or minutes per inch.

Direct Storm Water Infiltration – means any structure that is designed to infiltrate storm water into the subsurface and by design, bypasses the natural groundwater protection afforded by surface or near-surface soils. Direct infiltration systems include infiltration trenches, infiltration basins, and dry wells. These devices are typically constructed of gravel and can impact groundwater quality if improperly sited (e.g. in a drainage area susceptible to spills).

Indirect Storm Water infiltration – means infiltration into subsurface soils via surface facilities that include amended soils and sand. Indirect infiltration practices include vegetated swales, bioretention systems, and porous pavements. These LID practices are expressly designed to convey or detain runoff and allow it to filter through engineered soils prior to infiltration into shallow subsurface soils, generally less than 5 ft below ground surface. Treated storm water runoff may reach groundwater indirectly, or it may be underdrained through subsurface pipes to the conventional storm drain system. These devices are highly effective at removing pollutants from storm water and typically present little threat to groundwater quality.

Soil percolation describes the transport of soil water based on the most restrictive shallow soil layer (e.g. a clayey soil layer). Infiltration or percolation testing of existing site soils is often required by municipalities when storm water infiltration BMPs are proposed to be installed because infiltration or percolation rates are necessary to properly design storm water infiltration BMPs. Infiltration testing is typically conducted using a double ring infiltrometer and infiltration rates are typically reported in units of inches/hour. Whereas percolation testing methods are simpler than infiltration testing methods and are typically established for the permitting of septic system leach fields. Percolation rates are typically reported in units in minutes/inch. As can be seen on Figure 2-6, infiltration and percolation rates are dimensionally opposite from each other; as infiltration rates reported in inches/hour go down, corresponding percolation rates reported in minutes/inch goes up (e.g. 1.0 in/hr = 60 min/in and 0.5 in/hr = 120 min/in). This concept is important to understand when interpreting infiltration or percolation testing data for the design of storm water infiltration systems.

[2] Permeability describes the rate of water movement through the soil column under saturated conditions. Permeable materials are those that allow water to pass through them relatively easily. Permeability values are a function of the size of soil pores or voids and the degree to which they are interconnected.

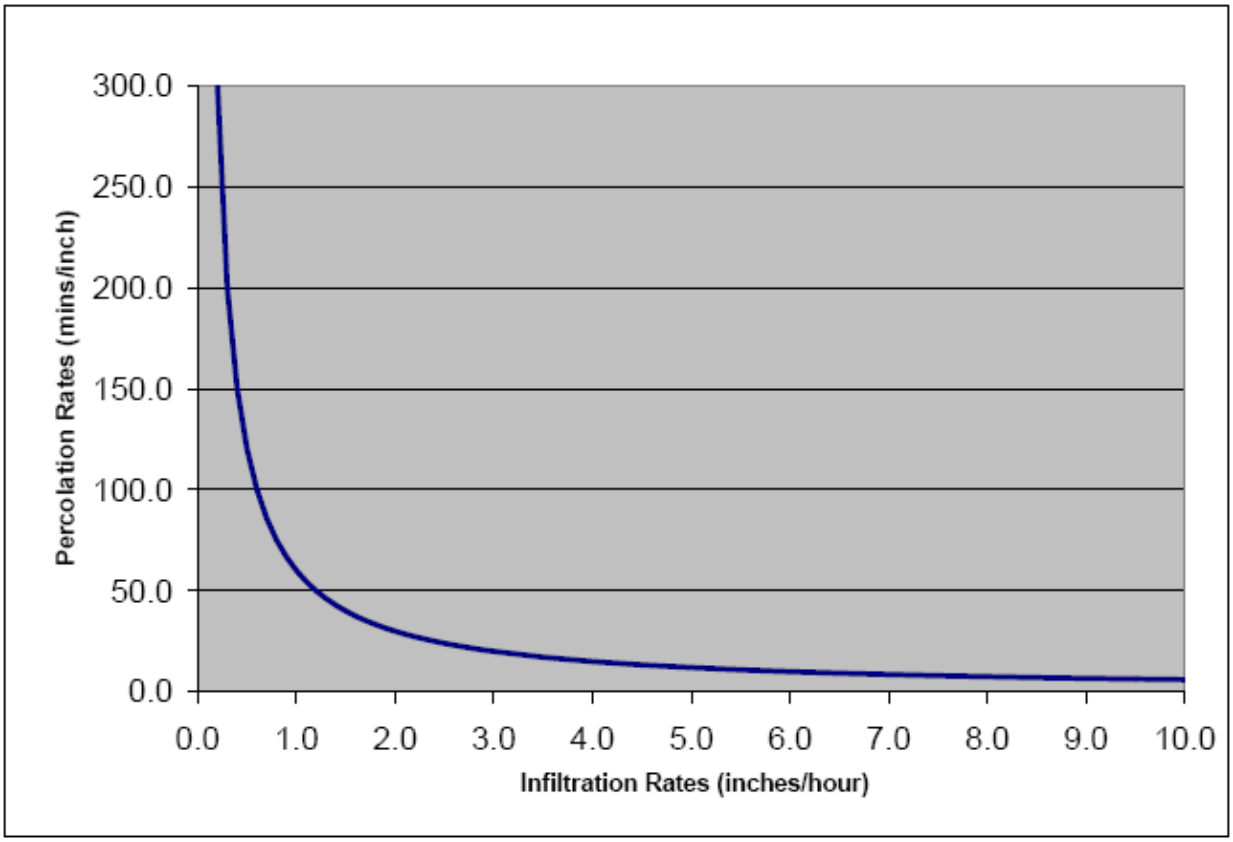


Figure 2-6: Relationship between infiltration rates and percolation rates. (Source: Kennedy/Jenks Consultants)

Additional information about infiltration of storm water in urban areas and the measures that must be taken to protect groundwater quality and structures such as building foundations, as well as a number of other parameters, is discussed in detail in Section 4.2.

2.9 Amended and Engineered Soils

Soil amendments are materials added to improve the physical properties of soils. They are typically mixed into soils to provide a better environment for plant roots. Engineered soils for LID practices are specific mixes of soil materials and amendments developed for the purpose of infiltrating and treating urban runoff while producing a favorable environment for plants.

When properly selected and applied, organic soil amendments increase soil organic matter content and improve soil aeration, water infiltration, and both water and nutrient holding capacity. Many organic amendments contain plant nutrients and act as organic fertilizers. Organic matter is also an important energy source for bacteria, fungi and earthworms that live in the soil. Soil bacteria and fungi degrade a number of the pollutants commonly found in urban runoff. Therefore establishment of soil bacteria and fungi are critical components of engineered soils for LID practices such as bioretention systems.

Soil amendments can be organic and inorganic. Organic amendments are derived from plant matter and animal waste. Inorganic amendments are either mined or man-made. Organic amendments include sphagnum peat moss, grass clippings, straw, compost, manure, biosolids, wood chips, sawdust and wood ash. Inorganic amendments include vermiculite, perlite, pea gravel and sand. Mulches are not considered soil amendments because they are placed on the soil surface to reduce erosion and improve soil moisture (e.g. they are not mixed into the soil).

Not all of the amendments noted above are recommended for use in vegetated LID practices. They are merely provided as examples. For example, wood products such as wood chips and sawdust are not desirable because they can tie up nitrogen in the soil and cause nitrogen deficiency in plants. Wood ash is typically high in both pH and salts and can magnify common soil problems. Therefore wood ash should not be used as a soil amendment in vegetated LID practices. Sand should also not be added to clay soils because it can create a soil structure similar to concrete.

Biosolids are byproducts of sewage treatment facilities. They may be found alone or composted with leaves and/or other organic materials. The primary concern about biosolids is that they may contain heavy metals, pathogens, and salts. Therefore biosolids should not be used as a soil amendment in vegetated LID practices. Manure can also contain elevated levels of ammonia and pathogens and should not be used. Manure must be composted for at least two heating cycles at 130 to 140 degrees F to kill any pathogens. Most home composting systems do not sustain temperatures at this level. In addition, composted manure typically contains elevated levels of phosphorus, potassium and salts. Therefore composts containing manure are also not recommended for vegetated LID practices.

Care should always be applied to the selection of the soil amendments in vegetated LID practices such as bioretention systems because if they contain relatively high levels of nitrogen, phosphorous, a relatively high P-index, or soluble salts, these components may leached out of the soil mix and into the effluent (draining to groundwater or discharging to a storm drain pipe or a drainage channel if an underdrain system is included in the design). Vegetated LID practices differ from ordinary conventional landscaping because they are designed to have urban runoff flow into them from adjacent developed impervious surfaces. Urban runoff therefore concentrates in vegetated LID practices by design and there is a much higher potential to leach nutrients out of bioretention systems if they are not designed correctly. Sphagnum peat moss and compost made from purely plant sources are low in salts and are good choices for amending soils in vegetated LID practices. An analysis of the soil mix is always recommended.

As noted above, engineered soils for LID practices represent specific mixes of soil materials and amendments. They are developed exclusively for the purpose of infiltrating and treating urban runoff while producing a favorable environment for plant roots. As discussed in detail in Section 4.4, engineered soils for bioretention systems should have a sandy loam or loamy sand texture and consist of 50-60% clean sand; 5-20% certified compost or peat moss; and 20-30% topsoil with a maximum clay content of <5%.

Soil amendments are defined by the SWRCB as any material that is added to the soil to change its chemical properties, engineering properties, or erosion resistance. Certain soil amendments can be mobilized by storm water and become pollutants. Soil amendments likely to fall in this category include lime, cementitious binders, chlorides, emulsions, polymers, soil stabilizers, and tackifiers applied as a stand-alone treatment (i.e., without mulch). In contrast, plant fibers (such

as straw or hay), wood and recycled paper fibers (such as mulches and matrices), bark or wood chips, green waste or composted organic materials, and biodegradable or synthetic blanket fibers are soil amendments that are likely to be visible in storm water runoff. All of the soil amendments noted above are much more likely to be mobilized by storm water and become pollutant when applied to conventional mounded (convex) landscaping. Whereas they are much more likely to be trapped and treated by depressed LID (concave) landscaping.

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Section 3: LID Designs and Practices

3.0 LID Planning Techniques

As discussed in detail in the previous section, conventional development and storm drain system designs typically increase runoff, contribute pollutants to surface waters, and reduce groundwater recharge. Therefore LID designs and practices must be implemented to offset these negative impacts. All successful designs and practices require proper planning and engineering. Therefore LID designs and practices must be carefully planned and adhere to a set of basic planning principles. LID planning principles require different site and facility design considerations than conventional development and storm drain system design. To be successful, LID planning principles for the protection of local water resources should consist of the following strategies:

1. Reducing or maintaining post-project runoff to pre-development conditions;
2. Controlling sources of pollutants; and
3. Treating polluted storm water runoff before discharging it to the storm drain system or to receiving waters (if still needed after implementing 1 and 2).

Planning elements 1 and 2 emphasize reducing or eliminating pollutants in storm water runoff at their source by capturing and reducing the volume and rate of runoff and the exposure of pollutants to rainfall and runoff from other sources. This can be accomplished by implementing LID practices in site designs and source control BMPs. Planning element 3 considers the implementation of structural treatment control BMPs, which are engineered systems typically consisting of piping, filter media, and concrete structures that primarily use physical methods to reduce pollutants in storm water. Source control and structural treatment control BMPs are discussed in detail in Section 5. If LID planning principles 1 and 2 are incorporated into the design of many new development and redevelopment projects, particularly land uses such as residential developments, LID practices and source control BMPs alone can effectively reduce runoff and control sources of pollutants. However, some industrial and commercial land uses may require a combination of LID practices, source and structural treatment control BMPs to meet local water quality standards and the MEP definition discussed in Section 2.4.

Every potential development site possesses a unique combination topography, physical features, geology, hydrology, soils, and vegetation. Some sites are more suitable than others for certain types of BMPs. However the integration and incorporation of LID landscaping techniques can be widely applied. Landscaping strategies that drain and filter storm water are the one of the most effective methods of minimizing surface and groundwater impacts from storm water runoff. Green roofs and routing roof runoff through LID landscaping techniques provide additional storm water management benefits. Reducing the amount of dry-weather flows through the use of efficient irrigation systems and discouraging outdoor washing activities also helps to reduce runoff and the transport of pollutants to receiving waters. LID landscaping techniques, roof runoff controls and efficient irrigation techniques have the additional benefit of assisting with water conservation efforts while minimizing public health vector nuisances. Finally, the labeling of storm drain inlets with messages such as “No Dumping – Flows to Creek” provides a highly visible public education message. It helps to educate the general public that

the storm water runoff from streets and parking lots is conveyed through the storm drain system and does not receive treatment prior to discharge to local streams, rivers and lakes.

The following sections discuss the LID planning principles of protecting Preserving Existing Vegetation, Filtering Waterways, Creating and Preserving Open Space, and Tree Planting and Parkway Designs. Additional information about planning principles and site design techniques that replicate pre-existing hydrologic site conditions can be obtained at the Low Impact Development (LID) Center http://www.lowimpactdevelopment.org/

3.0.0 Preserving Existing Vegetation

Measures to preserve existing vegetation, both native and established landscaping, should be implemented wherever possible to protect and preserve existing high value plants and trees in areas that will be exposed to land-disturbing activities. This LID planning principle should be used on all construction sites and is particularly applicable where projects areas are located in floodplains, near streams, wetlands, and steep slopes.

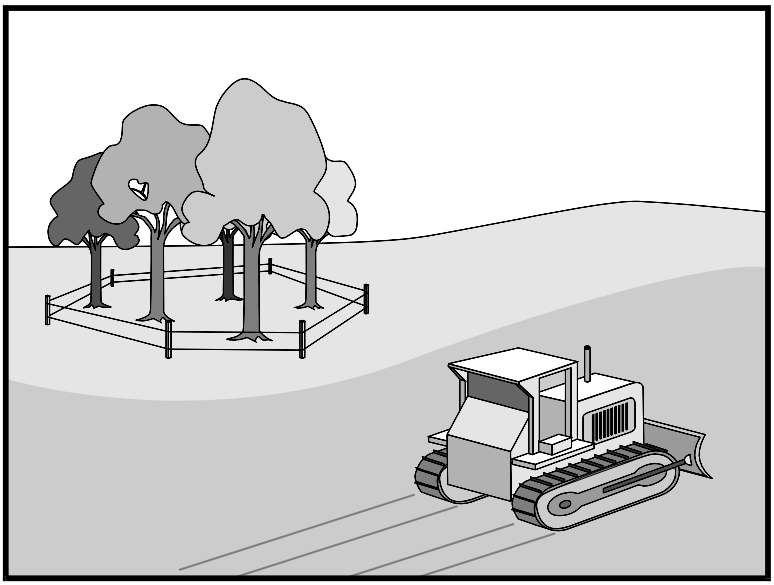
Design Planning Considerations

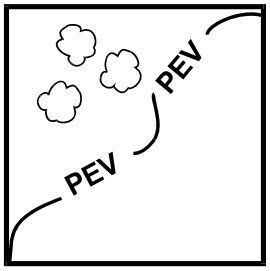
- Assess proposed development areas to determine areas of existing vegetation that should be preserved. Appropriate assessment professionals include botanists, biologists, arborists and landscape architects.
- Design sites to fit into existing contours and preserve existing vegetation to the extent feasible or required by local ordinances.
- Consider plant and tree health, age, species, space needed, aesthetic values, and habitat benefits.
- Design new landscaping to provide consistency with existing vegetation to be preserved on site or in the surrounding area.
- Follow existing contours and avoiding stands of trees and other high value vegetation when locating temporary roadways.

Construction Planning Considerations

- Clearly mark areas to be preserved on maps and plans with Preserve Existing Vegetation (PEV) lines.
- Install temporary fencing to protect existing vegetation before beginning clearing or other soil-disturbing activities.
- When protecting trees, extend the limits of fencing to at least the tree drip-line (the horizontal extent of the tree branches).
- Do not place equipment, construction materials, topsoil, or fill dirt within the limit of tree drip-lines or other preserved areas.
- Do not cut tree roots within the tree drip line and curving trenches around trees to avoid large root concentrations.

- Repair or replace damaged vegetation immediately. If tree roots are cut, the ends should be smoothly cut. Cover exposed tree roots with soil or wet burlap as soon as possible.
- Excavation within the drip line should not compact soil or disturb tree roots. This is best accomplished by hand excavation. Roots 1/2" in diameter and larger should be preserved.
- Any pruning of the branches or roots should be completed by, or under the supervision of, an arborist.
- Maintaining existing irrigation systems and supply additional supplemental irrigation when necessary to protect the health of existing plants and trees.
- Fertilizing broadleaf trees that have been stressed or damaged to aid the recovery and consulting an arborist to determine if and what kind of fertilizer is needed. Fertilization should be delayed after excavation to avoid root damage.





MAP SYMBOL

Figure 3-1: Example BMPs for preserving existing vegetation at construction sites. (Graphics used with permission of Caltrans)

3.0.1 Filtering Waterways

Waterways include wetlands, streams, rivers, ponds and lakes. Areas adjacent to streams and rivers that support a wide variety of plant and animal species are known as “riparian areas”. Riparian areas are dependent on the hydrology of streams and rivers and typically have shallow groundwater. Codes and ordinances must be developed and enforced to protect waterways and prevent or significantly limit development within specified limits or setbacks.

The City of Salinas Grading Ordinance protects riparian corridors and wetlands through minimum 100-ft setbacks. Developments must retain creeks and wetlands in their natural channels. It discourages the use of culverts or underground pipes and requires a

riparian/wetland habitat mitigation and management plan if impacts are incurred to such waterways during development.

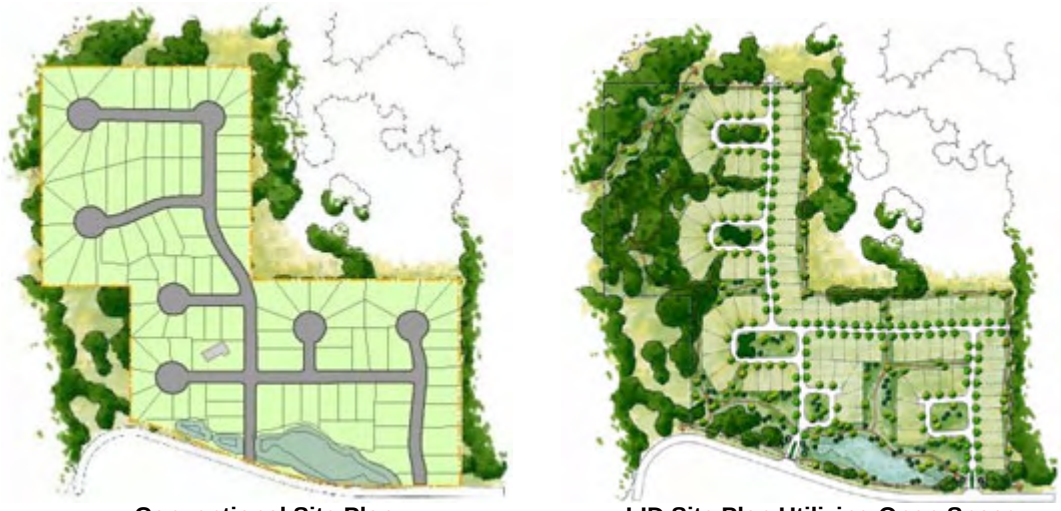
3.0.2 Creating and Preserving Open Space

Protecting natural drainageways (e.g. dry channels that convey water during storm events), areas of native vegetation, and high value open space is one of the primary principles of LID. Open space filters and greenbelt areas should be established to help define boundaries between development areas and neighborhoods, to prevent urban sprawl, and to protect sensitive habitats. Codes and ordinances should be developed and enforced that require the establishment of open space buffers and greenbelt areas.

The City of Salinas Zoning Code, Municipal Code, and General Plan contain language that supports the creation and preservation of open space in development areas.

Cluster and open space development are LID site design strategies that concentrate development to specific areas of a site, leaving portions of the development in open space. These designs include strategies such as smaller lot sizes, alternative street layouts to reduce road networks and area of impervious pavements, alternative driveway designs, and alternative sidewalk designs (discussed in the following sections). Often, a community's zoning regulations may need to be revised to meet these goals. When choosing the development envelope for a site, features such as riparian areas, woodland conservation areas, steep slopes, and highly erosive or permeable soils must be protected.

Figure 3-2: Comparison of a LID site plan to a conventional site plan on the same site.



Conventional Site Plan **LID Site Plan Utilizing Open Space and Cluster Development**

Source: Puget Sound Action Team

An example of a development that utilized cluster and open space development is the Pembroke development in northern Fredrick County, Maryland. The development utilized half-acre residential plots and LID site design strategies to address storm water management within

the subdivision. By utilizing LID strategies and preserving two-and-a-half acres of undisturbed open space and wetlands to aid in storm water runoff control, two storm water ponds were eliminated from the site plan, saving the developer $200,000 in infrastructure costs. LID site foot-printing techniques allowed for preservation of 50 percent of the site in undisturbed wooded condition. Two additional lots were also gained from LID site design increasing the site yield from 68 to 70 on the 43-acre site. Replacing curbs and gutters with vegetated swales and reducing road width from 36 to 30 feet reduced impervious cover. Paving costs were lowered by 17 percent with a $60,000 saving in utilizing swales.[3]

3.0.3 Tree Planting and Parkway Designs

Trees can be used in urban settings as part of a storm water management plan to reduce runoff and pollutant loads from development projects. Trees can be placed on residential lots, in landscape corridors, parking lots, and along street frontages. Urban areas with large numbers of trees exhibit hydrology more similar to pre-development conditions than urban areas with little to no tree canopy. This occurs because trees intercept rainfall and can retain a significant volume of the captured water on leaves and branches, allowing for evaporation and providing runoff reduction benefits. For example, a large oak tree can intercept and retain more than 500 to 1,000 gallons of rainfall in a given year[4]. Evergreen trees have the greatest potential to provide storm water management benefits because they retain their leaves throughout the rainy season. Generally, the larger the tree and the smaller the leaves, the more rain is intercepted. In addition, tree roots help to support infiltration into urban soils by providing pathways through relatively tight soils (clayey and silty soils)

The shade provided by trees also keeps the ground and impervious surfaces under trees cooler. This reduces the amount of heat gained in runoff that flows over the ground and impervious surfaces located under the trees. This attenuation of heat in storm water helps control increases in stream temperatures. On slopes, tree roots also hold soil in place and prevent erosion.

Planning Considerations

- Check with the local permitting agency about requirements for trees located in public utility easements.
- Trees must be located appropriate distances from infrastructure and structures that could be damaged by roots and branches. These include, but are not limited to, overhead utilities and lighting, underground utilities, signage, septic systems, curb/gutter and sidewalks, paved surfaces, building foundations and existing trees.
- Select tree species based on the soils found on the site, available water, and aesthetics.
- Consult a landscape architect or arborist to ensure suitability of species for site conditions and design intent.
- Do not plant trees too close together and avoid plant monocultures of same family, genus and/or cultivar.

[3] Natural Resources Defense Council (NRDC). 2001. Stormwater Strategies: Community Responses to Runoff Pollution http://www.nrdc.org/water/pollution/storm/chap12.asp

[4] Cappiella, K. 2004. *Urban Watershed Forestry Manual* (draft). Prepared for USDA Northeastern Area State and Private Forestry. Center for Watershed Protection, Ellicott City, MD

- New landscaping under existing trees should be carefully planned to avoid any grade changes and any excess moisture in trunk area, depending on tree species. Existing plants which are compatible as to irrigation requirements and which complement the trees as to color, texture and form should be saved.
- Avoid grade changes greater than six inches within the drip-line of existing trees.
- Avoid soil compaction within the tree drip-line (horizontal extent of the tree branches).
- Trees should be installed and irrigated in accordance with local permitting agency Landscaping Standards.
- When installing lawn around trees, install the grass no closer than 24 inches from the trunk.
- Consider using mulch around the base of the tree as a substitute to fertilizer. Do not place mulch within six inches of the trunk of the tree.
- Mulch trees with hardwood chips (not redwood or cedar).
- Minimize the use of chemicals to only what is necessary to maintain the health of the tree.

3.1 Minimizing and Disconnecting Impervious Surfaces

3.1.0 Rooftop Disconnection

Runoff from the roofs of buildings and homes contributes to the volume of storm water runoff as well as acting as a source of pollutants, particularly at industrial and commercial facilities. During a storm event, runoff from rooftops is generally collected in gutters and poured into downspouts, or, when downspouts are not present, it flows from eaves in concentrated sheet flows and causes erosion. This water is often directed to the storm drain system from downspouts or drip lines, picking up nutrients and sediments on the way. Controlling roof runoff by directing it to vegetated areas, filtering it through bioretention systems, vegetated swales or buffer strips, storing it for irrigation, or allowing for infiltration, reduces the peak flow rates and volume of storm water runoff and associated pollutants loads.

Photo: courtesy of Nevada NEMO

Figure 3-3: A downspout directed to a landscaped area.

Design Considerations

- Downspouts can be directed towards landscaping, vegetated swales, filter strips, bioretention systems, sand filters, infiltration trenches or infiltration basins.
- Roof runoff can also be stored for irrigation by directing downspouts to rainwater collection devices.
- Storm water planters and rock-lined trenches under roofline/dripline can help to control erosion from concentrated sheet flow off of the roof and promote infiltration.
- Plants installed along a building's drip line should be sturdy enough to handle heavy runoff sheet flows from rooftop runoff.
- Splash blocks or gravel splash pads should be used to dissipate runoff energy from downspouts.

- Appropriate for most single-family homes and multi-family developments, commercial and industrial areas.
- Can be applied in areas of new development or in areas of redevelopment.
- Rain barrels and cisterns must be securely covered to prevent vector breeding.
- Rain barrels and cisterns must be child proof.

Limitations

- Plantings under rooflines must be able to withstand heavy runoff sheet flows and soil saturation.
- Soil permeability may limit applicability of infiltration trenches.
- An uncovered rain barrel or cistern can provide mosquito habitat if it contains standing water.

Maintenance Considerations

- Routine landscape maintenance required for plantings located under rooflines and around downspouts.
- Inspect and maintain rain barrels and cisterns at least twice a year to ensure they are secure, functioning properly, and not breeding mosquitoes.

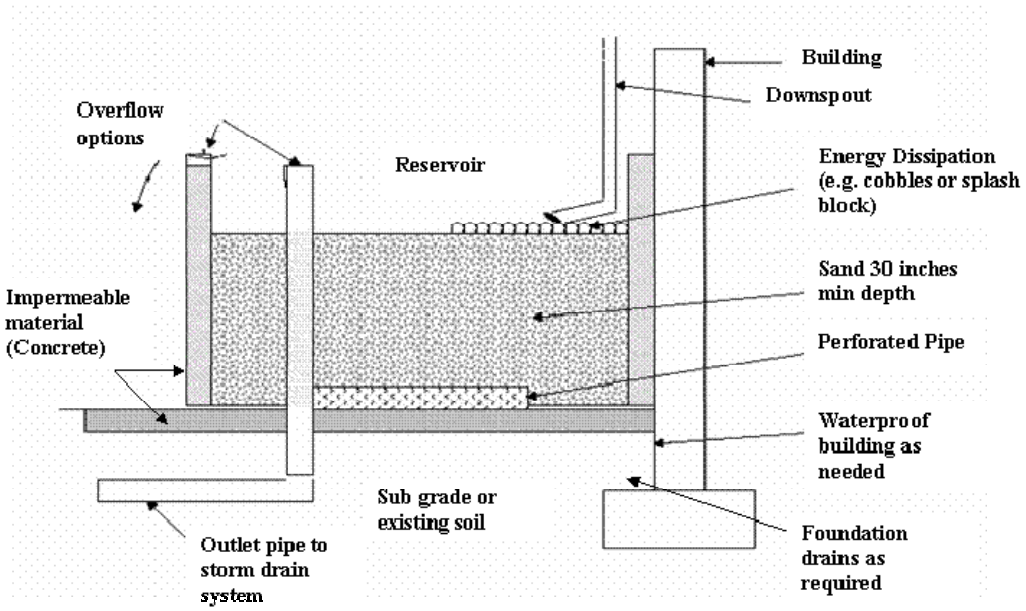


Figure 3-4: Example of a sand filter for roof runoff control. (modified from Portland, 2000)

3.1 Minimizing and Disconnecting Impervious Surfaces

3.1.1 Pavement Disconnection

In conventional development, impervious pavement in parking lots, streets, roads, highways, freeways, driveways, sidewalks and bike paths are often directly connected to each other and the storm drain system. Disconnecting pavement by designing runoff to sheet flow onto adjoining vegetated areas or porous pavement before it reaches the storm drain system reduces the rate, volume and pollutant loading of urban runoff. Urban runoff slows as it travels though vegetation or over a porous surface and water is infiltrated into the soil where the majority of pollutant removal occurs. The following sections present alternative LID designs for parking lots, streets and roadways, driveways, sidewalks and bike paths that have been shown to effectively reduce runoff and pollutants in storm water.

3.1.2 LID Parking Lot Design

Parking lots contribute a sizeable area of impervious coverage to urban developments and are significant sources of storm water runoff and the discharge of associated pollutants to the storm drain system and local surface waters. Several strategies can be implemented to mitigate this impact, including reducing impervious surfaces using permeable paving alternatives in overflow parking areas and landscaped detention (bioretention) basins installed in parking lot islands and perimeter landscaping.

Managing Runoff

Storm water management in parking lots can mimic natural hydrologic functions by installing design features that capture, treat, and infiltrate storm water runoff rather than conveying it directly into the storm drain system. Management options include:

- Landscaped detention and bioretention areas (Figure 3-5) can be installed within and/or at the perimeter of parking lots to capture and infiltrate runoff. These include permeable landscaped areas designed with grades below the impervious parking surface and can be delineated by flat concrete curbs, shrubs, trees or bollards.

Photo: Kennedy/Jenks

Figure 3-5: Parking lot bioretention

Photo: courtesy of ToolBase Services

Figure 3-6: Parking lot made of a permeable paving surface

- Porous surfaces can be installed in down gradient parking stalls and in overflow parking areas (Figure 3-6). Permeable materials that can be utilized include permeable pavers, porous asphalt, and porous concrete (see section 3.4). In some circumstances, gravel or wood chips can also be used.
- Storm water runoff from the top floor of parking garages can be drained to planter boxes located at the perimeter of the parking lot or at street level.

Reducing Impervious Surfaces

Research has shown that zoning regulations typically require more parking spaces than are needed. Parking lot size is usually based on peak demand rather than average usage. Parking codes should be reviewed and revised to reduce parking minimums. Parking codes should also be revised to allow shared parking for businesses with different hours of peak demand. Bus and shuttle services can be provided between commercial centers that only experience peak demands during holidays and parking areas such as government facilities and schools that are typically vacant over holidays. Other strategies that can also be implemented to reduce the total parking area include compact parking spaces, a reduction in stall dimensions, and determining the most space-efficient design for parking spaces (e.g. angled or perpendicular). Consideration should be given to design options such as underground parking or multi-storied garages. As noted above, vegetation and landscaping can be designed to intercept rainfall and capture storm water. Including trees in parking lot landscaping should also be considered. In addition to reducing impervious coverage and providing tree canopy to intercept rainfall, trees reduce the urban heat island effect of parking lots by shading heat-adsorbing surfaces.

Design Considerations

- Revise parking ratio requirements.
- Utilize minimum stall dimensions and compact parking spaces. In larger commercial lots, 30 percent compact parking spaces is suggested.
- Use porous concrete, porous asphalt or permeable pavers in overflow parking areas or down gradient parking stalls (e.g. at areas located at low points in the parking lot).
- Utilize the most space-efficient design for parking stalls.
- Utilize vegetation and landscaping for capture and infiltration of rainfall and storm water runoff, for impervious surface reduction, and for shading.
- Utilize flat curbs or curb cuts (Figure 3-7) to direct runoff into landscaped areas.

Limitations

- Existing parking requirements and codes can limit the use of LID techniques.

Maintenance Considerations

- Regular maintenance of landscaped areas is required.
- Irrigation of landscaped areas may be required.

- In areas receiving snowfall, to avoid excessive accumulation of sediments, snow should not be regularly stockpiled in landscaped detention areas.

Photo: Kennedy/Jenks Consultants

Figure 3-7: Curb cuts direct water into this parking lot bioretention system.

Examples

1. Based on construction cost estimates provided by the City of Reno, NV, storm drainage systems for parking lots with landscape detention (bioretention) basins installed in well draining soils would be expected to cost approximately 50% less than conventional storm drainage systems. Landscape detention basins installed in well draining soils typically do not include underdrain systems and only a limited amount of conventional storm drain infrastructure. Conventional storm drain infrastructure, such as catch basins and underground concrete pipe, are often one of the most expensive items in conventional parking lot construction. When landscape detention basins are installed in poorly draining soils, such as soils with a high silt or clay content, LID parking lot storm drainage system costs are comparable to conventional parking lot storm drainage system costs. However, conventional parking lot storm drainage systems increase the rate and volume of storm water runoff, and the associated pollutant loads to receiving waters. Whereas LID parking lot storm drainage systems reduce the storm water runoff and pollutant loads produced by the impervious surfaces of parking lots.

2. The Morton Arboretum in DuPage County, Illinois is a 1,700+ acre outdoor museum of woody plants adjacent to Meadow Lake and the East Branch of the DuPage River. When a new visitor center was proposed for the facility a “green” parking lot was constructed to accommodate the anticipated increase in visitation.

   A concrete paver system was utilized for the parking lot based on their durability and high strength to withstand heavy traffic loading. Biofiltration swales were designed along 9-foot medians in the parking lot to capture and infiltrate runoff from the parking lot. Perforated storm sewers were utilized along the length of each biofiltration swale so that run-off entering the storm sewer could have a chance to infiltrate back into the ground. A control structure was installed at the downstream end of the system to restrict flows and allow more time for water to infiltrate into the ground, which is removable in case the

sub-base becomes overly saturated. Also utilized were grassy filter strips, created wetlands, vegetated channels, and vortex-type oil traps.

After a year of use the paving system is functioning properly with a 2-year study currently underway to determine the effects of this parking lot and the combination of the BMP's utilized. Funding for this project was largely obtained through grant funding from the EPA. (Kelsey and Sikich, 2005)

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3.1.3 LID Street and Road Design

Streets and roads include a significant portion of impervious coverage in a community and are one of the largest contributors of storm water flows and pollutant loads. LID street and road design is a strategy to curb this impact by reducing impervious coverage and maximizing storm water infiltration and pollutant uptake.

Elements of LID Street and Road Design

- Road layout – consider alternatives that reduce impervious coverage, reducing the length of the road network by exploring alternative street layouts. Clustering homes and narrowing lot frontages can reduce road length by reducing the overall development area. Another approach is to lengthen street blocks and reduce cross streets, providing pedestrian and bicycle paths mid-block to increase access.

- Street width – determine based on a function of land use, density, road type, average daily traffic, traffic speeds, street layout, lot characteristics and parking, drainage and emergency access needs.

- Cul-de-sac design – Conventional cul-de-sac designs can create large areas of impervious coverage in neighborhoods. Alternative cul-de-sac designs can reduce impervious coverage but should be designed to accommodate street sweepers. Alternative cul-de-sac designs include landscaped center islands with bioretention (shown in Figure 3-8), reduction of the radius to 30 feet, a T-shaped hammerhead design, or a loop road network.

Photo: Center for Watershed Protection

Figure 3-8: Landscaped cul-de-sac

- Right-of-way – should reflect the minimum required to accommodate the travel lane, parking, sidewalk, and vegetation, if present.

- Permeable materials – use in alleys and on-street parking, particularly pull out areas.

- Increased access – create paths to open space and other streets for pedestrians and bicyclists in subdivisions where alternative street layouts such as loop networks and cul-de-sacs are utilized.

- Traffic calming features – traffic circles, chicanes, chokers, speed tables, center islands, and speed humps offer the opportunity for storm water management through the use of bioretention areas or infiltration within these areas while providing pedestrian safety.

Drainage Options

Maximize drainage – preserve natural drainage patterns and avoid locating streets in low areas or highly permeable soils.

Uncurbed roads – where feasible, build uncurbed roads using vegetated swales as an alternative (Figure 3-9).

Urban curb/swale system – runoff runs along a curb and enters a surface swale via a curb cut, instead of entering a catch basin to the storm drain system.

Dual drainage system – a pair of catch basins with the first sized to capture the water quality volume into a swale while the second collects the overflow into a storm drain.

Concave medians – median is depressed below the adjacent pavement and designed to receive runoff by curb inlets or sheet flow. Can be designed as a landscaped swale or a biofilter.

Photo: Center for Watershed Protection

Figure 3-9: An uncurbed road utilizing a vegetated swale

Benefits of LID Street Designs

- Storm water runoff is reduced.
- Narrower streets slow traffic and increase pedestrian, bicycle and driver safety.
- Less runoff generated from decreased impervious surfaces creates a reduction in storm water runoff, which may result in a decrease in expenses in storm water management structures and treatment.
- Paving costs of street network are reduced as less pavement is needed.

3.1 Minimizing and Disconnecting Impervious Surfaces

Design Considerations

- Reduce the length of residential streets by reviewing minimum lot widths and exploring alternative street layouts.
- When siting streets, consider natural drainage patterns and soil permeability.
- Consider access for large vehicles, equipment, and emergency vehicles when designing alternative street layouts and widths.
- Impervious cover created by each cul-de-sac turnaround option is presented below. (Schueler, 1995)

Turnaround Option	Impervious Area (square feet)
40-foot radius	5,024
40-foot radius with island	4,397
30-foot radius	2,826
30-foot radius with island	2,512
Hammerhead	1,250

Limitations

- Local zoning standards may require wide streets, sidewalks on one or both sides of streets, and curbed roads.
- Arterial, collector and other street types with greater traffic volumes are not candidates for narrower streets.
- Street width and turnaround design need to accommodate fire trucks and other large vehicles and equipment.
- Some Cul-de-sacs designs do not accommodate standard street sweepers, which can be used to keep pollutants out of stormdrains.
- Uncurbed roads or walks may conflict with American Disabilities Act requirements.

Maintenance Considerations

- Narrower streets may require less maintenance than wider streets as they present less surface area to maintain and repair.
- Landscaped and bioretention cul-de-sacs and traffic calming areas will require routine maintenance associated with these areas.

Examples

In Seattle, WA, a pilot project, Street Edge Alternatives Project (SEA Streets), attempts to mimic pre-developmental hydrologic conditions by reducing impervious surfaces by 11 percent less than a traditional street, incorporating LID principles such as reducing on-street parking, narrowing street widths, reducing sidewalks, eliminating curbs and gutters by providing surface detention in swales, and adding 100 evergreen trees and 1,100 shrubs. One of the most

prominent features of the project is the 14-foot wide curvilinear streets, which is wide enough for two standard size cars to pass each other slowly (Figure 3-10). The edge of the roadway has no curb and has a two-foot grass shoulder capable of bearing traffic loading to accommodate emergency vehicle passage. Parking stalls are grouped between swales and driveways with the number of spaces determined by homeowner needs. The sidewalk also follows a curvilinear design and is only located on one side of the street. Swales are located in the right of way adjacent to the street to capture runoff from the street, sidewalk and adjacent property. After two years of monitoring, the project has reduced the total volume of storm water leaving the street by 98 percent for a two-year storm event. (Seattle Public Utilities District, 2003)

Figure 3-10: Images of SEA Project streets. (Courtesy of Seattle Public Utilities District)

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3.1.4 LID Driveway Design

Driveways add a significant amount of impervious coverage to a community and are an element of a site's design that can be altered to minimize total impervious coverage. Driveways often slope directly to the street and storm drain system and contribute significantly to storm water pollution. There are several strategies that can be implemented to reduce this impact, including:

- Utilize shared driveways to provide access to several homes.
- Reduce driveway length by reducing front yard setbacks.
- Reduce driveway width by allowing tandem parking (one car in front of the other).
- Install a narrowed driveway with a flared entrance for multi-car garage access.
- Disconnect the driveway by directing surface flow from the driveway to a permeable landscaped area, such as a below grade bioretention basin.
- Consider ribbon driveways, which consist of two strips of pavement with grass or some other permeable surface in between the strips.
- Utilize porous surfaces such as porous concrete or asphalt, permeable pavers or crushed aggregate.
- Create a temporary parking area where parking or access is infrequent. These areas can be paved with permeable surfaces.

Figure 3-11: A residential driveway with multiple LID strategies, including permeable pavers and a slotted drain built in to catch sediment and runoff, which is funneled into a grassy swale.

(Photo courtesy of NEMO Nevada)

Design Considerations

- Shared Driveways:
  - Shared driveways can provide access to several homes.
  - Access may not need to be as wide as residential streets.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

- Disconnected Driveways:
  - The driveway cross slope must be greater than the longitudinal slope in order for runoff to be directed into adjacent landscape.
  - Adjacent landscape must be sized to accommodate the water quality volume.
  - The edge of the driveway must be approximately 3 inches above the vegetated area so to not impede flow from the driveway.
  - A slotted channel drain is installed at or below the surface of the driveway roughly perpendicular to the flow path, captures flow from driveway and directs it to an infiltration system or vegetated area. The slotted drain should have removable grates to allow access for cleaning. (See Figure 3-12)

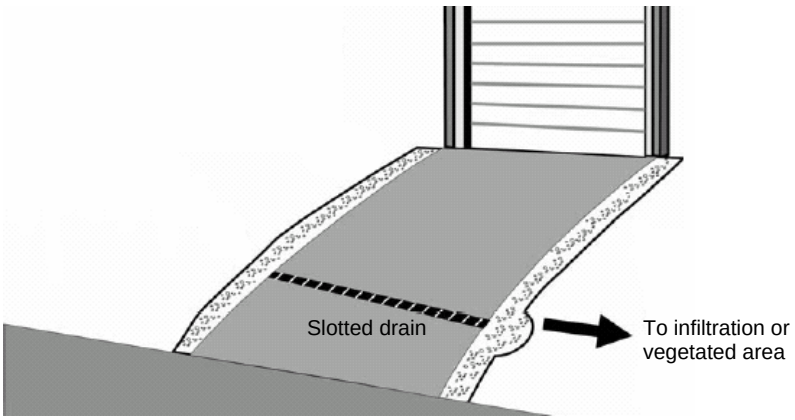

Figure 3-12: Schematic of a driveway with a slotted drain.
(adapted from BMP Retrofit Partners, 2003)

- Ribbon Driveways (Figure 3-13):
  - Wheel tracks should be wide enough to accommodate variability in driving and vehicle widths.
  - For soils with low infiltration rates, a perforated drain line buried between the wheel tracks may be appropriate to collect and direct runoff.
  - If vegetation is incorporated, it should be irrigated.

Photo: Courtesy of Nevada NEMO

Figure 3-13: Ribbon Driveway, also known as a Hollywood driveway.

- Flared Driveways:
  - Single lane width at street with flare at garage to serve multiple garage door openings.
  - Provide adequate space in front of multi-car garage for vehicle parking and maneuvering.
- Crushed Aggregate Driveways:
  - Use open-graded crushed aggregate rather than rounded stones.
  - Utilize a rigid edging material such as wood, concrete, metal, or brick to contain aggregate material.

Limitations

- Driveway length is generally determined by front yard setback requirements.
- Driveway width is usually mandated by municipal codes.
- Slotted drains and ribbon driveways – designer should be careful to meet American Disabilities Act requirements.

Maintenance Considerations

- For driveways connected to landscaped areas, maintenance and edging of the adjacent lawn is important to allow unimpeded flow.
- For ribbon driveways, the area between the wheel tracks requires edging and maintenance, including periodic weed control.
- Crushed aggregate driveways may require weed-control fabric, or periodic weed control and replenishment of the aggregate. Need for weed control may encourage herbicide use, which opposes LID principles if applied incorrectly.

- Slotted channel drains generally need to be cleaned twice a year, in the spring and fall, and should be swept or vacuumed out. Clear any loose surface debris on a regular basis. The outlet should be checked periodically for clogging.

References and Additional Sources of Information

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BMP Retrofit Partners. 2003. *How to Install Best Management Practices in the Lake Tahoe Basin: Manual for Building Landscaping Professionals*. University of Nevada Cooperative Extension.

Gibbons, Jim. 1999. *NEMO Technical Paper Number 6: Driveways.* University of Connecticut Cooperative Extension. www.nemo.uconn.edu/publications/tech_papers/tech_paper_6.pdf

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3.1.5 LID Sidewalks and Bike Paths

Sidewalks and bike paths are another source of impervious coverage that can adversely affect water quality by the runoff generated from their surface. Several management opportunities and strategies are available to reduce this impact, including:

- Reducing sidewalks to one side of the street.
- Disconnect bike paths from streets. Bike paths separated from roadways by vegetated strips reduce runoff and traffic hazards.
- Utilizing pervious materials to infiltrate or increase time of concentration of storm flows (Figure 3-14).
- Reducing sidewalk width when possible.
- Directing sidewalk runoff to adjacent vegetation to capture, infiltrate, and treat runoff.
- Installing a bioretention area or swale between the street and sidewalk and grading runoff from the sidewalk to these areas (see section 3.1.3).
- Planting trees between the sidewalk and streets to capture and infiltrate runoff.
- Installing grated infiltration systems in sidewalks and bike paths to receive runoff as sheet flow. These can be installed to protect trees or can provide off-line storm water management via a grate over an infiltration trench.

Figure 3-14: The sidewalk on the left is made of porous concrete and the walkway on the right is made of porous asphalt. (Photos courtesy of Cahill Associates and Stormwater Journal)

Design Considerations

- Grade sidewalks and bike paths at a two percent slope to direct runoff to an adjacent vegetated area.
- Pervious materials such as permeable pavers, porous concrete or asphalt, gravel, or mulch can be utilized for sidewalk surfaces.

- In some cases, sidewalks and bike paths can be placed between rows of homes to increase access and decrease overall effective imperviousness.
- Grated infiltration systems should include removable grates to allow for maintenance, and must be capable of bearing the weight of pedestrians.

Limitations

- Ordinances may require sidewalks on both sides of the street.
- Groundwater table must not be within 10 feet of the bottom of infiltration trenches.
- Bioretention or swales may require supplemental irrigation.
- Vector breeding may occur in bioretention and swales if not properly designed or maintained.

Maintenance Considerations

- For maintenance of pervious surfaces, including porous concrete and asphalt and permeable pavers see section 3.4.
- For maintenance of bioretention areas see section 3.3.
- For maintenance of swales see section 3.2.

Examples

As also described in Section 3.1.3 and also shown on Figure 3-15, the Seattle, WA Street Edge Alternatives (SEA) Streets project, attempts to mimic pre-developmental hydrologic conditions by reducing impervious surfaces 11 percent less than a traditional street, incorporating LID principles such as reducing on-street parking, narrowing street widths, reducing sidewalks, eliminating curbs and gutters by providing surface detention in swales, and adding 100 evergreen trees and 1,100 shrubs. After two years of monitoring, the project has reduced the total volume of storm water leaving the street by 98 percent for a two-year storm event. (Seattle Public Utilities District, 2003)

Photos: Seattle Public Utilities District

Figure 3-15: Images of SEA streets project sidewalks.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

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3.2 Swales and Filter Strips

Swales and filter strips can be effective storm water treatment control systems if runoff depths are shallow and velocities are slow. These systems rely upon the vegetation and the subsoil matrix to filter pollutants from runoff and can also provide infiltration and groundwater recharge. They can provide desirable open space buffers between developed impervious surfaces, the storm drain system, and receiving water bodies. Wherever possible, swales should be incorporated into natural drainage channels. Vegetative treatment systems such as swales and filter strips reduce the velocity of urban runoff and can serve as part of the storm drain system. They can be accessed by curb cuts or they can replace curbs, gutters and subsurface storm drain pipe systems. Swales sited on existing clayey or silty soils with low infiltration rates (less than 0.5 in/hr or 120 min/in) should also include underdrain systems.

Swales and filter strips can be accessed by grade design, curb cuts, or they can replace curbs, gutters, and subsurface storm drain pipe systems. By designing the grade of impervious surfaces such as driveways and sidewalks to flow towards vegetated areas instead of towards streets, they can be accessed directly. To facilitate flow into these LID practices and accommodate vegetation growth and sediment deposition, the edges of driveways and sidewalks should be designed to be 2 to 5 inches above the adjacent edge of swales and filter strips.

Swales are shallow open channels. Also known as vegetated swales, biofiltration swales or grassy swales, they are commonly vegetated with grasses (Figure 3-16). Rock lined low flow channels and underdrain systems can be added where native soils have poor infiltration characteristics (Figure 3-17) and grades that are less than 0.5 percent. Low flow channels and underdrain systems can reduce the potential of extended ponding and mosquito breeding. Xeriscape swales (Figure 3-18) are planted with native vegetation or low water use plants interspersed among rock and have little to no water requirements once established. Storm water runoff is conveyed along the length of the low slope channel, which decreases the velocity, traps sediments, and reduces erosion. Storm water runoff is treated by filtering sediments and associated pollutants through the engineered subsoil and vegetation and by infiltration into the underlying soils. Pollutant removal and treatment efficiency improves as contact time and the amount of infiltration increases.

Figure 3-16: Grassy swale

Figure 3-17: Swale with rock lined low flow channel

Photos: Kennedy/Jenks Consultants

3.2 SWALES AND FILTER STRIPS

Grassy and xeriscape swales are simple to design and install. They can serve as part of the storm drain system or can be used in place of curbs and gutters. These practices can also be used with other structural treatment controls and LID practices as part of a treatment train. They can be used to convey and treat runoff from parking lots, buildings, and roadways and can be applied in residential, commercial, industrial, and municipal land uses. Xeriscape swales are recommended wherever possible to assist with water conservation strategies. Grassy swales are appropriate in parks or private landscaped areas that are irrigated.

Figure 3-18: Xeriscape swale.

Photos: Kennedy/Jenks Consultants

Figure 3-19: Buffer strip.

Filter strips are also known as vegetated filter strips or buffer strips (Figure 3-19). They are gently sloping and uniformly graded vegetated strips that provide storm water treatment to relatively small drainage areas. Filter strips slow the velocity of runoff to promote filtration of sediments and pollutants and infiltration into underlying soils. They require sheet flow to function properly and often require a flow spreader to evenly distribute runoff across the width of the filter strip. This may be a porous pavement strip or another type of structure. Grassed or vegetated filters consist of uniformly graded, densely vegetated turf surfaces that can be interspersed with shrubs and trees to improve aesthetics and provide shade. In the semi arid climate of the Central Coast, irrigation is typically required for grassy filter strips to maintain a healthy and dense vegetative cover capable of withstanding the erosive forces of runoff from adjacent impervious areas.

Xeriscaped filter strips use the same concept as vegetated filter strips except they incorporate low to no water use plants and rock, allowing for water conservation. Filter strips are typically located on the edge of landscaping areas and can provide pretreatment for other treatment controls. Xeriscape filter strips (Figure 3-18) are ideal at the edge of landscaping features to reduce runoff and conserve water. Lawn areas adjacent to sidewalks, driveways and streets are typically hotter and drier and require more water than areas not adjacent to these impervious surfaces. By planting a xeriscape filter between sidewalks, driveways, and streets and the lawn, water needs will be reduced. Less runoff will also occur as the xeriscape filter strip captures and infiltrates the water leaving the lawn area. This can be particularly useful where lawn areas are located directly downwind of prevailing winds. Studies have shown that up to 40 percent of the water that leaves sprinklers can be lost to overspray, runoff, and evaporation.

3.2 SWALES AND FILTER STRIPS

The recommended plant species for vegetated swales and filter strips should meet the following criteria:

- Native or easily naturalized,
- Low water requirements,
- Low fertilizer requirements,
- Low maintenance requirements, and
- Attractive in all seasons.

Plant species located in the low zone (bottom) of vegetated swales must be able to withstand periodic flooding. Turf or other soil erosion grasses can also be used in vegetated swales (e.g. grassy swales) and buffer strips. However, turf requires regular irrigation, fertilizer application, and maintenance which may result in reduced pollutant removal effectiveness. Fertilizer use should be minimized in vegetated swales and buffer strips. Slow release fertilizers may be used provided it does not become a pollutant in storm water (e.g. never apply fertilizers when rain is predicted). Herbicides and pesticides are also not recommended unless absolutely required. Maintaining mulch and hand-weeding are the recommended weed-control measures. If herbicides are necessary, use natural alternatives such as insecticidal / herbicidal soap or herbicides that degrade quickly such as glyphosphate (e.g. Roundup). If pesticide use is necessary, biological pest and disease controls are recommended. Sources of information for natural pesticide alternatives include the following:

- *Suppliers of Beneficial Organisms in North America*, available from the California Department of Pesticide Regulation, Environmental Monitoring and Pest Management Branch, 830 K Street, Sacramento, CA, 95814, (916) 324-4100.
- *Directory of Least-toxic Pest Control Products,* available from the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA, 94707, (510) 524-2567.

3.2.0 VEGETATED SWALES

3.2.0 Vegetated Swales

Vegetated swales are also known as biofilters, biofiltration swales, landscaped swales, and grass swales. To be effective at storm water management, vegetative swales should be designed as wide, shallow earthen open channels covered with a dense vegetative growth (commonly grasses) along the bottom and side slopes. Storm water runoff is conveyed along the length of the low slope channel and vegetation traps sediments, decreases the velocity of overland flows, and reduces erosion. Storm water runoff is treated by filtering sediments and associated pollutants through the vegetation and by infiltration into underlying soils. Pollutant removal and treatment efficiency improves as contact time and infiltration increases. For this reason, the length of vegetated swales should not be less than 100 feet.

Vegetated swales are considered an LID practice and are relatively simple to design and install. They can serve as part of the storm drain system or can be used in place of curbs and gutters and can be used with other structural treatment controls as part of a treatment train. Vegetative swales can provide some reduction in peak flows during storm events by slowing the velocity of runoff and depending upon the properties of the underlying soils, they can also facilitate infiltration. However they do not typically reduce post construction flow rates and volumes to the levels required by local ordinances or NPDES storm water permit requirements. Therefore, additional detention, retention and/or infiltration facilities typically may need to be added to vegetated swales to address local, regional, and/or state requirements.

Photo: Sacramento, 2007

Applications and Advantages

Vegetated swales can be used to convey and treat runoff from parking lots, buildings, roadways, and residential properties. They are typically located in parks, parkways or private landscaped areas and in agency Right of Ways (ROWs). They can also be used as pretreatment devices for other structural treatment controls. They can be designed as natural drainage features with temporary irrigation provided to establish the vegetation and annual maintenance, or they can be designed as landscaped areas with permanent irrigation systems.

3.2.0 VEGETATED SWALES

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	60 – 95%
Total Phosphorus	5 – 45%
Total Nitrogen	15 – 65%
Nitrate	-25 – 65%
Metals	20 – 90%

Sources: UDFCD, 1999; CASQA, 2003

The large range in pollutant removal efficiencies reflects differences in design, variable influent concentration levels and flow rates, and the permeability of underlying soils. Pollutant removal efficiencies for vegetated swales generally increase when underlying soils provide for infiltration. The literature reviewed does not discuss the removal efficiency for organics or petrochemicals. Additional BMPs may be needed for treatment of these pollutants.

Limitations

- Vegetated or grassy swales typically require supplemental irrigation.
- Effectiveness is decreased by compacted soils, frozen ground conditions, short grass heights, steep slopes, large storm events, high discharge rates, high velocities, and a short runoff contact time.
- Requires a sufficient amount of available land area.
- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration rates of local soils can limit the application of vegetated swales, unless underdrains are installed.
- Effectiveness may be limited in areas where gophers or other burrowing animals are abundant.
- Possible formation of mosquito breeding habitat if water does not drain or infiltrate.

Siting Criteria

- Maximum swale drainage areas is 10 acres. Smaller drainage areas are preferred.
- Not to be applied in areas with adjacent slopes of 5 percent or greater or in areas with highly erodible soils.
- If possible, the preferred installation site is in a natural topographic low to preserve natural drainage and recharge patterns.
- To provide adequate contact time for pollutant removal, generally the minimum length of the swale should be 100 feet.

- Swales should be established with a minimum longitudinal slope of 0.5 percent and a maximum longitudinal slope of 2.5 percent. Swales or swale sections with longitudinal slopes between 2.5 and 5.0 percent may be allowed if check dams are installed to reduce runoff velocity to 2.0 ft/sec or less.

- If designed to infiltrate storm water into underlying soils, swales are considered indirect infiltration systems. Therefore, apply the site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design vegetated swales.
- Design vegetated swales to convey the Water Quality Flow (WQ_F) rate based on the method presented in Section 4.5.2.
- If possible, flows in excess of the WQ_F rate should be diverted around vegetated swales with upstream diversion structures.
- If a swale is be designed to both convey and treat the WQ_F rate and to convey the flows produced by larger storm flows, the swale should be designed to safely convey flows produced by the 100-year storm event.
- Trapezoidal or parabolic channels are recommended.
- Swale side slopes should not be steeper than 4H:1V (see Figure 3-20).
- The minimum bottom width should be no less than 2 feet (see Figure 3-20)
- The maximum bottom width should not exceed 10 ft.
- To size the bottom width, use the Manning's equation at the WQ_F with a roughness coefficient (*n*) value of 0.25 for grass and 0.40 for mixed vegetation and rocks[5].
- Improved pollutant removal efficiency occurs with a minimum 10-minute hydraulic residence time at the WQ_F.
- To determine the capacity of the swale to convey peak hydraulic flows, use a roughness coefficient (*n*) of 0.10 with Manning's Equation.
- A design vegetation height of 4 - 6 inches is recommended.
- A diverse selection of low growing plants that thrive under site specific soils and proposed watering conditions should be specified.
- For areas without regular irrigation, use drought tolerant vegetation, however pollutant removal efficiencies will typically be reduced.
- The swale must meet local ordinances and should be included on site plans.

[5] Manning's roughness coefficient (*n*) values used for open channels have historically ranged from approximately 0.02 to 0.10 (see Table 3-2). However, these values were applied to channels designed to efficiently and quickly transport water. For vegetated swales designed to treat storm water quality, higher *n* values should be applied (Minton, 2006).

- The swale must not hold standing water for more than 72 hours to prevent vector problems.
- Effectiveness can be improved by installing check dams at regular intervals.
- A 4-inch diameter PVC under drain should be provided in type C and D soils (e.g. silty or clayey soils with infiltration rates less than 0.5 in/hr) to increase infiltration capacity.
- Fertilizers and soil amendments should be specified based on soil testing results and vegetation requirements. Improper application of fertilizer can result in contamination of storm water runoff.

Inspection and Maintenance Requirements

- With proper inspection and maintenance, vegetated swales can last indefinitely.
- Proper maintenance includes mowing, weed control, removal of trash and debris, watering during the dry season, and reseeding of non-vegetated areas.
- When mowing grass, never cut shorter than the design flow (WQ_F) depth, and remove grass cuttings.
- Inspect swales at least twice annually for damage to vegetation, erosion, sediment accumulation and ponding water standing longer than 72 hours.
- Periodic litter collection and removal will be necessary if the swale is located adjacent to a main road.
- Sediments should be removed when depths exceed 3 inches.
- If a spill occurs and hazardous materials contaminate soils in vegetated swales, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

Examples

The Morton Arboretum in DuPage County, Illinois is a 1,700+ acre outdoor museum of woody plants adjacent to Meadow Lake and the East Branch of the DuPage River. When a new visitor center was proposed for the facility a “green” parking lot was constructed to accommodate the anticipated increase in visitation. The parking lot utilized biofiltration swales as parking lot medians to drain the parking lot. Also utilized were grassy filter strips, permeable pavement, created wetlands, vegetated channels, and vortex-type oil traps.

The biofiltration swales were designed along 9-foot wide medians in the parking lot with a barrier curb along the swales that incorporated 3-foot gaps to minimize the amount of concentrated flow into the swales. The curb cuts were spaced 3 stalls apart and located along parking lot stripes to avoid the potential for small vehicles or motorcycles from driving into the swales. Curb structures were specially graded with the gutter being pitched from the middle to slope at approximately 0.5 percent to the curb cut.

The swales were constructed to pond to a depth of 0.5 ft prior to overflowing to the conventional storm drain system. Side slopes were graded at a 3 H:1V slope, being approximately 1 foot below the edge of the pavement, and having a 3-foot bottom width. The soil consisted of a sandy loam mix with approximately 5 percent coarse organic matter.

3.2.0 VEGETATED SWALES

After a year of use, the parking lot biofiltration swales appear to be functioning properly. The only concern is utilization by pedestrians through some of the curb cuts. It is believed that through proper plantings and the installation of stepping-stones this problem can be mitigated. Funding for this project was largely obtained through a grant from the USEPA (Kelsey and Sikich, 2005).

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3.2.0 VEGETATED SWALES

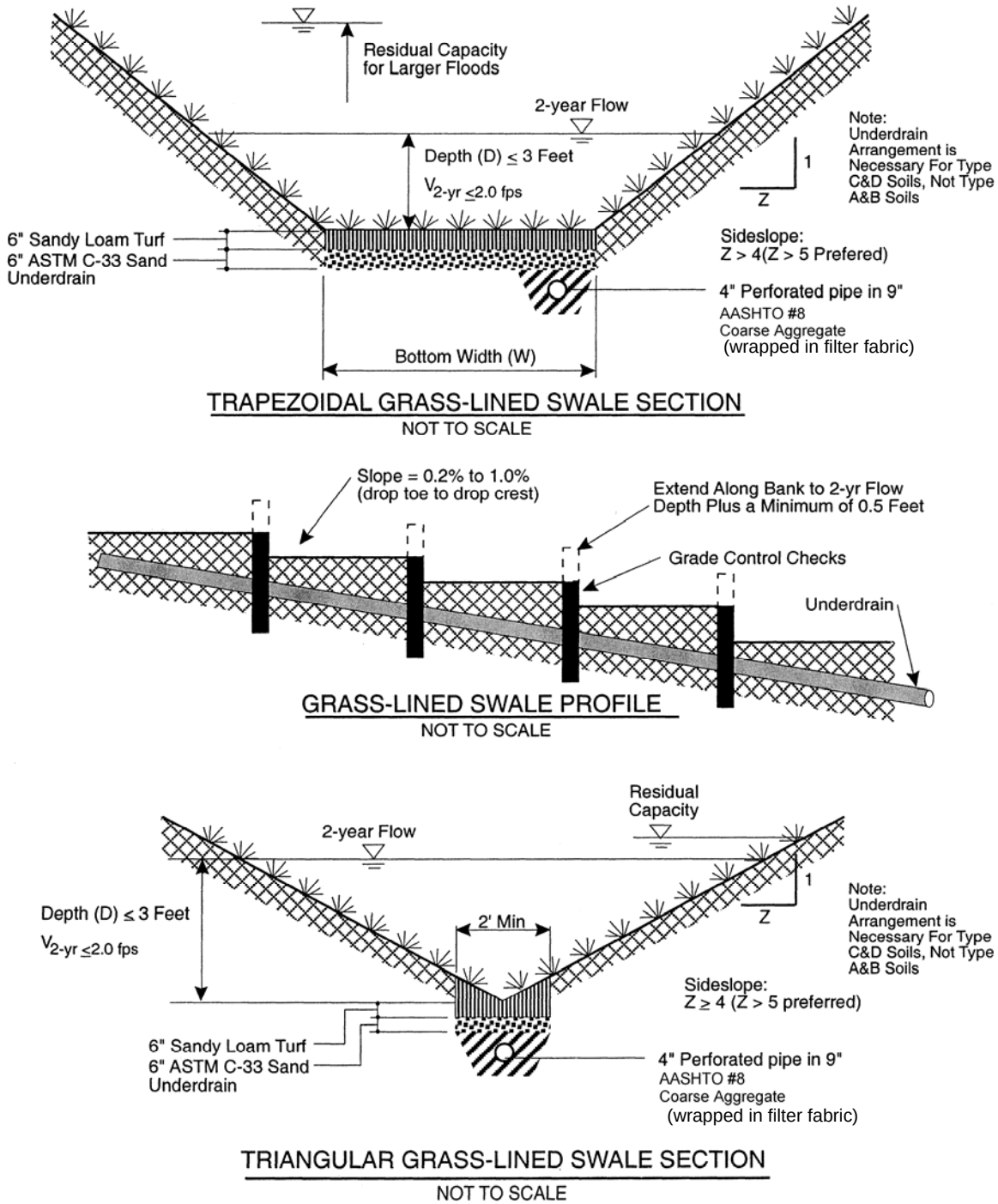

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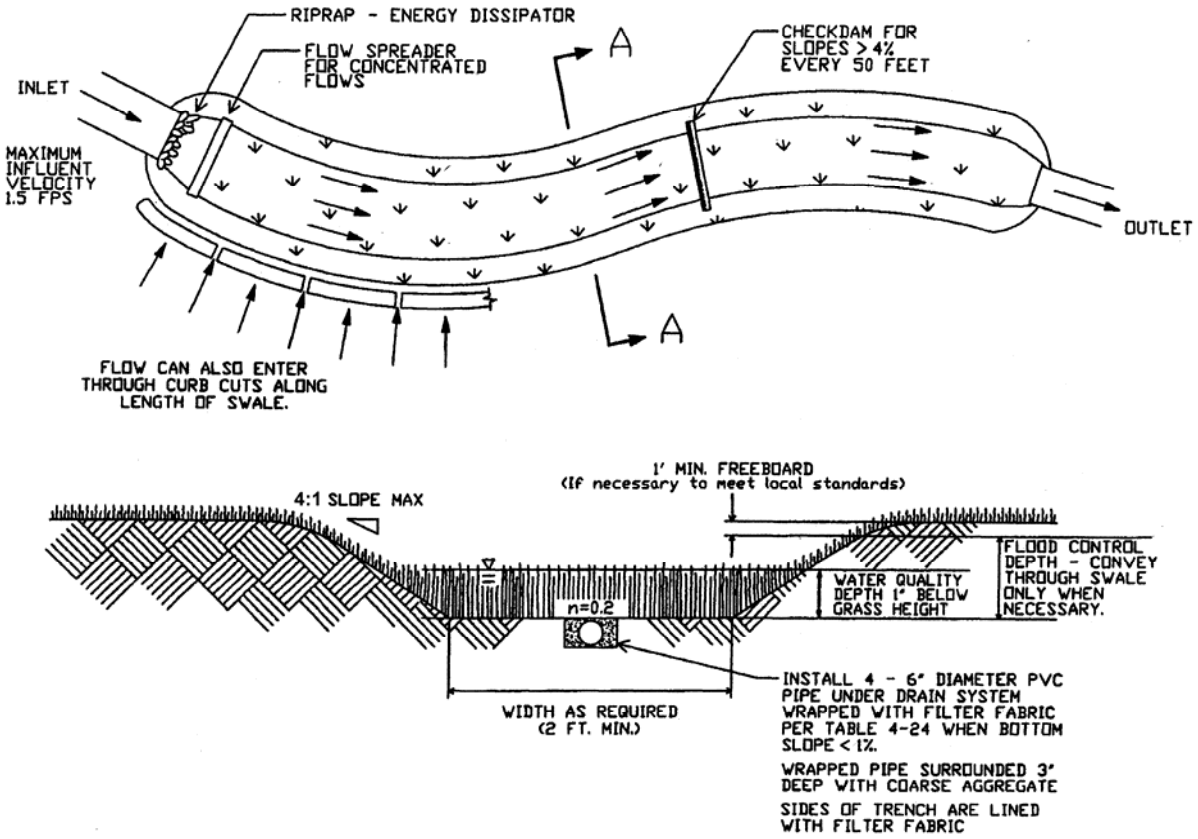
Figure 3-20: Typical design and structure of a Vegetated Swale. (modified from UDFCD, 1999)

3.2.0 VEGETATED SWALES



NOTES:

1. An energy dissipator and flow spreader should be installed at the entrance to the swale to reduce velocity and evenly distribute flows across the swale.
2. Maximum allowable side-slope 4H:1V
3. Grass height maintained in accordance with design specifications. Design grass height between 4 to 6 inches.
4. Flow height to be one-inch below design grass height for water quality design storm flow (2 year - 6 hour storm). Use a Mannings roughness coefficient of 0.2 to design for water quality flow through the swale vegetation.
5. n value above water quality height determined based on type of vegetation used. Typical value: 0.035
6. If the swale bottom slope exceeds 4% or soils very permeable, install check dams every 50 feet to slow the velocity to prohibit scouring and promote infiltration.
7. If the swale bottom slope is less than 1% install under drain system to prevent standing water.
8. Flows in excess of water quality flow should be diverted around the swale. If necessary for swale to convey flood waters, provisions shall be made to ensure conveyance in accordance with City or County Standards. Provide 1 ft. freeboard if necessary for flood control.

Figure 3-21: General design guidelines for a typical Vegetated Swale (modified from Sacramento, 2000).

3.2.1 Vegetated Filter Strips

Also known as buffer strips, or grassed buffers, vegetated filter strips consist of dense turf surfaces that can be interspersed with shrubs and trees to improve aesthetics and provide shade. They are gently sloping and uniformly graded and provide storm water treatment to relatively small drainage areas. Vegetated filter strips slow the velocity of runoff waters to promote infiltration and the filtration of sediments and pollutants. They require sheet flow to function properly and often require a flow spreader to evenly distribute runoff across the width of the filter strip. Vegetated filter strips can be used as pretreatment devices for other treatment controls and can also be combined with riparian zones for treating sheet flows and stabilizing channel banks adjacent to drainageways and receiving water bodies. Irrigation is typically required to maintain a healthy and dense vegetative cover capable of withstanding the erosive forces of runoff from adjacent impervious areas.

Photo: Caltrans

Applications and Advantages

Vegetated filter strips are appropriate along the edge of residential and commercial developments where irrigated landscaping is planned. They are commonly applied along roadside shoulders in humid areas and have historically been used in agricultural practices.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	10 - 74
Total Phosphorus	0 - 10
Total Nitrogen	0 - 15
Total Recoverable Zinc	0 - 10

Sources: UDFCD, 1999; CASQA, 2003.

3.2.1 VEGETATED FILTER STRIPS

Pollutant removal depends on factors such as soil permeability, land uses and slopes of adjacent drainage area, runoff volumes and velocities, the flow path across the filter strip and the type and density of the vegetation used. The general pollutant removal efficiency for both particulate and soluble pollutants is low to moderate.

Limitations

- Typically requires supplemental irrigation.
- A uniformly graded thick vegetative cover is required to function properly.
- May not be applicable adjacent to industrial sites or locations where spills may occur.
- Filter strips are not capable of treating storm water from large drainage areas.
- It may be difficult to establish the level slopes necessary for filter strips.
- Sheet flow is required.
- Drainage area is limited due to the sizing requirements for a filter strip.
- Cannot be applied in areas with highly erodible soils.

Siting Criteria

- Avoid areas that are highly trafficked, both by automobiles and people.
- Limited to areas with gently sloping surfaces where vegetation is hearty and shallow flow occurs.
- Best suited for treating runoff from roads, roofs, small parking lots, and pervious surfaces.
- Impractical in highly urban areas with little pervious ground.
- Vegetated filter strips do not increase water temperatures and thus are useful for protecting cold-water streams.
- If designed to infiltrate storm water into underlying soils, filter strips are considered indirect infiltration systems. Therefore apply the site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- A conceptual design can be found on Figure 3-22.
- Registered professional civil engineers and landscape architects should work together on the design vegetated filter strips.
- Slopes should not be greater than 4 percent (2 to 4 percent is preferred).
- Maximum drainage area is 5 acres.
- Sheet flow must be maintained across filter strips.
- To create sheet flows install a level spreader at the top edge of the filter strip along a contour. A porous pavement strip may be used to create sheet-flow conditions.

3.2.1 VEGETATED FILTER STRIPS

- Channelized flow across filter strips should not be permitted.
- The top of the vegetated filter strip should be installed 2 – 5 inches lower than the impervious surface that is being drained.
- If supplemental irrigation is not available, use drought tolerant species in the filter strip to minimize irrigation in dry climates.
- If seeds are used to plant the vegetated filter strip, they will need to be protected with mulch for a minimum of 75 days.
- The hydraulic load should not exceed 0.05 cfs/linear foot of the vegetated filter strip during the 2-year storm (WQ_F) to maintain a sheet flow of 1 inch or less trough dense grass that is at least 2 inches high.
- The minimum length of a vegetated filter strip (normal to flow) should be determined using the following equation:

$$L_G = WQ_F / 0.05$$

Where: L_G = minimum design length (ft)

WQ_F = water quality flow (cfs)

- The minimum width of a vegetated filter strip (in the direction of flow) should be determined based on the flow conditions upstream of the filter strip.
- For a sheet flow control level spreader, use the following equation:

$$W_G = 0.2L_L \text{ or 8 feet (whichever is greater)}$$

Where: W_G = width of the filter strip

L_L = the length of the flow path over the upstream impervious drainage area (ft)

- For a concentrated flow control level spreader, use the following equation:

$$W_G = 0.15(A_t / L_t) \text{ or 8 feet (whichever is greater)}$$

Where: A_t = the drainage area (ft^2)

L_t = the length of the drainage area (normal to flow) adjacent to the filter strip (ft)

- Increasing the width (W_G) will increase runoff contact time, filtration of particulates and pollutants, and infiltration of runoff.
- A vegetated swale can be used to collect outflow from a filter strip and can provide additional treatment prior to conveying flows to the storm drain system or receiving waters.

Inspection and Maintenance Requirements

- Required maintenance includes weed removal as well as mowing and irrigation of grasses.
- Grasses or turf should be maintained at a height of 2 – 4 inches.
- Filter strips should be irrigated during the dry season.

3.2.1 VEGETATED FILTER STRIPS

- Trash, litter, rocks, and branches should be frequently collected from filter strips, especially those located along highways.
- Regularly inspect filter strips for pools of standing water that may be acting as mosquito breeding habitat.
- Filter strips should be inspected at least two times a year, preferably before and after the winter/wet season.
- Sediments that accumulate along the upstream edge of filter strips and/or in level spreaders should be collected and removed at least once a year.
- The owner/operator of the property must be responsible for maintaining vegetated filter strips.
- If a spill occurs and hazardous materials contaminate soils in vegetated filter strips, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

References

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

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #39 – Vegetative Filter Strip. http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp39.asp

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District (UDFCD), 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

3.2.1 VEGETATED FILTER STRIPS

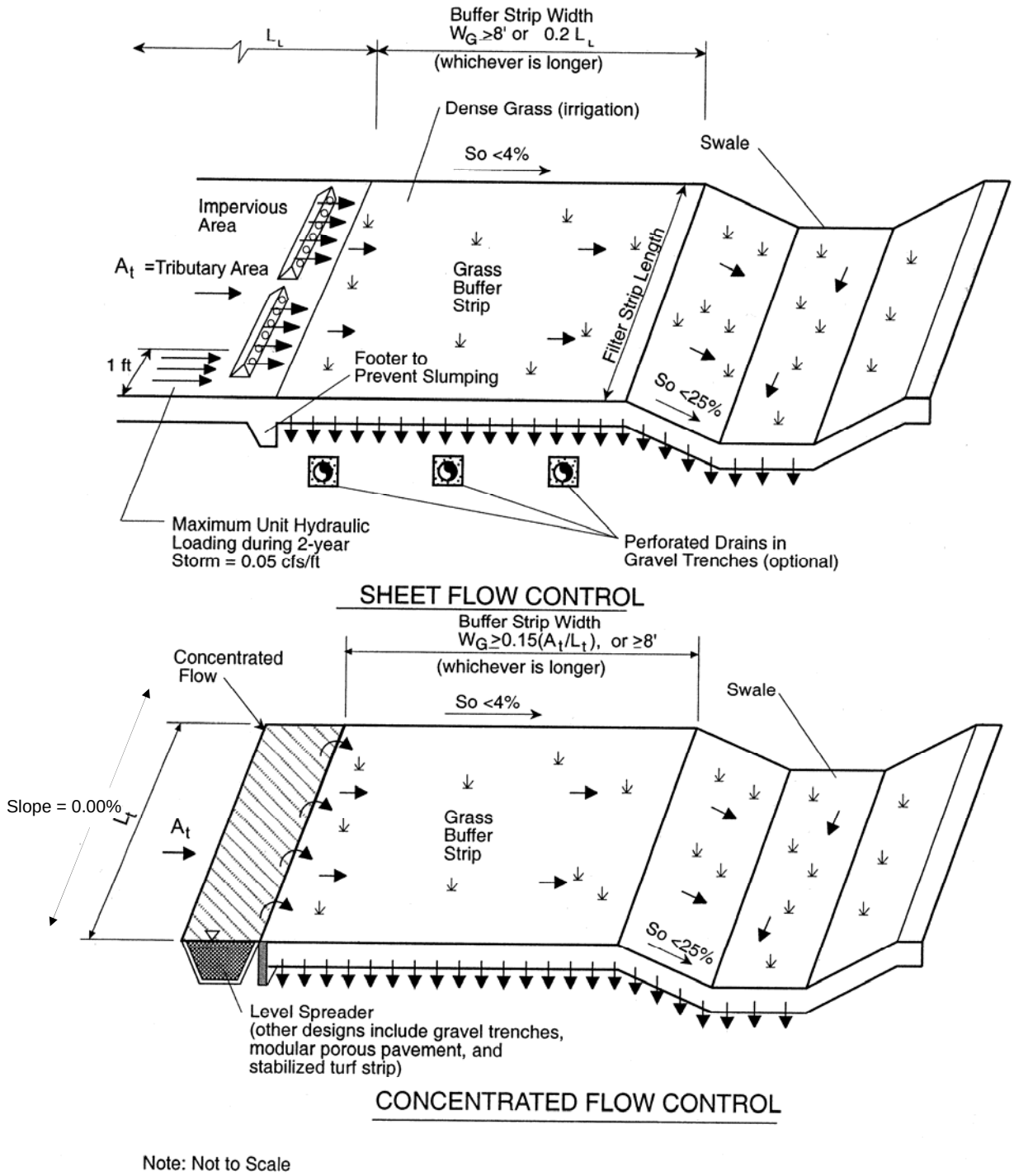


Figure 3-22: General design guidelines for a typical Vegetated Filter Strip. (modified from UDFCD, 1999)

3.3 Bioretention Systems

General Description

Bioretention systems consist of depressed vegetated areas with porous engineered soils designed and to capture and treat urban runoff and infiltrate treated water to the subsurface where existing site soils allow. Bioretention systems are also known as landscape detention, rain gardens, tree box filters, and storm water planters. This type of LID practice is very versatile and can be implemented in most areas where landscaping is to be incorporated into new development or redevelopment projects. Bioretention systems are very effective at reducing the volume and pollutant loading of removing urban runoff because they utilize a combination of porous engineered soils, plants, and their root systems. The volume of urban runoff is reduced by soil retention, plant uptake, evapotranspiration and infiltration. Pollutants are effectively removed by a number of processes including physical filtering, ion exchange, adsorption, biological processing, and conversion. Bioretention systems can be installed into existing site soils or within concrete enclosures. When existing soils are excavated and replaced with engineered soils to create a bioretention system, a layer of pea gravel (not filter fabric) should be used at the base of the excavated pit. Although generally not considered necessary, a geotextile filter fabric or an impermeable liner such as visqueen can be placed along the sides of the excavation to separate the engineered soils from the existing site soils.

A typical bioretention system design includes a depressed ponding area (at a grade below adjacent impervious surfaces), an engineered soil mix, and where existing soils have slow infiltration rates, an underdrain system. The ponding area is designed to capture, detain and infiltrate the water quality volume (WQ_V) into an engineered soil mix consisting of a well mixed combination of topsoil, clean sand, and certified compost and/or peat moss (see Section 4.4.0 for additional engineered soil mix details). Where underlying existing site soils have relatively slow infiltration rates (less than 0.5 inch/hr or greater than 120 min/inch), an underdrain system consisting of a perforated pipe in a gravel layer should be included in the design to facilitate proper drainage. Discharge from the underdrain pipe can be routed to a down gradient storm drain pipe or channel. Urban runoff from relatively small storm events, as well as from upgradient washing and irrigation activities; passes through pipes, slotted curbs curb cuts or curb inlets and is distributed evenly at non erosive velocities along the length of the flat ponding area of bioretention systems. Runoff ponds to a depth of approximately 6 to 12 inches and then gradually filters through the engineered soils mix, where it is retained in the porous soils, utilized by plants, evapotranspired, and either infiltrated into the underlying soils, or drained into an underdrain system over a period of days.

Erosion control/energy dissipation features should be provided where runoff enters bioretention systems (e.g. cobbles or riprap beneath a curb cut opening or a splash block beneath a roof drain downspout). In addition, vegetated swales or filter strips can be added to the design to provide pretreatment (e.g. for sediment reduction). Excess runoff from large storm events should be allowed to bypass bioretention systems and flow towards the conventional storm drain system or another downstream BMP. This can be accomplished by providing overflow outlets or inlet control structures such as weirs, inlet pipes and/or grade control features.

3.3 BIORETENTION SYSTEMS

Photo: Center for Watershed Protection

Photo: Seattle SEA Streets Project

Figure 3-23: Bioretention systems located on-lot in a multifamily development (left) and in a street right of way of a residential development (right).

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutants	Percent Removal Efficiency
Total Suspended Solids	75 - 90
Total Phosphorus	70 - 80
Total Nitrogen	65 - 80
Total Zinc	75 - 80
Total Lead	75 - 80
Organics	75 - 90
Bacteria	75 - 90

Sources: CASQA, 2003; UDFCD, 1999.

Applications and Advantages

Bioretention systems can be incorporated into all aspects of urban development, including residential, commercial, municipal, and industrial areas. They are well suited for planters along buildings, within street median strips, parking lot islands, and roadside areas where landscaping is planned. In addition to providing significant water quality benefits, bioretention systems can provide shade and wind breaks, absorb noise, improve an area's aesthetics, reduce irrigation needs, and reduce or eliminate the need for an underground storm drain system. Bioretention systems should be integrated into a site's overall landscaping to reduce the volume, rate and pollutant loading of urban runoff to pre-development levels.

Figures 3-23 through 3-27 provide examples of some of the various applications of bioretention systems. These versatile LID practices can be applied to:

3.3 BIORETENTION SYSTEMS

Parking lot islands

Parking lot perimeters – curbless or curbed with curb cuts

Tree wells and tree box filters – boxed bioretention cells placed at the curb typically just upstream of storm drain inlets

Within right-of-ways along roads

Street median strips

Driveway perimeters

Cul-de-sacs

Landscaped areas in apartment complexes and multifamily housing

Landscaped areas in commercial, industrial, and municipal developments

Residential on-lot bioretention – landscape detention or rain gardens

Planters at rooftop eaves

Rooftop gardens, particularly on large commercial structures and parking garages

Photo: Kennedy/Jenks Consultants

Figure 3-24: Parking lot island bioretention system.

Photo: Kennedy/Jenks Consultants

Figure 3-26: Roadway ROW bioretention system.

Photo: Filterra ™

Figure 3-25: Tree box filter bioretention system.

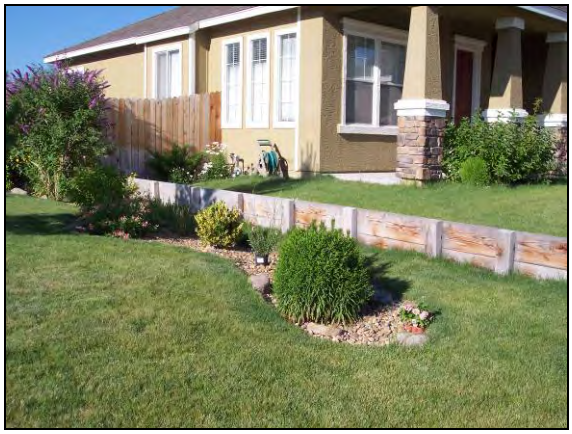


Photo: Kennedy/Jenks Consultants

Figure 3-27: Residential on-lot bioretention system.

3.3 BIORETENTION SYSTEMS

Limitations

- May not suitable for locations where the seasonally high groundwater table is within 5 feet of the ground surface (unless enclosed within an impermeable liner or a concrete box with an underdrain system). See Section 4.2 for additional setback, site screening and infiltration testing requirements.
- Clogging may be a problem in areas with high sediment loads in the runoff. In this case upgradient pretreatment may be required with sediment traps and/or vegetated swales or filter strips.
- If located in the vicinity of active construction sites, sediment controls and fencing should be installed to prevent clogging and compaction of engineered and existing site soils from heavy equipment.
- If the engineered soil mix is not properly designed, it may leach nutrients and salts into the groundwater or the treated effluent that discharges to an underdrain system. Leaching of nutrients and salts may only occur during the first year when the plants and soil system are becoming established.

General Design Considerations

- The temporary ponding area in bioretention systems should be designed to retain the water quality volume (WQ_V) determined using the method outlined in Section 4.5.
- Bioretention systems should include an engineered soil mix consisting of a well mixed combination of 50-60% clean sand, 20-30% topsoil, and 5-20% certified compost and/or peat installed to a minimum depth of 18 inches beneath the temporary ponding area (see Section 4.4.0 for additional details).
- Bioretention systems installed in existing site soils with infiltration rates of 0.5 in/hr or greater (120 min/inch or less) typically do not require an underdrain system. Discharge from underdrain pipes can be directed to nearby underground storm drain pipes, channels or other drainage features if sufficient head is available.
- If an underdrain system is required, at a minimum it should consist of a 3 to 4 inch diameter perforated pipe inside the bioretention system, surrounded by an envelope of clean coarse aggregate and pea gravel. XX (aggregate specifications to be developed by the City of Salinas)
- Filter fabric should <u>not</u> be installed at the base of bioretention systems because it can be prone to clogging. Therefore filter fabric liners should not be placed at the bottom of excavated basins to separate engineered soils from existing site soils or at the bottom of a concrete box than includes drainage holes to facilitate infiltration into existing site soils.
- Bioretention systems should include design features which will allow large flows from relatively large storm events to either bypass the system or overflow to a conventional storm drain structure such as a channel, a curb and gutter system, or a storm drain inlet. Bypass flows or overflows can also be routed to another downstream storm water treatment system such as a vegetated swale or an extended detention basin. The design of diversion structures is discussed in Section 4.6.

3.3 BIORETENTION SYSTEMS

Photo: Portland BES

Figure 3-28: Bioretention system incorporated into a traffic calming feature with inflow and overflow through curb openings.

3.3.0 Landscape Detention

Description

Landscape detention is a type of bioretention system that is also known as a bioretention basin or porous landscape detention. It consists of a low-lying vegetated area underlain by an engineered soil mix. If underlying existing site soils allow for a significant amount of infiltration (0.5 inch/hr or more or 120 min/inch of less), an underdrain system may not be needed. Storm water runoff from relatively small storm events and urban water use (e.g. washing and irrigation) typically passes through curb opening and onto a rock apron, which slows its velocity and distributes it evenly along the length of the ponding area. Water ponded to approximately 6 to 12 inches gradually infiltrates through the engineered soil mix an infiltrates into underlying soils and/or into an underdrain system (if included). The surrounding impervious area should be graded to direct runoff into the landscape detention area. Curb openings, weirs or grade controls structures should be included in the design to divert excess runoff from large events away from the landscape detention area towards the conventional storm drain system.

Siting Criteria

- Drainage area should be less than 1 acre.
- May be located on-line or off-line of the primary drainage system.
- Not recommended for areas with slopes greater than 20 percent.
- Layout should be determined based on site constraints such as location of utilities, underlying soil conditions, existing vegetation, and drainage patterns.
- Not to be used in areas where the infiltration rate of existing site soils is less than 0.5 inch/hr (120 min/inch) and there is no adjacent storm drain system or other acceptable drainage feature nearby that can be used accept discharge from an underdrain system.

3.3 BIORETENTION SYSTEMS

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design landscape detention basins. Appropriate plant species can stabilize banks and increase the infiltration capacity and the pollutant treatment effectiveness of landscape detention basins. See Section 4.4 for recommended plant species, additional bioretention system design criteria and engineered soils testing requirements.
- The size of a landscape detention basin is a function of the drainage area that will discharge to the system, the additional runoff generated from the impervious surfaces in the drainage area, and the ponding depth in the basin.
- Size the ponding area in a landscape detention basin to capture and treat the Water Quality Volume (WQ_V) using the method outlined in Section 4.5.
- If an underdrain system is required (e.g. existing site soils have an infiltration < 0.5 in/hr), at a minimum it should consist of a 3 to 4 inch diameter perforated pipe surrounded by an envelope of clean coarse aggregate and pea gravel. XX (aggregate specifications to be developed by the City of Salinas)
- The underdrain pipe system should have a vertical solid section that extends above the surface of the ponding area in the basin to provide a monitoring well and clean out access port. The opening should be normally sealed with a watertight screw on cap to prevent short circuiting (e.g. direct drainage into the underdrain pipe).
- Flows in excess of the WQ_V should bypass the landscape detention basin or overflow and flow to the conventional storm drain system or another downstream BMP. Figures 3-32 and 33 show landscape detention basins that overflow through a curb opening and onto a paved section that slopes away from the basin and flows towards the conventional storm drain system. Figures 3-35 and 36 show landscape detention basins that overflow to storm drain inlets located into and next to the basins, respectively. Refer to Section 4.6 for additional information on diversion structures.
- Determine the ponding depth of the landscape detention basin (D_{WQV}) based on the available surface area (SA) using the following equation:

  $$D_{WQV} = (WQ_v / SA) \times 12$$

  Where: D_{WQV} = ponding depth of the temporary ponded runoff (ft)

  WQ_v = Water Quality Volume (ft^3) per the method outlined in Section 4.5

  SA = Surface area of ponding area based on the length and width at the toe of the side slopes and the ponding depth.

- Maximum recommended ponding depth is 12 inches and minimum ponding depth is 6 inches with water standing no longer than 4 to 6 hours. This prevents problems with mosquito breeding and plants that can't tolerate standing water for extended periods.
- Landscape detention basins longer than 20 ft should be twice as long as they are wide.
- An impermeable liner and an underdrain system should be installed in areas where existing site soils are expansive clays or where there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur (see Figure 3-36).

- Approximately 2-3 inches of shredded hardwood mulch can be applied to the surface of the landscape detention area to assist with soil moisture retention and plant health.
- A general rule of thumb is one tree or shrub should be included for each 50 ft^2 of landscape detention area.
- Plant selection and layout should consider aesthetics, maintenance, native versus non-native invasive species, and regional landscaping practices.
- Trees can also be planted on the perimeter of landscape detention basins to provide shade and shelter.
- Whenever possible, avoid the use of heavy equipment during construction on areas where bioretention systems are to be installed. If soils are compacted, additional ripping may be necessary to re-establish soil permeability.
- After basin excavation, do not compact the native underlying soils.
- When installing the engineered soil mix, drop it from the bucket and *do not compact it*.

Inspection and Maintenance Requirements

- Upon installation and during the first year, landscape detention basins should be inspected monthly and after relatively large storm events for potential erosion and/or extended ponding.
- Key inspection/maintenance areas include inlet and overflow areas for potential erosion, the ponding area in basin for trash and debris, and the monitoring well/clean out port for potential early signs of stagnant water in the system if an underdrain system is included.
- Inspections can be reduced to a semi-annual schedule once the landscape detention basin has proven to work efficiently and properly and vegetation is established.
- A health evaluation of trees and shrubs should be conducted biannually.
- Pruning, weeding and trash removal should be conducted as necessary.
- Mulch replacement is generally required every two to three years.
- If ponding is observed to exceed 72 hours, particularly during the primary mosquito breeding season (June through October), the cause may be clogged filter fabric (if used, which is not recommend), compacted soils from construction activities, improper placement and compaction of the engineered soil mix, or surface clogging with fines from a heavy loading source in the drainage area (e.g. a dirt lot or a construction site without BMPs). The reason for the extended ponding should de determined and mitigated (e.g. removal of filter fabric, cleaning of the underdrain system, replacement of engineered soils, and/or ripping of underlying native soils to re-establish permeability).
- If a spill occurs and hazardous materials contaminate soils in landscape detention areas, the affected materials should be removed immediately and the appropriate soils and materials replaced as soon as possible.

3.3 BIORETENTION SYSTEMS

Photo: Center for Watershed Protection

Photo: Colorado AWARE

Figure 3-29: Landscape detention basins located at the edge of a parking lot (left photo) and in a parking lot island with turf and shrubs and trees (right photo).

Photo: Center for Watershed Protection

Photo: Center for Watershed Protection

Figure 3-30: Curb opening design for a landscape detention system located upstream of a conventional storm drain inlet (left photo). A bioretention system retrofit into an existing parking lot island (right photo).

3.3 BIORETENTION SYSTEMS

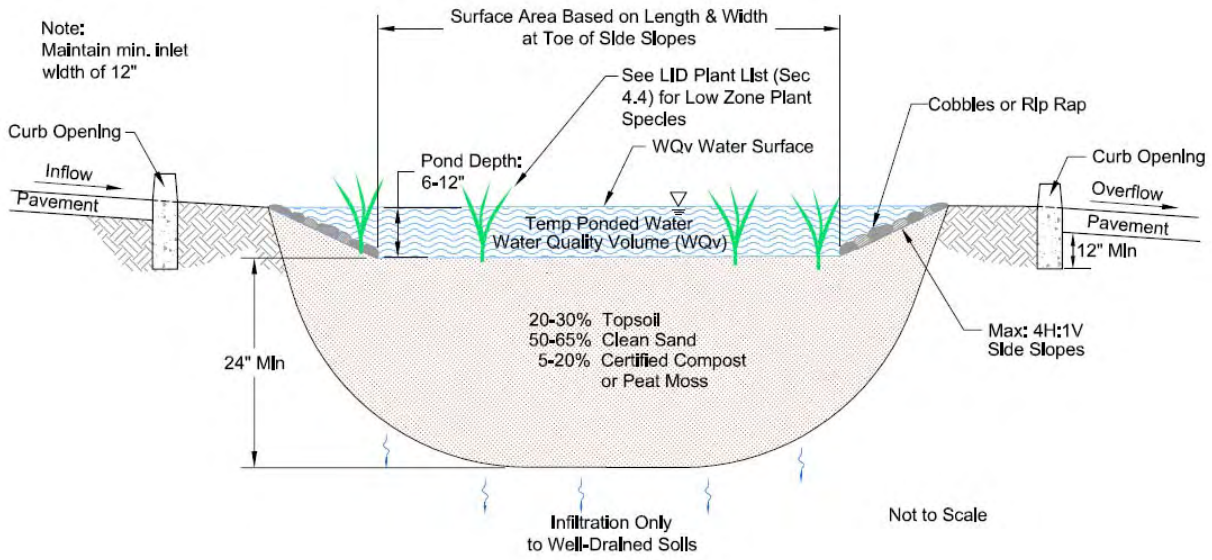


Figure 3-31: Schematic of a landscape detention basin located in existing (native) site soils with an infiltration of 0.5 inch/hr or greater (120 min/inch or less). (Source: Kennedy/Jenks Consultants)

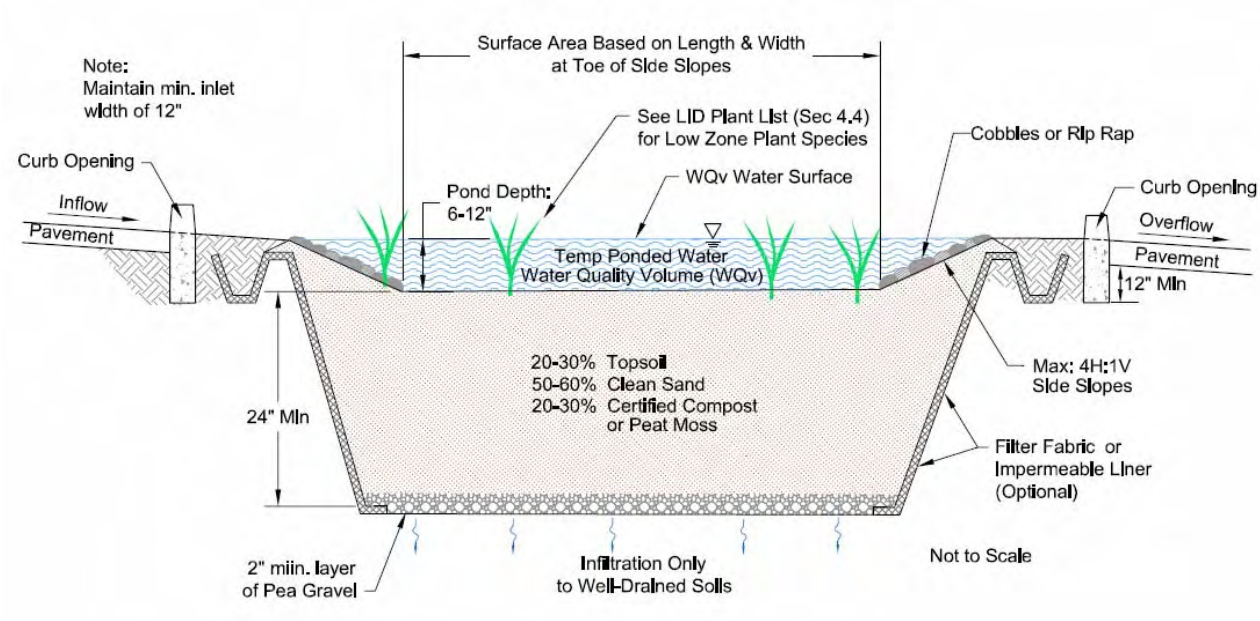


Figure 3-32: Schematic of a landscape detention basin in well draining soils with an optional filter fabric liner installed along the basin side walls. (Source: Kennedy/Jenks Consultants)

3.3 BIORETENTION SYSTEMS

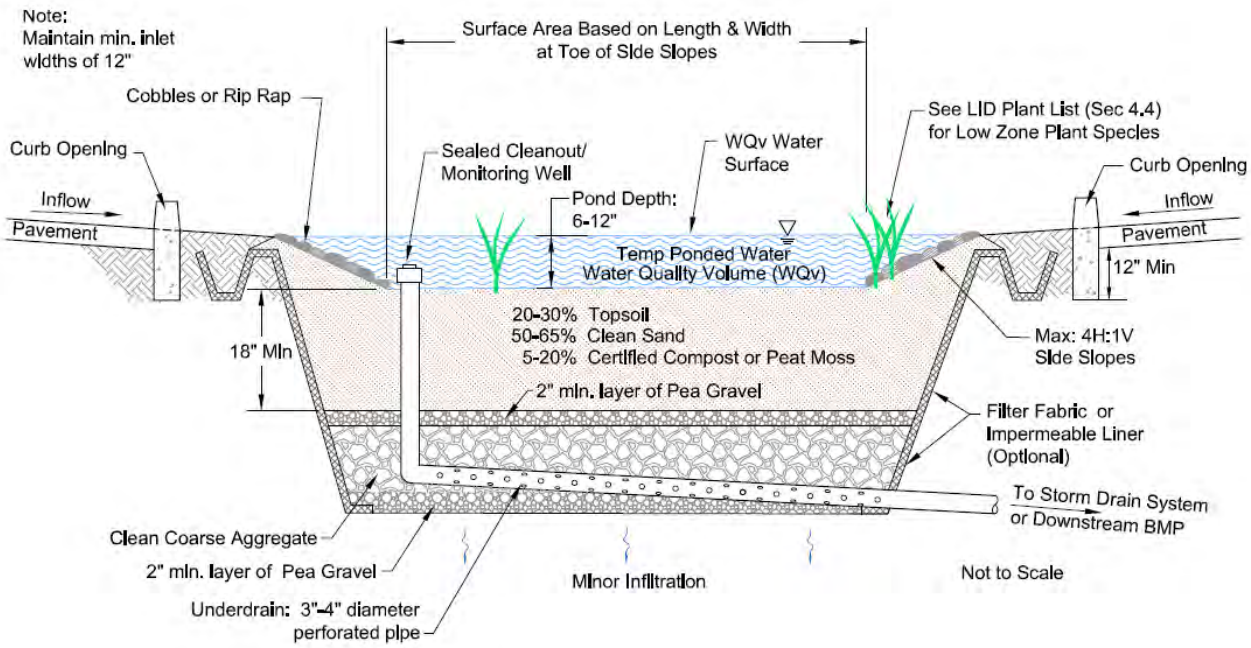


Figure 3-33: Schematic of a landscape detention basin in slow draining soils with an underdrain system piped to a nearby downgradient storm drain pipe, channel, or BMP. In this example the overflow feature is not shown. (Source: Kennedy/Jenks Consultants)

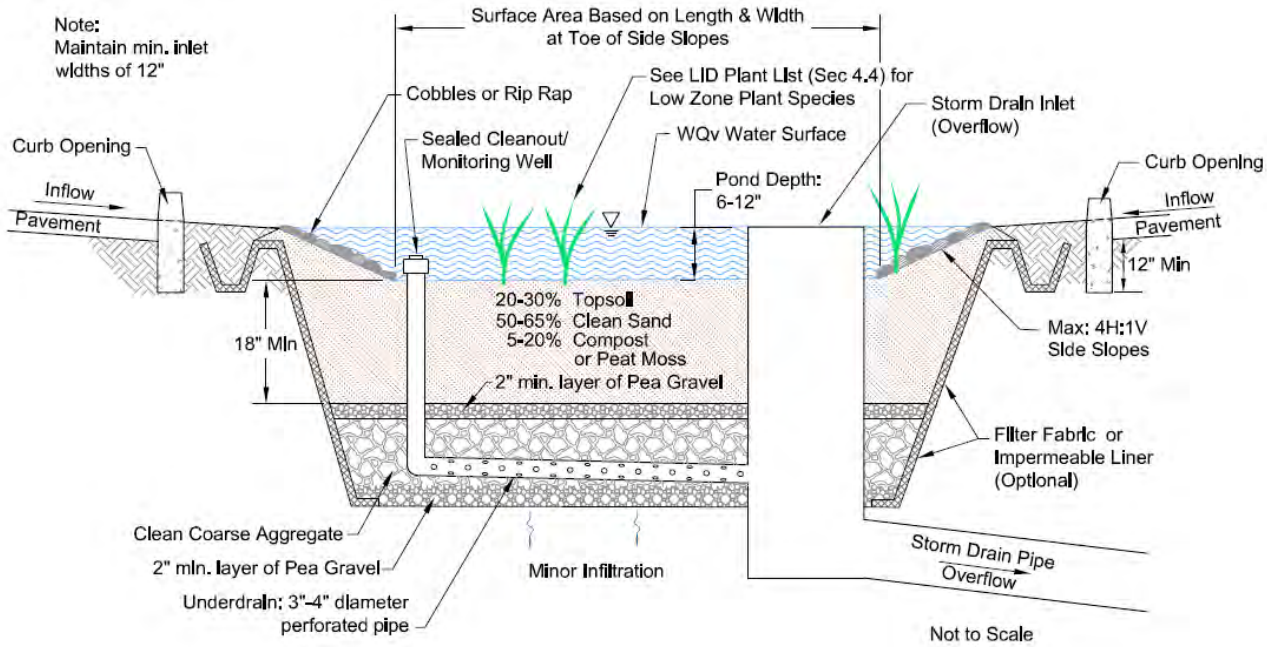


Figure 3-34: Schematic of a landscape detention basin located in slow draining soils with an underdrain system and a storm drain inlet located inside the basin to capture overflow from relatively large storm events. (Source: Kennedy/Jenks Consultants).

3.3 BIORETENTION SYSTEMS

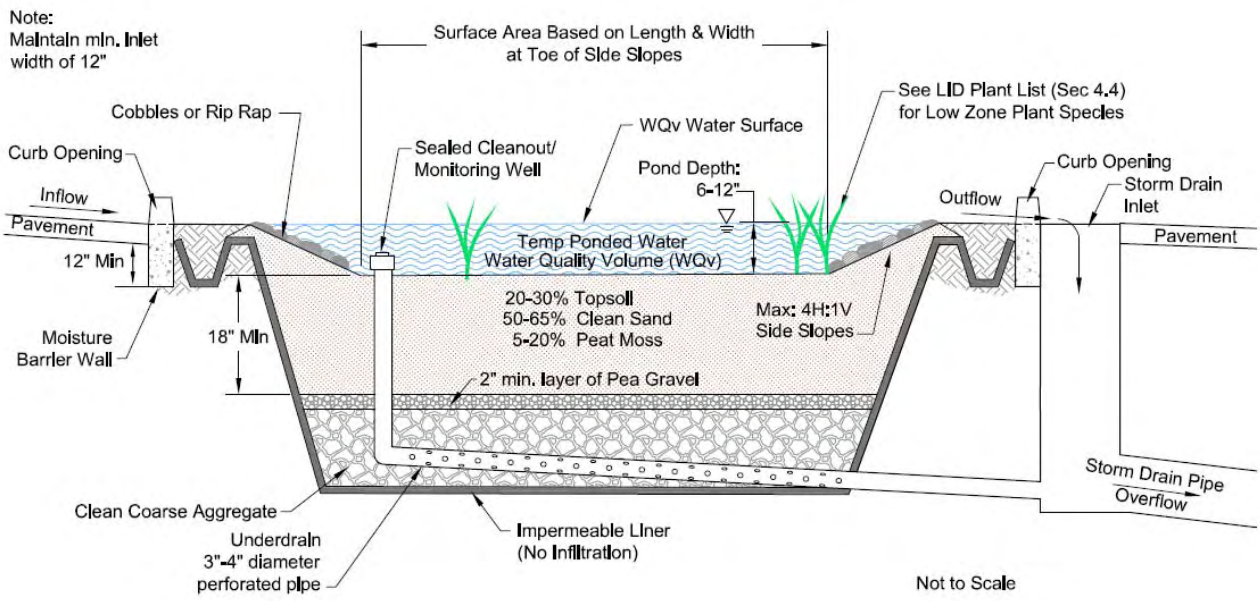


Figure 3-35: Schematic of a landscape detention basin located in expansive clays or where there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur.
(Source: Kennedy/Jenks Consultants).

Examples

1. In 1995, a new development called Somerset in Prince George's County, Maryland, incorporated rain gardens into each of the nearly 200 lots of a 60-acre development. Combined with grassy swales that replaced curbs and gutters, and disconnection of impervious areas through rain barrels and other LID strategies, the development had considerably lower runoff volumes and peak flow rates when compared to a neighboring conventional development (Cheng, 2003). The cost of installing LID storm water facilities when compared to conventional storm drainage facilities brought about a savings of approximately $300,000. Additionally, utilization of LID techniques in the development yielded six additional lots, where storm water ponds would traditionally have been housed if conventional storm water strategies had been applied (Guillette, 2005).

2. In Maplewood, Minnesota, as a demonstration project, residents of a two-block area of a residential neighborhood volunteered to have small rain gardens constructed on their property. This neighborhood had been experiencing periodic flooding and was slated for repaving, curbs and gutters, and a conventional underground storm drain system. The rain gardens effectively controlled runoff by slowing and infiltrating storm water, negating the need for curbs and gutters and costly underground storm drain infrastructure. The success of this project prompted the City of Maplewood to incorporate rain gardens into other neighborhoods (Hager, 2003).

3. In central North Carolina, a field-scale bioretention study was conducted to assess hydraulic retention and the effectiveness of the saturated zone at removal of phosphorus and nitrogen from storm water. The study contained two pairs of bioretention cells in two separate locations. The first pair, in Greensboro, consisted of one conventionally drained cell and one cell containing an induced saturated zone (an anaerobic zone). The cells were contained within a small shopping center with a parking lot. The second pair of bioretention cells was situated alongside the Tar River in Louisburg, North Carolina. Both of the Louisburg cells consisted of an engineered soil matrix and a conventional underdrain system to a total depth of 36 inches. The soil media used in these cells had a very low P-index and contained approximately 90 percent sand and 8 percent clay. One cell in this pair was lined with impermeable plastic. Both pairs of cells were planted with trees and shrubs and topped with 7-10 cm of double-shredded hardwood mulch.

   It was found that each bioretention cell in the study considerably reduced runoff with 76 to 93 percent of the runoff received being infiltrated. It was also noted that there was a lag time to runoff from the cells, highlighting a bioretention cell's ability to dampen peak flows. The anaerobic drainage configuration at the Greensboro site resulted in significantly lower Total Phosphorus concentrations in outflow than the conventional cells. The anaerobic drainage configuration was also found to have higher pollutant load removals and lower outflow concentrations during the non-growing season than the conventional cells. At the Louisburg site, it was found that the lined cell produced more outflow than the unlined cell and that pollutant removal was greater in the lined cell. Another finding from this study is a strong correlation between Total Phosphorus reduction rates and the P-index of the engineered soil matrix. Therefore, this study recommended that non-agricultural fill soils containing a low P-index be used in the engineered soil matrix of bioretention systems (Hunt and Sharkey, 2005).

3.3 BIORETENTION SYSTEMS

3.3.1 Tree Box Filters

Tree box filters are bioretention systems enclosed in concrete boxes that drain runoff from paved areas via a standard storm drain inlet structure. They are typically located upstream of a conventional storm drain inlet and should not be located in sump areas (e.g. topographic low points). Where existing site soils are sufficiently permeable (infiltration rates > 0.5 in/hr), tree box filters can be designed to drain directly to underlying soils via drain holes installed in the base of the concrete box. Where slow draining native soils exist, they should be designed with an underdrain pipe which is typically connected to the conventional storm drain system pipe in the street. Most of the general design standards noted above for landscape detention basins also apply to tree box filters. In addition tree box filters should generally be designed per the bioretention system design criteria and engineered soils testing requirements discussed in Section 4.4, and the Water Quality Volume (WQ_V) method outlined in Section 4.5. However many of the setback standards for indirect infiltration systems may not apply if a tree box filter is contained with a concrete box and only drains to an underdrain system that discharges to the conventional storm drain system.

Filterra™ manufactures a proprietary tree box filter system (See Figure 3-36). Therefore designers should contact Filterra™ to avoid potential patent right infringement claims if a tree box filter design is similar to the Filterra™ system noted in the figures below.

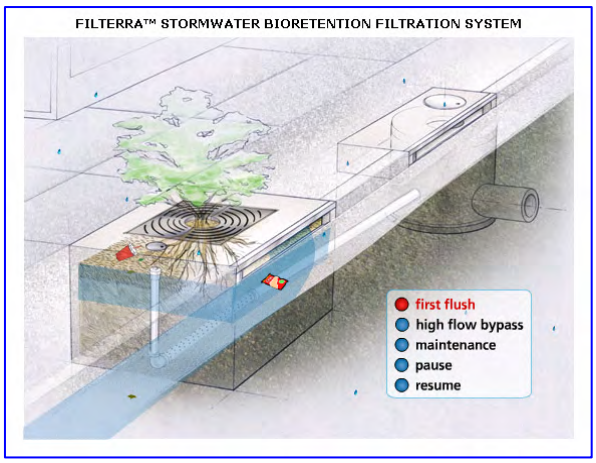


Figure 3-36: Schematic and photo of a tree box filter, which is a manufactured (proprietary) bioretention system. (figure and photo provided by Filterra™)

Providing parking lot treatment by impaired waters.

Typical Filterra placement at a fast food chain.

Even the largest Filterra unit blends in with landscaping.

Filterra used with a flumed bypass in a commercial parking lot.

Ideal for stormwater treatment where space is tight.

Filterra featuring a beautiful Crape Myrtle in bloom.

Figure 3-37: Various Filterra™ tree box filter configurations. (photographs provided by Filterra™)

3.3.2 Storm Water Planters

Storm water planters, also known as infiltration planters or flow through planters, are also bioretention systems in enclosed in concrete structures. They can be designed to drain runoff from paved areas via curb inlet structures (Figure 3-26) or pipes (Figure 3-38), or they can be located under roof drain downspouts (Figure 3-39) for treatment of roof runoff. Where existing site soils are sufficiently permeable (infiltration rates > 0.5 in/hr), storm water planters can be designed as flow through systems with concrete walls on 4 sides and no floor (Figure 3-38). This type of system drains directly to underlying soils and should consider the setback standards for indirect infiltration systems presented in Section 4.2. When located next to buildings and other structures, or when slow draining native soils exist, they should be designed with an underdrain pipe. Waterproofing should be incorporated into the designs of storm water planters sited near buildings and other structures. When designed with underdrains and waterproofing, storm water planters typically do not need to apply the setback standards and infiltration testing requirements noted in Section 4.2.

Most of the general design standards noted above for landscape detention basins also apply to storm water planters. For example, the ponding area in storm water planters should be designed to detain the Water Quality Volume (WQ_V) per the method outlined in Section 4.5. In addition, storm water planters should be designed engineered soils per the standards presented in Section 4.4. Plants can also be selected from the LID plant list presented in Section 4.4.

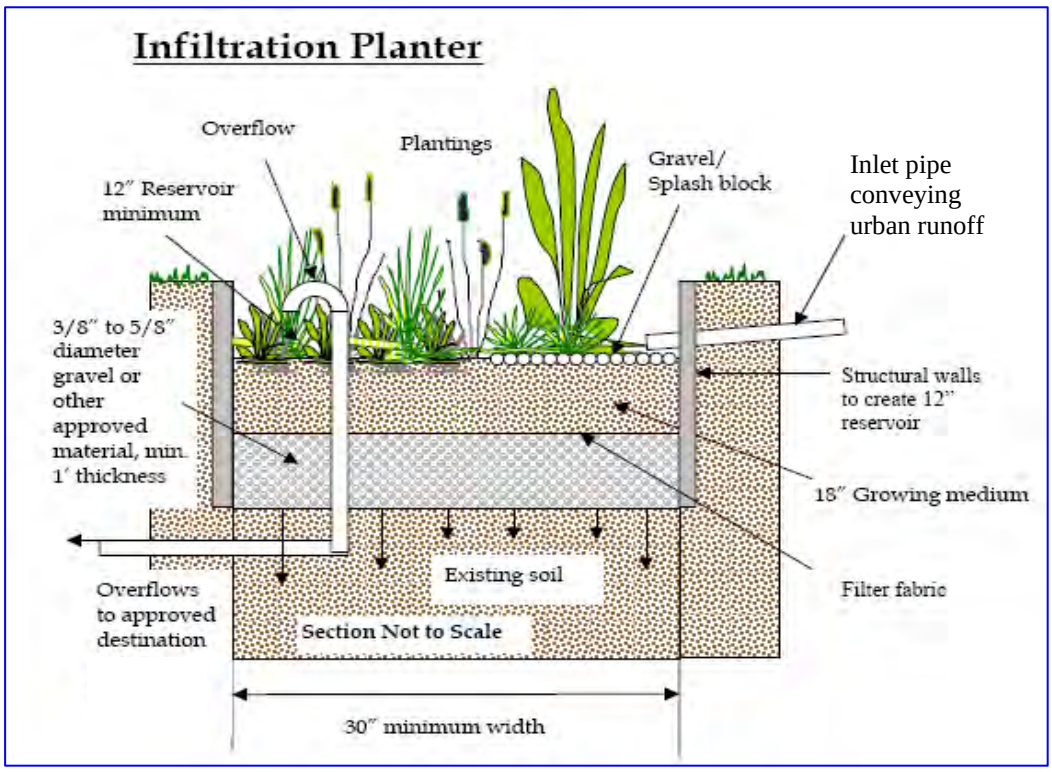


Figure 3-38: Schematic of a storm water planter that receives urban runoff from a pipe, drains directly to underlying soils, and overflows to the conventional storm drain system via an overflow pipe. (adapted from Portland BES).

3.3 BIORETENTION SYSTEMS

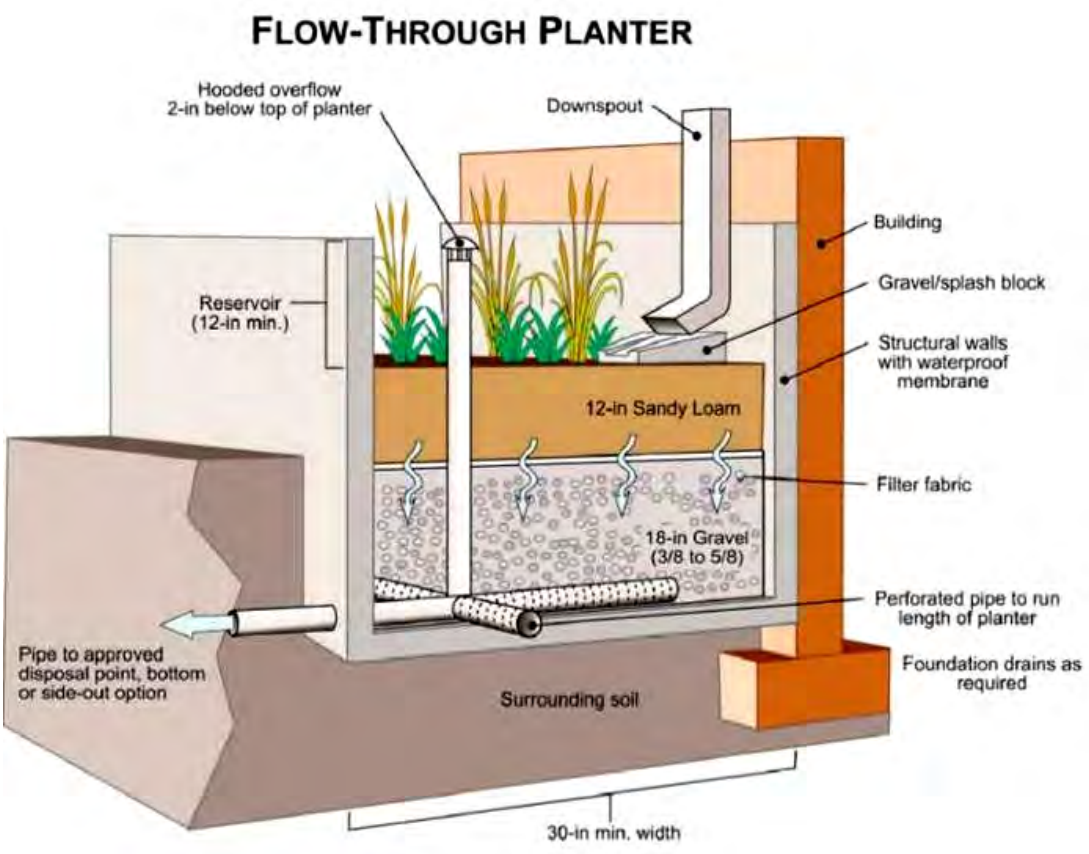


Figure 3-39: Schematic of a storm water planter that detains and treats roof runoff, and drains and overflows to the conventional storm drain system via an underdrain and overflow pipe system. (Source: Portland BES)

Figure 3-40: Storm water planters installed next to office buildings. (Source: Portland BES)

3.3 BIORETENTION SYSTEMS

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3.4 POROUS PAVING SYSTEMS

3.2 Porous Paving Systems

Porous paving systems allow infiltration of storm water while providing a stable load-bearing surface for walking and driving. These systems contain void spaces to provide infiltration of runoff into their underlying engineered porous materials and then into existing site soils. Generally, underlying engineered materials consist of clean sands or gravels separated from existing site soils by a synthetic filter fabric. Underlying engineered materials detain and filter pollutants prior to infiltration into underlying soils or discharge to a conventional storm drain system through an underdrain system. Porous paving systems can preserve natural drainage patterns, enhance groundwater recharge and soil moisture, and can help establish and maintain roadside vegetation. Although a good substitute for conventional concrete and asphalt, porous paving systems are typically not suitable for heavily trafficked applications. There are several different types of porous paving systems, which are referred to here as:

- Porous Pavement Detention
- Open-Celled Block Pavers
- Open-Jointed Block Pavers
- Porous Asphalt and Porous Concrete Pavement
- Porous Turf
- Porous Gravel
- Open-Celled Plastic Grid

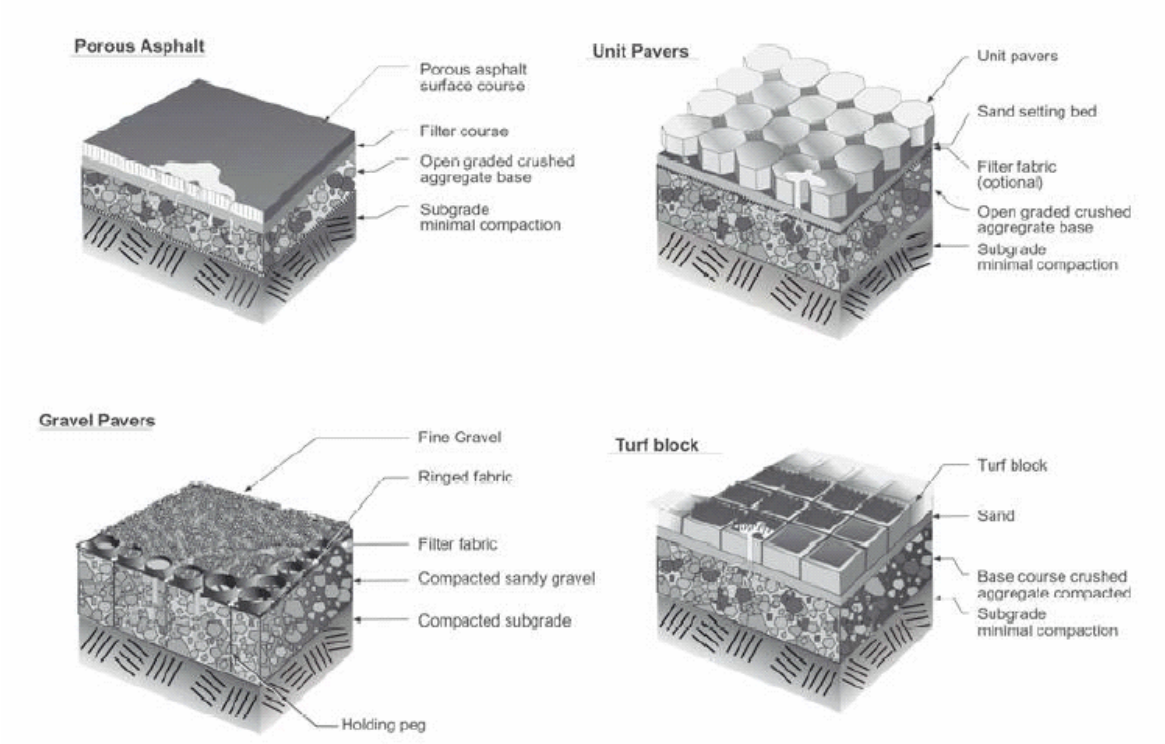

Figure 3-41: Cross-sections of typical porous pavement installations and different types of porous pavement. (from Sacramento, 2000)

3.4 POROUS PAVING SYSTEMS

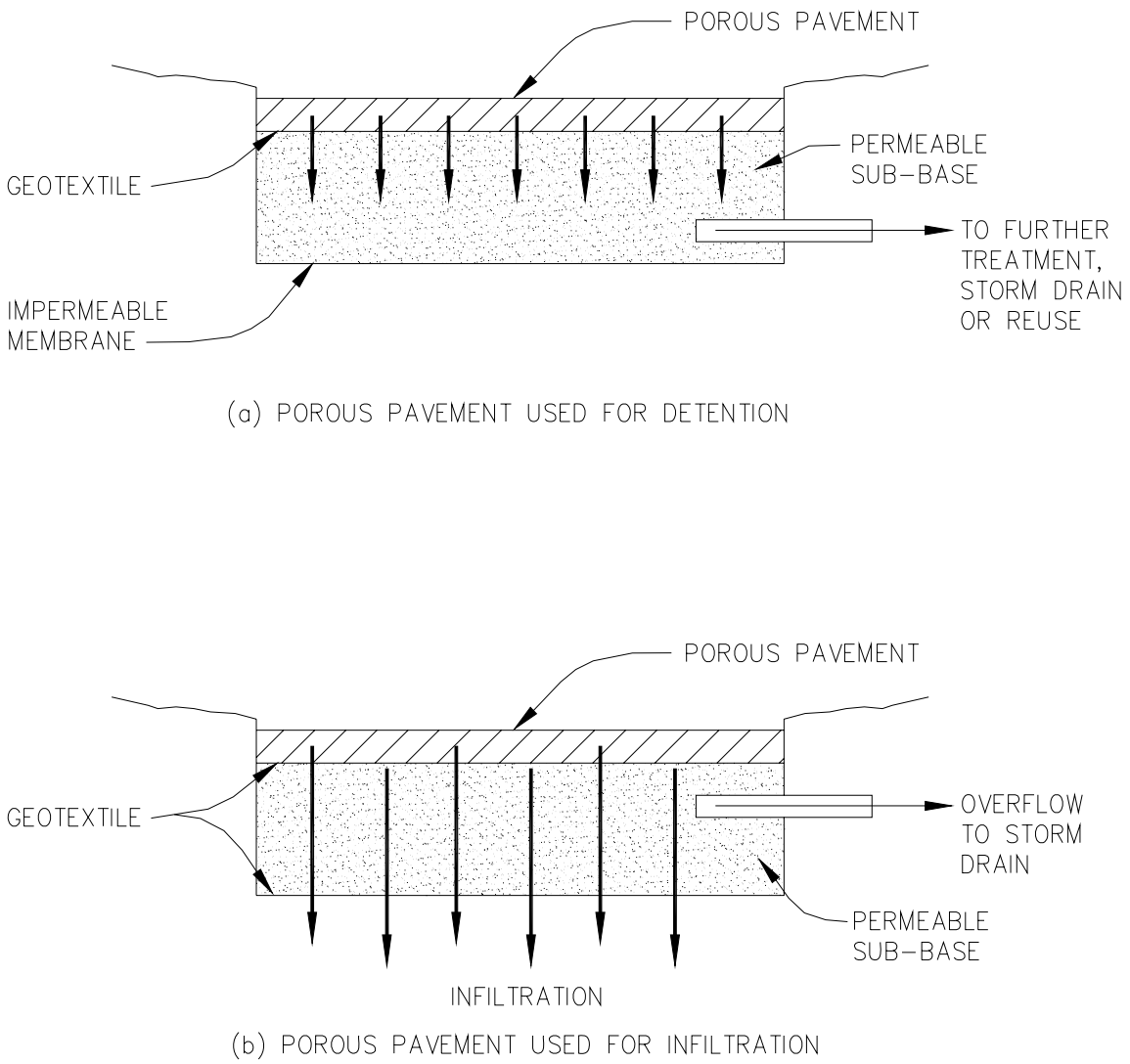

Figure 3-42: Typical porous pavement and drainage pipe configurations for a) filtering and detaining storm water runoff and, b) filtering and infiltrating storm water runoff.
(modified from CASQA, 2003)

3.4.0 POROUS PAVEMENT DETENTION

3.4.0 Porous Pavement Detention

Description

Porous pavement detention is an installation of open-celled block pavers that is flat and is provided with a 2-inch deep surcharge zone to temporarily store the WQv. Open-celled block pavers consist of blocks or slabs made of concrete or brick with open surface voids that penetrate their surface area. The modular blocks are placed over a porous sub-base and the openings within and between the blocks are filled with pervious materials (e.g. open-graded aggregate). Porous materials such as clean gravels placed below the porous pavement detain and filter pollutants prior to infiltration into underlying soils or discharge to drainage to a conventional storm drain system.

Applications and Advantages

Porous pavement detention can be used as a substitute for conventional pavement, but should be limited to parking areas and low traffic volume roadways where little to no truck traffic is anticipated. Examples include residential driveways, residential street parking lanes, parking stalls in commercial or retail parking lots, overflow parking areas, maintenance walkways/trails, emergency vehicle and fire access lanes, stopping lanes on divided highways, equipment storage areas, and patios.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Not to be applied in heavily trafficked areas or where speeds exceed 30 miles per hour.
- Care must be taken when applying in commercial or industrial areas.
- May become clogged if not properly installed and maintained.
- Maintenance costs can be relatively high if the blocks frequently become clogged with sediment from offsite sources.
- Porous pavements may cause uneven driving surfaces and may be problematic for high heel shoes.

- May not be suitable for areas that require wheelchair access because of the pavement texture.
- Snow removal may be difficult, since plows may damage blocks if not installed correctly or performed above the block surface; sand application can result in clogging; and use of salt can result in groundwater contamination.
- Do not install sand or pavers during rain or heavy snowfall.
- Do not install over frozen base materials.

Siting Criteria

- Porous pavement detention installations should be installed in areas that are flat in all directions (i.e. 0% slope).
- If designed to infiltrate storm water into underlying soils, porous pavements are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Calculate the Water Quality Volume (WQ_v) per the methods presented in Section 4.5.1 to determine the minimum required surface area for the porous pavement detention:

  Minimum surface area = WQ_v/0.17ft
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- Block patterns should have a minimum surface area void space of 40 percent.
- Use an open-graded aggregate base course to provide a permeable reservoir. XX (aggregate specifications to be developed by the City of Salinas)
- When designing the base course, or base reservoir, to detain the water quality volume, select the appropriate porosity[6] value for the material used.
- Strength and durability of materials under saturated conditions must be considered.
- When installing the base course, it must be compacted as it is placed in lifts.
- A bedding layer should be laid over the base course as level bedding for the blocks consisting of relatively small open-graded aggregate meeting criteria for a filter layer, or "choke layer". XX (aggregate specifications to be developed by the City of Salinas).
- Appropriate gradations of aggregate material must be used to prevent migration of particles from one layer to the next. If this cannot be achieved, a woven geotextile

[6] Porosity is the ratio of void space volume to the total volume of soil or rocks. Generally the higher the soil porosity, the greater the ability to hold, transmit and infiltrate water.

should be used under the bedding layer above the base course to prevent migration. A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal can be used.

- For aggregate fill in the cells, material should consist of open-graded sand and can be the same material as the bedding material.
- An overflow, possibly with an inlet to a storm sewer, should be installed at 2 inches above the level of the porous pavement surface.
- A concrete perimeter wall should be installed to confine the edges of the block installation. The perimeter wall should be 6 inches thick and to extend 6 inches deeper than the base course, bedding layer, and block depth combined.
- Direct sediment-laden runoff away from the porous pavements.
- Filter fabrics should be placed on the bottom and sides of the sub-base layer.
- An impermeable liner should be installed under the base course to inhibit infiltration when installing over expansive soils or if the tributary area contains activities that store, manufacture, or handle fertilizers, chemicals, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Follow pavement manufactures specifications.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.
- Once porous pavement is in place, ensure contributing drainage areas of the construction site have erosion and sediment control measures in place and are maintained until the site is stabilized.
- The storage capacity of the stone reservoir beneath porous pavements depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.

Inspection and Maintenance Requirements

- Accumulated debris and litter removal as needed.
- Maintenance such as vacuuming is required to prevent clogging of the pervious surface.
- Inspect sand filter routinely and after storm events to insure proper infiltration and drainage.
- Frequently inspect the pavement to insure proper infiltration and drainage during the first wet season, and then once a year following that time.
- Replacement of surface sand filter layer may occur when runoff does not infiltrate readily into the surface.

3.4.0 POROUS PAVEMENT DETENTION

References

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Urban Drainage and Flood Control District (UDFCD), 2005. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices.

3.4.1 Open-Celled Block Pavers

Description

Open-celled block pavers, also known as modular block pavers, consist of blocks or slabs made of concrete or brick with open surface voids that penetrate their surface area. The modular blocks are placed over a porous sub-base and the openings within and between the blocks are filled with pervious materials (e.g. open-graded aggregate). Porous materials such as clean gravels placed below the porous pavement detain and filter pollutants prior to infiltration into underlying soils or discharge to drainage to a conventional storm drain system. This type of surface reduces runoff from paved areas and the ponding that typically occurs in parking lots during and after storm events.

Applications and Advantages

Open-celled block pavers can be used as a substitute for conventional pavement, but should be limited to parking areas and low traffic volume roadways where little to no truck traffic is anticipated. Examples include residential driveways, residential street parking lanes, parking stalls in commercial or retail parking lots, overflow parking areas, maintenance walkways/trails, emergency vehicle and fire access lanes, stopping lanes on divided highways, equipment storage areas, and patios as well as alternative to conventional paving in areas where tree protection and preservation is a concern.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Not to be applied in heavily trafficked areas or where speeds exceed 30 miles per hour.
- Care must be taken when applying in commercial or industrial areas.
- May become clogged if not properly installed and maintained.
- Maintenance costs can be relatively high if the blocks frequently become clogged with sediment from offsite sources.
- Porous pavements may cause uneven driving surfaces and may be problematic for high heel shoes.

- May not be suitable for areas that require wheelchair access because of the pavement texture.
- Snow removal may be difficult, since plows may damage blocks if not installed correctly or performed above the block surface; sand application can result in clogging; and use of salt can result in groundwater contamination.
- Do not install sand or pavers during rain or heavy snowfall.
- Do not install over frozen base materials.

Siting Criteria

- Ideally, pervious pavement should be installed on flat surfaces adjacent to gently sloping conventional pavement surfaces. However they can also be placed on gentle slopes that do not exceed 5 percent.
- If designed to infiltrate storm water into underlying soils, porous pavements are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- Block patterns should have a minimum surface area void space of 20 percent.
- Use an open-graded aggregate base course to provide a permeable reservoir. XX (aggregate specifications to be developed by the City of Salinas), is a locally available open-graded aggregate.
- When designing the base course, or base reservoir, to detain the water quality volume, select the appropriate porosity value for the material used.
- Strength and durability of materials under saturated conditions must be considered.
- When installing the base course, it must be compacted as it is placed in lifts.
- A bedding layer should be laid over the base course as level bedding for the blocks consisting of relatively small open-graded aggregate meeting criteria for a filter layer, or “choke layer”. XX (aggregate specifications to be developed by the City of Salinas).
- Appropriate gradations of aggregate material must be used to prevent migration of particles from one layer to the next. . If this cannot be achieved, a woven geotextile should be used under the bedding layer above the base course to prevent migration. A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal can be used.
- Open-celled block pavers are vibrated into place into the bedding layer.
- Filter fabrics should be placed on the bottom and sides of the base layer.

3.4.1 OPEN-CELLED BLOCK PAVERS

- An impermeable liner should be installed under the base course to inhibit infiltration when installing over expansive soils or if the tributary area contains activities that store, manufacture, or handle fertilizers, chemicals, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Edge restraints should be installed on compacted subgrade or base material, not on the bedding.
- For aggregate fill in the cells, material should consist of open-graded sand and can be the same material as the bedding material. XX (aggregate specifications to be developed by the City of Salinas).
- A concrete perimeter wall should be installed to confine the edges of the block installation. The perimeter wall should be 6 inches thick and to extend 6 inches deeper than the base course.
- Lateral-flow cut-off barriers should be installed using a 16 mil or thicker PE or PVC impermeable membrane liner or concrete walls installed normal to flow. This prevents flow of water downstream resurfacing at the toe of the block installation.
- Distance between cut-off barriers shall not exceed:

$$L_{MAX} = D/(1.5*S_o)$$

Where, L_{MAX} = Max distance between cut-off barriers normal to flow (ft)

D = Depth of the aggregate base course (ft/ft)

S_o = Slope of the base course (ft)

- An underdrain should be installed where impermeable liners are installed or when soils inhibit proper infiltration rates. Locate each underdrain pipe just upstream of the lateral-flow cut-off barrier.
- For rooting vegetation in the joints, planting medium should be sandy and open-graded. In bedding and base course a limited amount of planting medium could be mixed into open-graded aggregate to deepen rooting.
- Plant grass in open-joints as plugs or broadcast seed at a reduced rate to account for concrete grids.
- All installations should be designed and constructed to pavement manufactures specifications.
- Follow pavement manufactures specifications.
- Direct sediment-laden runoff away from the porous pavements.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.
- Once porous pavement is in place, ensure contributing drainage areas of the construction site have erosion and sediment control measures in place and are maintained until the site is stabilized.

- The storage capacity of the base reservoir beneath porous pavements depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.

Inspection and Maintenance Requirements

- Open-celled block pavers should not be washed to remove debris and sediment in the openings between pavers, rather sweeping with suction should be utilized annually. Replace lost sand infill.
- Joints between block pavers may require occasional weed suppression.
- Pavers can be removed individually and replaced when utility work is needed.
- Top course aggregate can be removed or replaced in pavers if they become clogged or contaminated.
- Replace surface filter layer by vacuuming out sand media from blocks when it becomes evident that runoff does not rapidly infiltrate into the surface.
- For pavers planted with turf, regular turf maintenance will be necessary. However, pesticides, fertilizers and other chemicals can have adverse effects on concrete products, so their use should be restricted.

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3.4.2 Open-Jointed Block Pavers

Description

Open-jointed block pavers consist of solid block units made of concrete, clay, or stone that form an interlocking, flexible pavement surface. Open voids are created, by beveling the corners of each block or creating wider spacing between the blocks. The blocks themselves also commonly contain small voids to increase permeability. The modular blocks are placed over a porous sub-base and the openings within and between the blocks are filled with pervious materials (e.g. clean sand). The pavers are placed on a gravel sub-grade to detain and filter pollutants prior to infiltration into underlying soils or discharge to drainage to a conventional storm drain system. This type of surface reduces runoff from paved areas and the ponding that typically occurs in parking lots during and after storm events.

Photo: courtesy of the ICPI

Figure 3-43: Example of an Open Jointed Block Paver Installation.

Applications and Advantages

Open-jointed block pavers can be used as a substitute for conventional pavement, but should be limited to parking areas and low traffic volume roadways where little to no truck traffic is anticipated. Examples include residential driveways, residential street parking lanes, parking stalls in commercial or retail parking lots, overflow parking areas, maintenance walkways/trails, emergency vehicle and fire access lanes, stopping lanes on divided highways, equipment storage areas, and patios, as well as alternative to conventional paving in areas where tree protection and preservation is a concern.

Limitations

- Care must be taken when applying in commercial or industrial areas.
- May become clogged if not properly installed and maintained.
- Maintenance costs can be relatively high if the blocks frequently become clogged with sediment from offsite sources.
- Porous pavements may cause uneven driving surfaces and may be problematic for high heel shoes.

- Snow removal may be difficult, since plows may damage blocks if not installed correctly or performed above the block surface; sand application can result in clogging; and use of salt can result in groundwater contamination.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Siting Criteria

- Do not install pavers on slopes greater than 15 percent.
- If designed to infiltrate storm water into underlying soils, porous pavements are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.
- May not be suitable for areas that require wheelchair access because of the pavement texture.
- Not to be applied in heavily trafficked areas or where speeds exceed 30 miles per hour.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Do not install sand or pavers during rain or heavy snowfall.
- Do not install over frozen base materials.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- Consult a qualified engineer, architect, and/or landscape architect for paver applications.
- To be installed by a qualified contractor experienced in paver applications.
- Block patterns should have a minimum surface area void space of 8 percent.
- Use an open-graded aggregate base course to provide a permeable reservoir. XX (aggregate specifications to be developed by the City of Salinas), is a locally available open-graded aggregate.

3.4.2 OPEN-JOINTED BLOCK PAVERS

- When designing the base course, or base reservoir, to detain the water quality volume, select the appropriate porosity value for the material used.
- Strength and durability of materials under saturated conditions must be considered.
- When installing the base course, it must be placed and compacted in maximum 12 inch thick lifts.
- A bedding layer should be laid over the base course as level bedding for the blocks consisting of relatively small open-graded aggregate meeting criteria for a filter layer, or "choke layer". XX (aggregate specifications to be developed by the City of Salinas), is recommended for this purpose.
- Do not use concrete sand, which is traditionally used for interlocking concrete pavement bedding layer construction and has been shown to have low permeability.
- Appropriate gradations of aggregate material must be used to prevent migration of particles from one layer to the next. If this cannot be achieved, a geotextile should be used under the bedding layer above the base course to prevent migration.
- Filter fabrics should be placed on the bottom and sides of the base layer.
- Impermeable liner should be installed under the base course to inhibit infiltration when installing over expansive soils or if the tributary area contains activities that store, manufacture, or handle fertilizers, chemicals, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Edge restraints are required around the perimeter and should be installed on compacted subgrade or base material, not on the bedding.
- Joint-fill material should consist of XX (aggregate specifications to be developed by the City of Salinas).
- Do not sweep sand into the joints after the pavers are installed to fill joints as this can compromise the permeability and porosity of pavers.
- A concrete perimeter wall should be installed to confine the edges of the block installation. The perimeter wall should be 6 inches thick and to extend 6 inches deeper than the base course.
- Lateral-flow cut-off barriers should be installed using a 16 mil or thicker PE or PVC impermeable membrane liner or concrete walls installed normal to flow. This prevents flow of water downstream resurfacing at the toe of the block installation.
- Distance between cut-off barriers shall not exceed:

$$L_{MAX} = D/(1.5*S_o)$$

Where, L_{MAX} = Max distance between cut-off barriers normal to flow (ft)

D = Depth of the aggregate base course (ft/ft)

S_o = Slope of the base course (ft)

- An underdrain should be installed where impermeable liners are installed or when soils inhibit proper infiltration rates. Locate each underdrain pipe just upstream of the lateral-flow cut-off barrier.

- For rooting vegetation in the joints, planting medium should be sandy and open-graded. In bedding and base course a limited amount of planting medium could be mixed into open-graded aggregate to deepen rooting.
- Cut pavers with a paver splitter or masonry saw. Cut pavers should be no smaller than one-third of the full unit size along edges subject to vehicular traffic.
- All installations should be designed and constructed to pavement manufactures specifications.
- Direct sediment-laden runoff away from the porous pavements.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.
- Once porous pavement is in place, ensure contributing drainage areas of the construction site have erosion and sediment control measures in place and are maintained until the site is stabilized.
- The storage capacity of the base reservoir beneath porous pavements depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.

Inspection and Maintenance Requirements

- Blocks should not be washed to remove debris and sediment in the openings between pavers, rather sweeping with suction should be utilized annually. Replace lost sand infill.
- Joints between pavers may require occasional weed suppression.
- Pavers can be removed individually and replaced when utility work is needed.
- Replace surface filter layer by vacuuming out sand media from blocks when it becomes evident that runoff does not rapidly infiltrate into the surface. If vacuuming does not adequately remove fill, blocks can be lifted and reset with new joint fill material.
- If soils swell or subside, blocks can be removed individually, the base leveled, and blocks reset.

3.4.2 OPEN-JOINTED BLOCK PAVERS

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3.4.2 OPEN-JOINTED BLOCK PAVERS

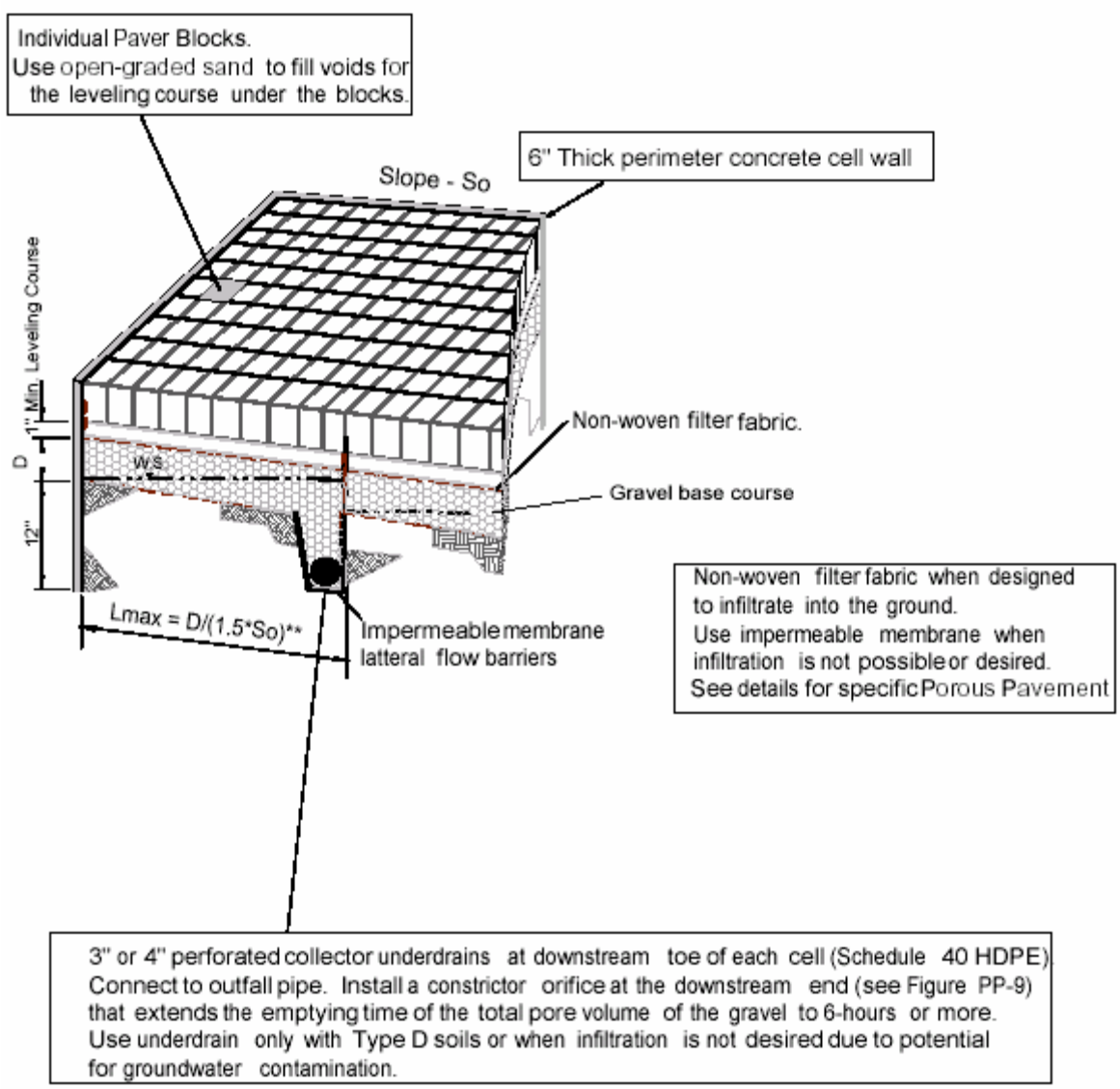

Figure 3-44: View of a paver block installation showing perimeter wall and contained cells. (modified from UDFCD 2005)

3.4.2 OPEN-JOINTED BLOCK PAVERS

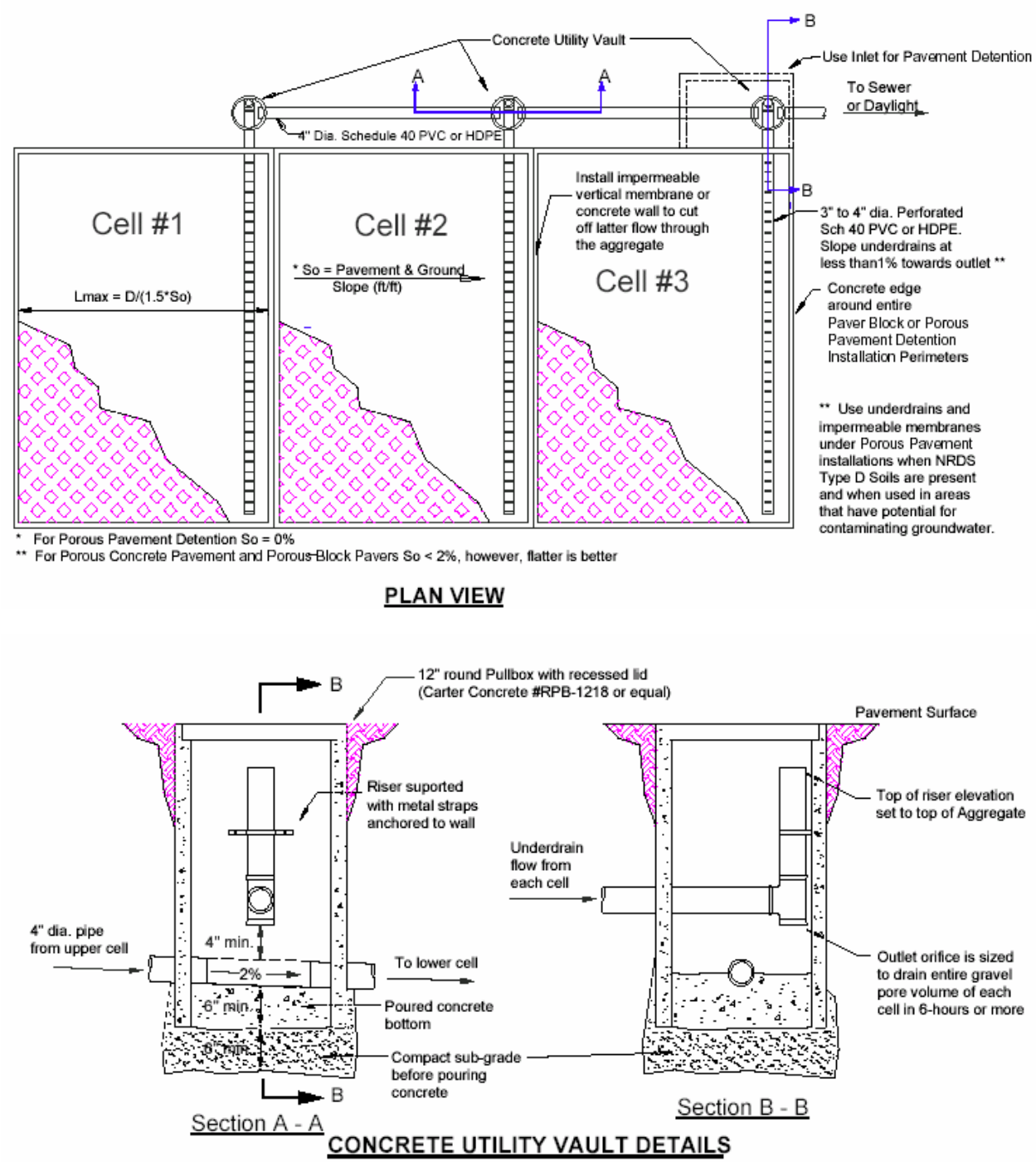

Figure 3-45: Layout for underdrain system for porous pavement installations. (Modified from UDFCD, 2005).

3.4.3 Porous Concrete and Asphalt

Description

Porous concrete and asphalt both make a continuous, smooth paving surface like their impervious counterparts. However, they are made by binding open-graded aggregate, and therefore contain void spaces that allow water to pass through to a permeable subbase layer. Porous materials such as clean gravels placed below the porous concrete or asphalt detain and filter pollutants prior to infiltration into the underlying soils or discharge to an underdrain and the conventional storm drain system.

Applications and Advantages

Porous concrete and asphalt are ideal for light to medium duty applications such as residential access roads, residential street parking lanes, parking lot stalls in parking lots, overflow parking areas, utility access, sidewalks, bike paths, maintenance walkways/trails, residential driveways, stopping lanes on divided highways, and patios. Porous asphalt has, however, also been used in heavy applications such as airport runways and highways because its porosity creates a favorable driving surface in rainy weather.

Porous concrete and asphalt can also reduce icing hazards during winter freeze and thaw cycles as runoff will tend to infiltrate rather than freeze onto the surface of roadways, parking lots, driveways and sidewalks. (Photo source: Cahill & Associates)

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Typically not to be applied on streets where speeds exceed 30 mph or streets that experience high-traffic loads.
- Not recommended for slopes over 5 percent.

3.4.3 POROUS CONCRETE AND ASPHALT

- Not applicable where the seasonal high groundwater table is less than 3 feet below the bottom of the gravel sub-base.
- Sand and salt applied to porous roadways, parking lots, and sidewalks in winter can clog void spaces and render permeability ineffective if not removed annually.
- Porous concrete may experience raveling if not properly installed.
- Porous asphalt and concrete may become clogged if not protected from nearby construction activities, areas of bare soil without landscaping, downslope of steep, erosion-prone areas, or when not maintained.
- Applications with underdrain systems are typically more expensive than conventional asphalt and concrete.
- Porous asphalt and concrete should be avoided in drainage areas with activities generate highly contaminated runoff.
- Not to be applied in areas where wind erosion supplies significant amounts of windblown sediments.

Siting Criteria

- Ideally, pervious pavement should be installed on flat surfaces adjacent to gently sloping conventional pavement surfaces. However, they can also be placed on gentle slopes that do not exceed 5 percent.
- Do not use in areas where the potential for spills is high (e.g. near service/gas stations, truck stops or industrial sites).
- The seasonal high water table should be more than 3 feet below the bottom of the gravel sub-base.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements
- Avoid installing in high traffic areas.
- Slopes should be flat or very gentle (less than 5 percent).
- Pretreatment recommended to treat runoff from surrounding areas.
- Filter fabric should be placed on the bottom and sides of the subbase reservoir.
- Impermeable liner should be installed under the base course to inhibit infiltration when installing over expansive soils or if the tributary area contains activities that store, manufacture, or handle fertilizers, chemicals, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Use an open-graded aggregate to provide open voids in the gravel subbase.
- Erosion and sediment introduction from surrounding areas must be strictly controlled during and after construction to prevent clogging of void spaces in base material and permeable surface.

3.4.3 POROUS CONCRETE AND ASPHALT

- Install porous asphalt and concrete towards the end of construction activities to minimize sediment problems.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.
- During emplacement of porous concrete, boards should be used to separate individual pours and to produce uniform seams between adjacent pours.
- The surface of each pour should be finished as soon as possible as porous concrete can set up very rapidly in our local arid environment.
- Overall project cost savings can be realized where porous asphalt or concrete is installed in well draining soils (e.g. infiltration rates of 0.5 in/hr (120 min/in) or greater), and conventional storm drain pipes and catch basins can be reduced.

Inspection and Maintenance Requirements

- The overall maintenance goal is to avoid clogging of the void spaces.
- Accumulated debris and litter should be routinely removed as a source control measure.
- Inspect porous asphalt and concrete several times during the first few storms to insure proper infiltration and drainage. After the first year, inspect at least once a year.
- Permeable pavements and materials should be cleaned with a vacuum-type street cleaner a minimum of twice a year (before and after the winter).
- Hand held pressure washers can be effective for cleaning the void spaces of small areas and should follow vacuum cleaning.
- Maintenance personnel must be instructed not to seal or pave with non-porous materials.
- Pavement must not be sanded in the winter to avoid clogging the void spaces.

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3.4.3 POROUS CONCRETE AND ASPHALT

3.4.4 Porous Turf Pavement

Description

Porous turf pavement is a stabilized grass surface that can support intermittent pedestrian or vehicular traffic, underlain by an open-graded (single-sized) sandy root zone, and a permeable aggregate base course. Porous turf pavement applications should be applied when the appearance of grass is desired, but a load bearing capability of a pavement surface is needed. The turf surface can be either reinforced or unreinforced, with reinforced turf containing synthetic reinforcement that assists the turf in resisting wear and compaction, allowing it to bear a heavier traffic load. Advantages of porous turf pavement include the appearance of a "green space" when not used for parking, as well as the benefit of a living surface which actively cools by transpiration counteracting the urban heat island effect (Ferguson, 2005).

Applications and Advantages

Porous turf pavement is suitable for any area that desire turf application and also for parking areas with frequencies of up to once per week. Ideal settings are sports fields, overflow parking areas, church and football stadium parking lots, event parking, roadway shoulders, parking lanes, crossover lanes on divided highways, flea market parking, and maintenance roads and trails. The suitable application of these porous turf pavement applications for parking lots would be to have the vehicle movement lanes leading up to the porous turf constructed of another type of material such as porous concrete or asphalt pavement (i.e. porous turf parking pads with porous concrete or asphalt lanes). This reduces grass wear from excessive traffic on the porous turf surface, decreasing the porosity and increasing maintenance. Porous turf applications can also be multiuse facilities, for example a sports field that also serves as a special event parking lot.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Not to be applied in heavily trafficked areas, grass wear can result.
- Until grass is established, surface cannot be used.
- Requires supplemental irrigation.
- A uniformly graded vegetative cover is required to function properly.

3.4.4 POROUS TURF PAVEMENT

- Excessive traffic can cause soil compaction and reduce infiltration.
- Weed invasion can result from thinning of grass cover.
- Turning action of vehicles can be problematic for porous turf, damaging structure of the leaves and sometimes causing root damage.
- May be problematic for high-heeled shoes. Smooth-soled shoes can slip on wet grass.
- Grass species should be selected based on wear tolerance and irrigation needs for specific site conditions.
- Grass selection, traffic control, and good maintenance for health and vigor are all important for turf grass wear prevention and recovery.

Siting Criteria

- Do not use in areas where the potential for spills is high (e.g. near service/gas stations, truck stops or industrial sites).
- Must be installed only in settings where they will be free of traffic on a predictable schedule for maintenance.
- If designed to infiltrate storm water into underlying soils, porous pavements are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- When designing the sub-base reservoir to detain the water quality volume, select the appropriate porosity value for the sub-base material used.
- Direct sediment-laden runoff away from the porous pavements.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.
- The surface course, or root zone, should consist of an aggregate meeting the gradation requirements from XX (aggregate specifications to be developed by the City of Salinas).
- The sandy root zone should have a thickness of 12 inches.
- A permeable aggregate base course should be constructed of XX (aggregate specifications to be developed by the City of Salinas).
- If Class C backfill is used, a woven filter fabric should be installed between the root zone and the aggregate base course.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.

- The aggregate base course should be at least several inches thick.
- The storage capacity of the open-graded aggregate base course depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.
- If needed, a filter fabric or a filter layer of coarse sand 2 to 4 inches in depth can be installed between the root zone and aggregate base course.
- An impermeable liner is required under the base course when installing over expansive soils or if the tributary may have activities that store, manufacture, or handle fertilizers, chemical, or petroleum products.
- Underdrains are required for installations over NRCS type C or D soils with infiltration rates of 0.5 in/hr (120 min/in) or less or when an impermeable membrane liner is needed.
- Turf should be installed by laying sod, seeding, or sprigging. Root zone material should be tested by a qualified lab and soil treated with appropriate lime or fertilizer as recommended for establishment success.
- Proprietary meshes, mats, and fibers are available for reinforcing turf root zones.
- Turf can also be installed in open-celled grids or pavers.
- Once porous pavement is in place, ensure contributing drainage areas of the construction site have erosion and sediment control measures in place and are maintained until the site is stabilized.
- Allow turf at least one full growing season to establish before use.
- If seeding, seed in the fall or early spring to avoid heat stress.

Inspection and Maintenance Requirements

- Porous turf requires regular maintenance associated with regular lawns such as irrigation, mowing, fertilization, aeration, topdressing, overseeding, disease control, insect control, and weed management.
- Soil testing should be conducted at least once every other year to determine proper fertilization, which will help to maintain turf stress tolerance.
- Routine mowing will be required in the growing season.
- Above ground biomass is important in wear tolerance, therefore high mowing can increase a grasses resistance to traffic stress. Mowing patters should also be altered regularly to limit wear from repetitive wheel action.
- Reseeding may be required to maintain a uniform turf cover.
- Topdressing material should be at least as coarse and open-graded as the root zone.
- To aid in water conservation, irrigation operations should be scheduled as follows:
    - After the ground has thawed, or in the month of March – two deep waterings
    - As the weather begins to warm in April and May – once per week
    - In June, July and August – up to twice per week

  - As the weather begins to cool in September – cut back to deep watering once a week, then once every two weeks
  - Do not water from November to March while lawn is dormant!
  - Water in the early morning during the summer to reduce water lost to evaporation and spray drift caused by wind.
- Traffic routes can be spread out or rotated to give the turf time to recover between uses. Traffic control can also divert traffic away from areas which are showing signs of wear.

References

Bay Area Stormwater Management Agencies Association (BASMAA). 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.* Prepared by Tom Richman & Associates. www.basmaa.org

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3.4.5 Porous Gravel Pavement

Description

Porous gravel pavement, or crushed aggregate, consists of a loose gravel-surface paving placed over a porous sub-base. Porous materials such as clean gravels placed below the porous pavement detain and filter pollutants prior to infiltration into underlying soils or discharge to drainage to a conventional storm drain system. This type of pavement reduces runoff from paved areas and the ponding that typically occurs in parking lots during and after storm events.

Application

Porous gravel pavement can be used as a substitute for conventional pavement. It is most appropriate for industrial sites and uses such as storage yards or for vehicle parking. Other examples include residential driveways, residential street parking, low vehicle movement zones such as parking lots and maintenance roads, maintenance walkways/trails, and stopping lanes on divided highways.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Not to be applied in heavily trafficked areas or where speeds exceed 30 miles per hour.
- Care must be taken when applying in commercial or industrial areas.
- May become clogged if not properly installed and maintained.
- Porous pavements may cause uneven driving surfaces and may be problematic for high heel shoes.

Siting Criteria

- Ideally, pervious gravel pavement should be installed on flat surfaces adjacent to gently sloping conventional pavement surfaces. However they can also be placed on gentle slopes that do not exceed 5 percent.
- Do not use in areas where the potential for spills is high (e.g. near service/gas stations, truck stops or industrial sites).

- The seasonal high water table should be more than 4 feet below the ground surface

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- Use a single size grading to provide open voids between sand or gravel sub-bases.
- When designing the sub-base reservoir to detain the water quality volume, select the appropriate porosity value for the sub-base material used.
- Direct sediment-laden runoff away from the porous pavements.
- Thickness of porous gravel layer should be designed to support the traffic and vehicle loads pavement will need to carry.
- Filter fabrics should be placed on the bottom and sides of the sub-base layer.
- An impermeable liner is required under the base course when installing over expansive soils or if the tributary may have activities that store, manufacture, or handle fertilizers, chemical, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Lateral-flow cut-off barriers should be installed using a 16 mil or thicker PE or PVC impermeable membrane liner or concrete walls installed normal to flow. This prevents flow of water downstream resurfacing at the toe of the block installation.
- Distance between cut-off barriers shall not exceed:

$$L_{MAX} = D/(1.5*S_o)$$

Where, L_{MAX} = Max distance between cut-off barriers normal to flow (ft)

D = Depth of the aggregate base course (ft/ft)

S_o = Slope of the base course (ft)

- Underdrains are required for installations over NRCS type D soils or when an impermeable membrane liner is needed. Locate each underdrain pipe just upstream of the lateral-flow cut-off barrier.
- A sand filter layer is required for installations over expansive soils or when underdrains are required.
- A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal should be placed on top of and below the sand filter layer.
- During construction, do not allow construction or heavy vehicles to traverse excavated recharge beds or areas of completed porous pavement.

3.4.5 POROUS GRAVEL PAVEMENT

- Once porous pavement is in place, ensure contributing drainage areas of the construction site have erosion and sediment control measures in place and are maintained until the site is stabilized.
- The storage capacity of the stone reservoir beneath porous pavements depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.

Inspection and Maintenance Requirements

- Accumulated debris and litter removal as needed.
- Maintenance is required to prevent clogging of the pervious surface.
- Occasional weed suppression may be required.
- Periodic replenishing and/or raking of displaced gravel may be required.
- Inspect sand filter routinely and after storm events to insure proper infiltration and drainage.
- Frequently inspect the pavement to insure proper infiltration and drainage during the first wet season, and then once a year following that time.
- Replacement of surface sand filter layer may occur when runoff does not infiltrate readily into the surface.
- Inspect surface gravels once a year. When inspections show accumulation of sediment and debris on top of gravel or slow infiltration, remove and replace top few inches of gravel.

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3.4.6 Open-Celled Plastic Grids

Description

Open-celled plastic grids, also known as geocells, are manufactured plastic lattices which can be filled with aggregate or topsoil and planted with turf. Many of these systems are made from recycled plastics. The grid systems contain hollow rings or hexagonal cells from 1 to 2 inches thick and a few inches wide. Since the cells occupy very little surface area in most systems, they appear as a turf or gravel surface. Some models are also joined at the bottom by either a perforated plastic sheet or geotextile fused to the bottom of the grid which is placed on the underlying base course. It is important that this area is open for rooting of grasses. Most open-celled grid systems are flexible, so they are tolerant of swelling or freezing soils and are applicable on uneven sites.

Applications and Advantages

Open-celled grids should be limited to low intensity use and areas with low traffic speeds. Examples include driveways, residential street parking lanes, parking stalls in commercial or retail parking lots, overflow parking areas, maintenance walkways/trails, utility access, ATV and off-road bike trails, golf cart paths, emergency vehicle and fire access lanes, loading areas, and alleys.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	70 - 90
Total Phosphorus	40 - 55
Total Nitrogen	10 - 20
Total Zinc	40 - 80
Total Lead	60 - 70

Source: UDFCD, 1999.

Limitations

- Sharp turning on grids should be avoided.
- May be problematic for high-heeled shoes.
- Irrigation of porous turf installation in open-celled grids has the potential to require heavier irrigation than normal due to the low water holding capacity of the soil in grids.
- Slopes should not exceed 5%.
- Not to be applied in heavily trafficked areas or where speeds exceed 20 miles per hour.

3.4.6 OPEN-CELLED PLASTIC GRIDS

Siting Criteria

- Ideally, pervious pavement should be installed on flat surfaces adjacent to gently sloping conventional pavement surfaces. However they can also be placed on gentle slopes that do not exceed 5 percent.
- If designed to infiltrate storm water into underlying soils, porous pavements are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers should design porous pavements.
- Sub-base layers should be capable of bearing an appropriate load without deforming.
- Pervious pavements should be the last thing to install during construction or redevelopment.
- An open-graded permeable base course should be constructed according to manufacturers' specifications.
- The storage capacity of the open-graded aggregate base course depends upon local detention requirements and can be sized to capture, detain and filter the Water Quality Volume as discussed in Section 4.5.
- Lattices come in pre-assembled panels or rolls in various dimensions, from a few square feet to rolls that can be spread out to cover large areas.
- Grids need to be anchored to the base in some applications, depending on the model, to prevent being jarred by moving traffic. Anchors may consist of plastic spikes, pins, or rods, or even boulders, logs, or wheel stops over the surface.
- A setting bed of smaller aggregate may be needed over the base course to make a uniform surface for the open-celled grids.
- Woven filter fabrics should be placed on the bottom and sides of the base course layer.
- An impermeable liner is required under the base course when installing over expansive soils or if the tributary may have activities that store, manufacture, or handle fertilizers, chemical, or petroleum products.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Underdrains are required for installations over NRCS type D soils or when an impermeable membrane liner is needed.

For Open-Celled Grids filled with Aggregate

- Aggregate fill must be open-graded, with common installation sizes being XX (aggregate specifications to be developed by the City of Salinas).
- Aggregate is compacted into place with a vibrating plate or roller.

- Follow manufacturer's specifications for top course installation.

For Open-Celled Plastic Grids planted with Turf

- The planting medium should be settled into cells by vibrating or watering.
- The planting medium should consist of open-graded fine aggregate conforming to XX (aggregate specifications to be developed by the City of Salinas).
- Sod should only be installed with thin-walled grid systems.
- Sod can be installed by pressing into empty cells. Sod should be cut to a depth of the grid system.
- Anchoring may protect growing grass roots and promote deeper rooting, which will add strength to pavement structure.
- If filter fabric is needed on top of the base course, instead an open-graded aggregate filter layer may be used.
- Traffic should not be allowed on the surface until after turf is established.

Inspection and Maintenance Requirements

- Equip snow plow blades with skids or rollers to keep the plow surface one or two inches above the surface.
- Sections can be removed and replaced for utility access and pavement repair.
- Remove and replace grid segments where three or more adjacent rings are broken or damaged.

For Open-Celled Plastic Grids filled with aggregate

- Accumulated debris and litter removal as needed.
- Maintenance is required to prevent clogging of the pervious surface.
- Occasional weed suppression may be required.
- Periodic replenishing and/or raking of displaced gravel may be required.
- Inspect surface gravels once a year. When inspections show accumulation of sediment and debris on top of gravel or slow infiltration, remove and replace top few inches of gravel.

For Open-Celled Plastic Grids planted with turf

- For open-celled grids filled with turf, mechanical aeration of must be avoided, as this can damage the plastic material.
- See maintenance requirements for Porous Turf.

3.4.6 OPEN-CELLED PLASTIC GRIDS

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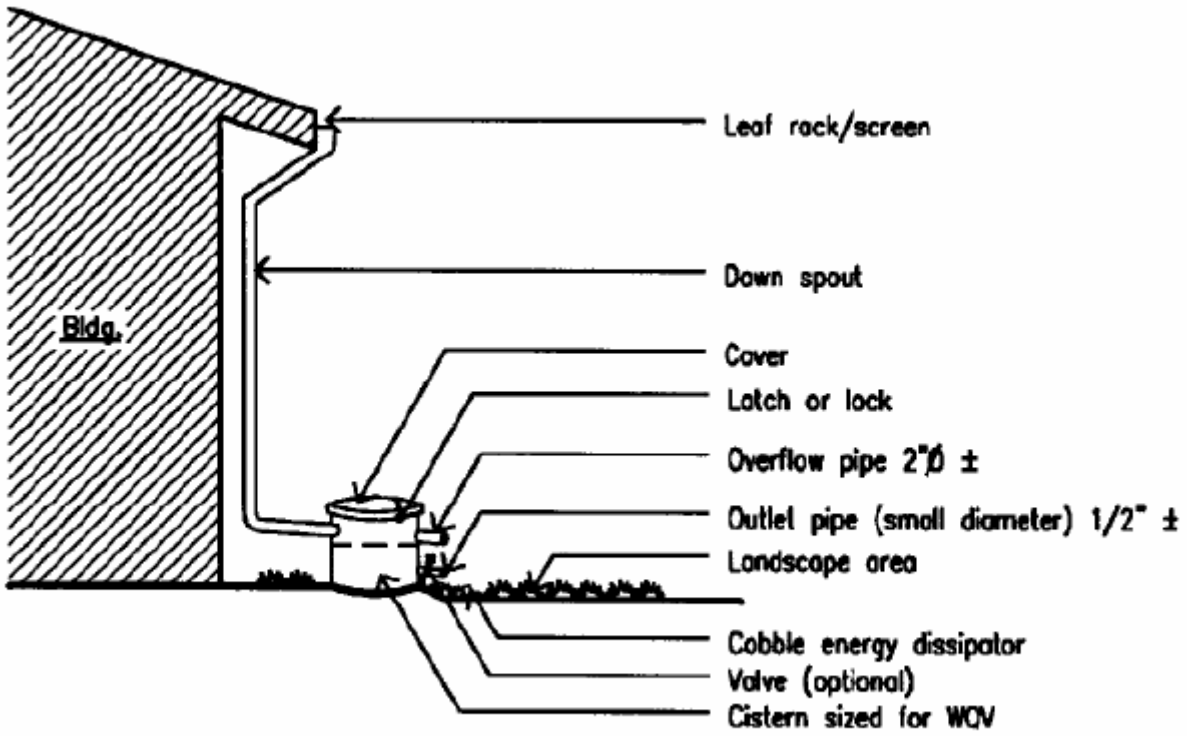
3.5 RAINWATER CATCHMENT SYSTEMS

3.0 Rainwater Catchment Systems

General Description

Rainwater catchment systems (also known as rainwater harvesting) have been used for thousands of years in many parts of the world, particularly in arid areas where water is scarce. They are simple structures that are designed to collect and store storm water runoff from impervious surfaces such as roofs, paved terraces, and patios. Storm water from these impervious surfaces is conveyed through gutters and downspouts, and through a screening device to remove leaves and other debris before discharging to above or below ground storage tanks or cisterns. The water collected by these systems may be reused for non-potable water uses within a house or building, or for exterior landscape irrigation purposes. Uses can include water for toilets and irrigation at exterior hose bibs.

Rainwater catchment systems can reduce a sites water needs and provide storm water management benefits, including reducing rate, volume and pollutant loading of urban runoff from developed sites. Reducing the water used from the City water system can reduce a site's water bill. However, a water budget should be developed and rainwater catchment systems may be required to meet plumbing and health department codes prior to use.



Bay Area Stormwater Management Agencies Association, *Start at the Source* (1999)

Figure 3-46: Rainwater catchment system schematic.

3.5 RAINWATER CATCHMENT SYSTEMS

Applications and Advantages

Rainwater catchment systems can provide a storm water management solution where impervious surfaces are unavoidable and site constraints limit the use of other LID practices. Such situations may include highly urbanized areas (such as downtown centers) or dense housing developments without adequate space for storm water infiltration or detention or where soil and groundwater conditions do not permit infiltration. In addition to storm water management benefits, rainwater catchment systems can be utilized as a sustainable building approach to reduce a development's dependence on municipal water supplies.

Rainwater catchment systems can be designed to fit a wide range of site conditions. Storage tanks and cisterns should be sized according to the impervious surfaces feeding into the system utilizing the "storm water quality design storm" (see Sections 2.7 and 4.5). Additional storage capacity can also be provided to assist with site water needs. In addition to determining the required storage tank volume, a regular use for the non-potable water needs to be planned into the system such that there is an assurance that there will be available volume to capture the WQ_V from subsequent storm events (e.g. a consistent use such as toilet flushing and/or regular irrigation). Therefore, a water budget should be developed for each proposed rainwater catchment system to determine the minimum required storage volume (e.g. the WQ_V), dedicated water uses, and the schedule necessary to maintain a regular use. If a rainwater catchment system is proposed for storm water management, a water budget should be included as part of the development plans to be reviewed by City staff. Such calculations will help evaluate whether a rainwater catchment system is a feasible storm water management strategy for a particular site.

Figure 3-47: A rainwater catchment system on a residential home. (Photo: Kennedy/Jenks Consultants)

Storm Water Management

Flow and volume control: In areas where on-site infiltration is not feasible, rainwater catchment systems can provide significant flow rate and volume reduction into the offsite conventional storm drain system and local receiving waters.

Pollution reduction: As a result of the significant reduction in off-site flows that can be achieved, a significant reduction in the discharge of pollutants associated with storm water can also be accomplished. This can be particularly significant where rainwater catchment systems are used to capture and reuse roof runoff from large industrial or commercial facilities or from elevated parking garages.

3.5 RAINWATER CATCHMENT SYSTEMS

Limitations

As discussed above Rainwater Catchment Systems have potential to serve as a storm water management technique and can reduce the rate, volume and pollutant loading of urban runoff. There are however, several management and maintenance factors for the owners of the Rainwater Catchment Systems. Such management responsibilities may become the City's burden to maintain or enforce. This should be considered when and if the City permits the use of these systems as a storm water management approach. Considerations include:

Regular use for harvested water volume: The storage capacity needs to be available to catch the next storm event's flow. For example, if the water in the storage tank is only used for landscape irrigation and the need for irrigation water during the rainy season is minimal, the tank may fill after the first few storms and the overflow during subsequent storms. Therefore, rainwater catchment systems that are only used for landscape irrigation may not be effective for storm water management during the rainy season. However, if a rainwater catchment system is plumbed to a structures toilets and urinals, the storage tanks and cisterns would be more likely to be emptied throughout the year and have available capacity for storm water management during the rainy season. Development of a water budget and careful review of the calculations by City staff should be conducted prior to permitting.

Mosquitoes: Water standing for more than 72 hours can provide mosquito breeding habitat. To prevent mosquitoes from breeding in rainwater catchment systems, the storage tanks and cisterns need to remain tightly sealed and screened. Mosquitoes can fit into holes as small at 1/16". Vector control will likely need to closely monitor these systems.

Siting: As discussed in the Siting Criteria section below, there are a number of considerations in the placement of a water tank on a site that may limit the viability of this technique.

Climate: Seasonal rainfall patterns of the Central Coast of California make water storage and reuse less practical than in some other climates.

Siting Criteria

If it is determined that Rainwater Catchment Systems may be an appropriate storm water management option, further criteria will determine where the system can be placed on the site. The tanks need to be placed on level pads in areas not vulnerable to settling, erosion or slope failure. Tanks should be located at least 10 feet from a building to avoid foundation damage in case the tank leaks (unless secondary containment and/or foundation waterproofing is provided). In addition to storing water, tanks can serve multiple functions such as shading, providing visual screens, and moderating hot and cold temperature extremes within a building. The higher on the site above-ground tanks are located, the more gravity-feed pressure will be available. Water can be distributed by gravity flow or by a booster pump via hoses, irrigation systems, channels, or perforated pipes. The interior space of the tanks will also need to be easily accessible for regular maintenance.

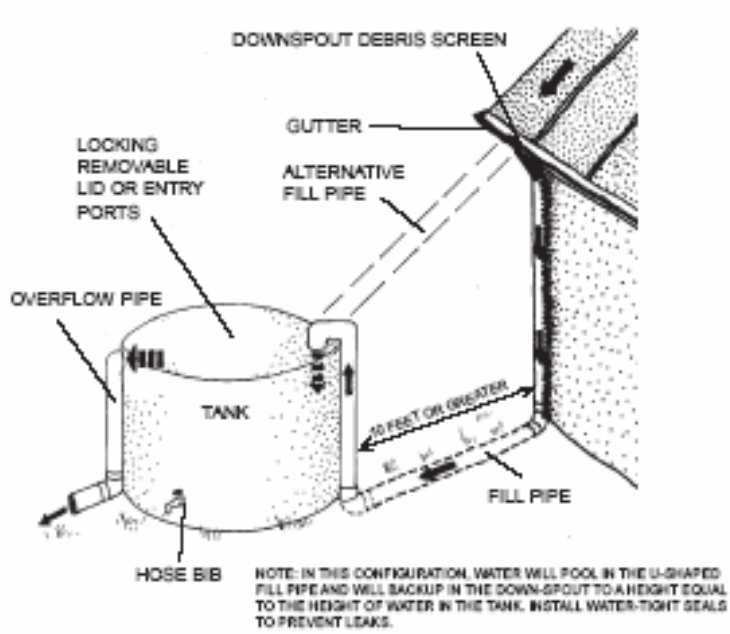
Design and Construction Criteria

The site, development program, and water use will inform the design of the system. The size of the storage tanks, the shape and placement of impervious surfaces, soils composition, slopes, and water use will direct the placement of the of the rainwater catchment system.

3.5 RAINWATER CATCHMENT SYSTEMS

Though rainwater catchment systems can be designed with various materials and configurations, components of a basic system should consist of the following:

- An impervious surface to collect runoff from (e.g. roofs or elevated paved surfaces);
- Devices to collect and convey water from the impervious surfaces (e.g. gutters, and downspouts);
- A debris screening device (also known as a “First Flush” or “Foul Flush” filter);
- Pipes to carry the water to the tank 10’ from the building’s foundation (e.g. fill pipe);
- Tank(s) or cistern(s) to contain the calculated rainwater volume needed to contain the runoff from the impervious surface during the “design storm” (See Sections 2.7 and 4.5) plus any additional water desired for site needs (e.g. toilets and landscape irrigation);
- A locking (recommended), removable lid or entry port;
- An overflow pipe;
- An exit point to distribute the harvested rainwater (e.g. hose bib); and,
- A booster pump (if gravity alone cannot deliver the water to its destination).



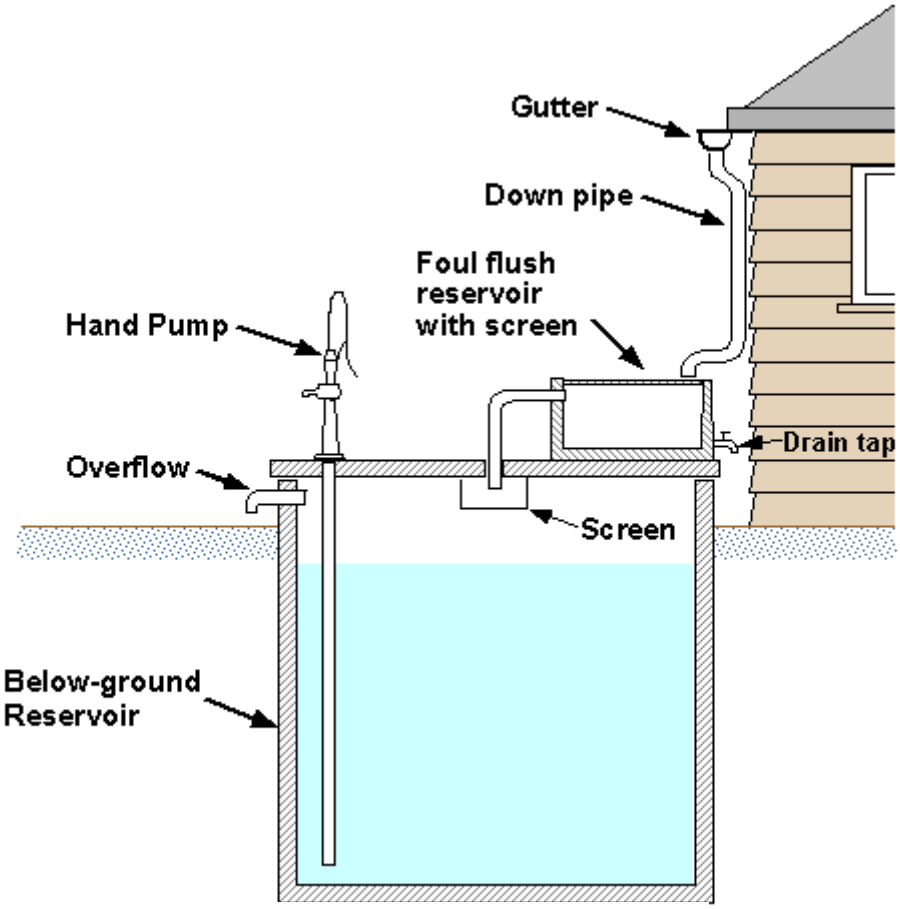
Source: City of Tucson, AZ

Figure 3-48: Rainwater catchment system schematic with an above-ground storage tank.

The following parameters should be considered in the design and construction of any Rainwater Catchment System:

- Prefabricated tanks of plastic, metal, or concrete that can be purchased and installed professionally.

- Tanks should be securely capped with opaque material to prevent evaporation, mosquito breeding, and algae growth. Lock all caps and entry ports for safety.
- The interior of the storage tank(s) should be accessible for periodic inspection and maintenance.
- Downspouts, inlets and outlets must be screened to keep mosquitoes, animals and debris out of the tank (e.g. with a “First Flush” filter, which are commercially available).
- Position outlet pipes several inches above the bottom of the tank to allow sediment to settle in the bottom.
- All tanks need an overflow pipe of equal or greater capacity than the fill pipe.
- Overflow pipes must be able to operate passively (i.e. not be dependent on a pump).



Source: www.worlhungeryear.org

Figure 3-49: Rainwater catchment system schematic with a below-ground storage tank or cistern.

- Below-ground tanks save land area, but typically require substantially more construction and booster pumps to supply the water to its intended uses.
- Route overflow water into a bioretention basin, adjacent tank, French drain, or other useful location away from buildings.

- Water in aboveground tanks should be delivered by gravity flow alone to low-pressure uses nearby whenever possible.
- A booster pump can be added to increase water pressure. Tank water should be filtered before it enters supply pipes, particularly to keep debris from plugging the irrigation system and prior to entering interior building pipes that supply water to toilets.
- Tanks can be constructed individually or in a series with the overflow from one tank filling the adjoining tank, or connected at the bottom to maintain the same water level in all tanks.
- Avoid placing vegetation with intrusive roots near or on top of below-ground tanks.

Inspection and Maintenance

Regular maintenance is critical to any dependable Rainwater Catchment System. The following inspection and maintenance practices are recommended.

- Clean out gutters, inflow and outflow pipes of leaves and debris as needed.
- Make sure gutters and downspouts are free of debris prior to the rainy season. The "first flush", or the runoff created by the first storm event after a long dry spell, will need to be carefully monitored to ensure that the system is working properly.
- Inspect water tanks periodically and any remove debris and sediment that may interfere with the proper function of the system.
- Screen inlet and outlet pipes to keep the system closed to mosquitoes. No opening shall be greater the 1/16" on systems where water will be retained for more than 72 hours.
- Cap and lock tanks for safety. Caps should have access ports for interior inspection and maintenance.

Proper monitoring and maintenance is important for any Rainwater Catchment System to work appropriately and efficiently. Each configuration will perform differently. After the system has stabilized, inspection and maintenance might be needed several times a year and particularly prior to the rainy season and after heavy rainfall events.

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3.6 Green Roofs

A Green Roof is a vegetated roofing system. Green Roofs typically consists of a number of layers: a waterproofing membrane, a drainage system, root protection, growing media (soil) and vegetation. Green Roofs provide numerous environmental benefits and offer a valuable tool for integrated storm water management.

Photo: Jonathan Feldman

Figure 3-50: Green roof on Carmel Valley, CA residence.

Photo: www.infrastructures.com

Figure 3-51: Green roof on a commercial office building.

Green Roofs have been a popular sustainable building practice to improve urban environments in Europe since the 1970s. However, it is still an immature market and evolving practice in the United States[7]. Many terms may be used to describe Green Roof systems. The list below describes some of the related terms:

- *Ecoroof* is used to describe lightweight vegetated roof systems, implemented as a sustainable building technique that limits impacts on the natural environment.
- *Roof garden* is a term generally describes a useable garden space that includes some vegetation. This type of roof system typically requires extra structural support and consequently, costs more to build.
- *Vegetated roof* is a general term that may describe a number of Green Roof objectives.
- *Living roof* is a general term that may describe a number of Green Roof objectives.

[7] Rozenzweig, C. etal., and Green Roofs for Healthy Cities

3.6 GREEN ROOFS

Structurally, there are two types of Green Roofs: intensive and extensive. Extensive Green Roofs are lightweight vegetated roofs consisting of 4-8 inches of growth media (or soil), planted with hardy, drought-tolerant species to minimize additional irrigation, maintenance, cost and weight[8]. They typically require supplemental irrigation to support growth during extended dry periods.

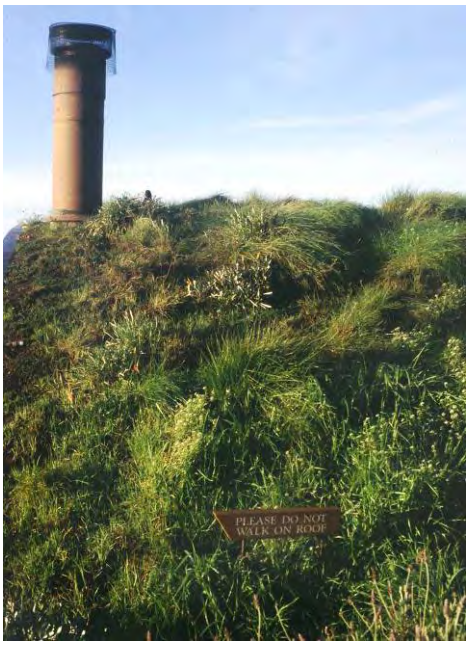

Photo: Rana Creek

Figure 3-52: Extensive green roof Big Sur, California.

Photo: Rana Creek

Figure 3-53: Extensive green roof at Post Ranch Inn, Big Sur, CA.

Alternatively, *intensive* Green Roofs can be designed to support lawns, trees, and create a useable outdoor garden space; often referred to as *roof gardens*. While these amenities do not preclude environmental benefits of Green Roofs, they do require extra structural support, cost, and have functional goals in addition to sustainable building objectives. They also typically require supplemental irrigation systems.

Photo: Rana Creek

Photo: Rana Creek

Figure 3-54: Intensive Green Roof on a parking structure at Stanford University, Palo Alto, California.

[8] Rozenzweig, C. etal. and City of Portland, Bureau of Environmental Services

3.6 GREEN ROOFS

Storm water management

As a storm water management strategy, Green Roofs can help meet the following Low Impact Development (LID) objectives:

- Absorbs rainfall
- Reduces urban runoff at its source
- Increases evapotranspiration
- Reduces heat island effect

Green Roofs provide small-scale decentralized controls that collect, absorb, and increase the evopotranspiration rates of rainfall. Additionally, Green Roofs are effective in reducing the heat island effect of urbanized areas containing large impervious surfaces. By reducing the temperatures of the runoff, the thermal impacts of urban runoff on local waterways are reduced.

Benefits

Green Roofs provide numerous environmental, economic and social benefits listed below.

- **Absorbs rainfall at the source.** 10-100% of roof runoff is absorbed and utilized by the vegetation[9]. Peak storm water flow rates are also reduced.
- **Improves building insulation**. This reduces heating and cooling costs and energy consumption.[10]
- **Reduces heat island effect** and the associated effects on waterway temperatures.
- **Increases wildlife habitat** for birds and insects that is often scarce in urban areas.
- **Absorbs noise pollution** through soils, plants, and trapped layers of air.
- **Reduces glare** that affects adjacent buildings and habitat.
- **Increases life-span of roof** by protecting the roof's structural elements from UV rays, wind and temperature fluctuations. Green Roofs typically last twice as long as conventional roofs.[11]
- **Improves air quality** by reducing air temperatures, filtering smog, binding dust particles, and converting carbon dioxide to oxygen through photosynthesis.
- **Provides an attractive roof.** In urbanized areas, Green Roofs integrate living systems into the built environment. In less urbanized areas, Green Roofs can help blend a structure into the surrounding landscape.

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[9] City of Portland, Bureau of Environmental Services. Note: estimates vary depending on the climate, depth of growing media, and plant materials.

[10] Rozenzweig, C. etal.

[11] Green Roofs for Healthy Cities, City of Portland, Bureau of Environmental Services, and Rosenzweig, C. et al.

3.6 GREEN ROOFS

Siting Criteria

Regional Criteria:

As a storm water management strategy on California's Central Coast, Green Roofs are best utilized in highly urbanized areas where there is little pervious ground surface to infiltrate and manage storm water or on buildings with significant roof areas such as industrial facilities, warehouses, shopping centers, and office buildings. Though environmental benefits still pertain in less urbanized areas, the initial cost of Green Roof implementation may preclude their use as a storm water management strategy in these areas because more cost effective solutions that utilize open spaces or landscaped areas may be available. Green Roofs are also utilized on the Central Coast in an effort to blend structures into the scenic landscapes and protect native plant species, such as on the Big Sur coastline.

The Central Coast's temperate climate is amenable to succulents, grasses, and native perennials that are recommended for Green Roofs. Short bursts of supplemental irrigation may be necessary to maintain a green appearance and for fire protection during the dry season.

Photo: Jonathan Feldman

Figure 3-55: Residential green roof, Carmel Valley, CA.

Photo: Rana Creek

Figure 3-56: Green roof at GAP Corporate Campus, San Bruno, CA.

Limitations

- **Initial costs** can be prohibitive, especially for re-roofing a standard roof. However, it should be noted that extensive Green Roofs can be competitive on a life cycle basis.
- **Specific maintenance**, such as irrigation and cleaning out drainage features will need to be factored into the long-term building care.
- **Untraditional** design and installation may stall the permitting process. Green Roof systems are still an evolving market and practice that needs perfecting in North America.
- **Immature market and government policies**. Not yet widely understood, regional and local governments may not yet be providing economic or policy incentives to implement Green Roofs.

3.6 GREEN ROOFS

Figure 3-57: Comparison of green vs. conventional roofing costs.

(Source: City of Portland, OR)

	Ecoroof (cost per square foot)	Conventional Roof (cost per square foot)
New construction (including structural support)	$10 to $15	$3 to $9
Re-roofing	$15 to $25	$5 to $20

Source: Bureau of Environmental Services estimates based on City of Portland demonstration projects, and information obtained from roof contractors.

As shown in the comparison of roofing costs above, it is important to note that there is a wide range of costs depending on many factors. Since Green Roofs typically last twice as long as conventional roofs, the life cycle costs are competitive with conventional roofs.

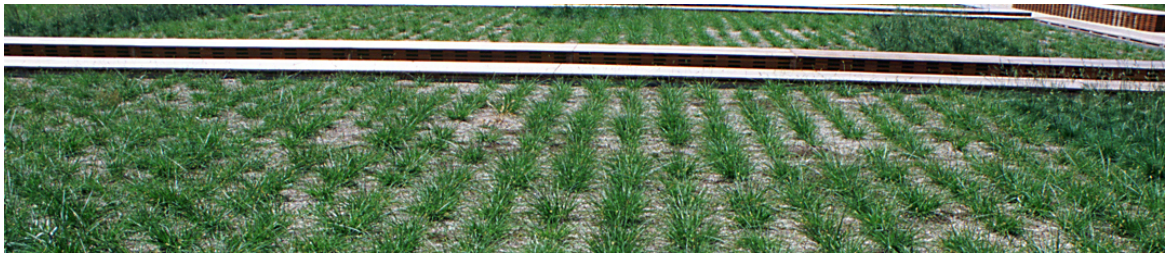

Photo: Rana Creek

PROGRESSIVE POLICIES AND INCENTIVES

Numerous economic benefits can help to offset initial costs of Green Roofs including: reduced energy costs, extended roof life, increased property values. Some jurisdictions are promoting their implementation through various incentive programs such as:

- Lowered storm water utility fees
- Increased floor to area ratios and/or density bonuses
- Faster permitting for new projects
- Energy tax credits
- Grants and subsidies for Green Roofs and energy efficient building
- LEED credits from the U.S. Green Building Council

Design and Construction

Green Roofs can be placed on flat or pitched roof structures at slopes up to 40 percent (or 5 in 12 pitch).[12] Green Roofs can be incorporated into new construction or to re-roof existing buildings. Though several site factors will need to be considered, such as the aspect of the roof, the microclimate of the site, prevailing winds and the building's functions – most factors can be accommodated into a successful Green Roof design.

Extensive Green Roof systems are composed of several layers. The roof systems may be modular interlocking components or each layer may be installed separately. Either way an

[12] City of Portland, Bureau of Environmental Services.

extensive Green Roof is constructed with the following basic layers (starting at the bottom): structural support, a waterproof roofing membrane (including flashing), a root barrier, drainage, a filter fabric (for fine soils), growing medium (soil) and plant materials and mulch. Other elements shown in the diagram below may be optional or required depending upon the conditions of the roof design.

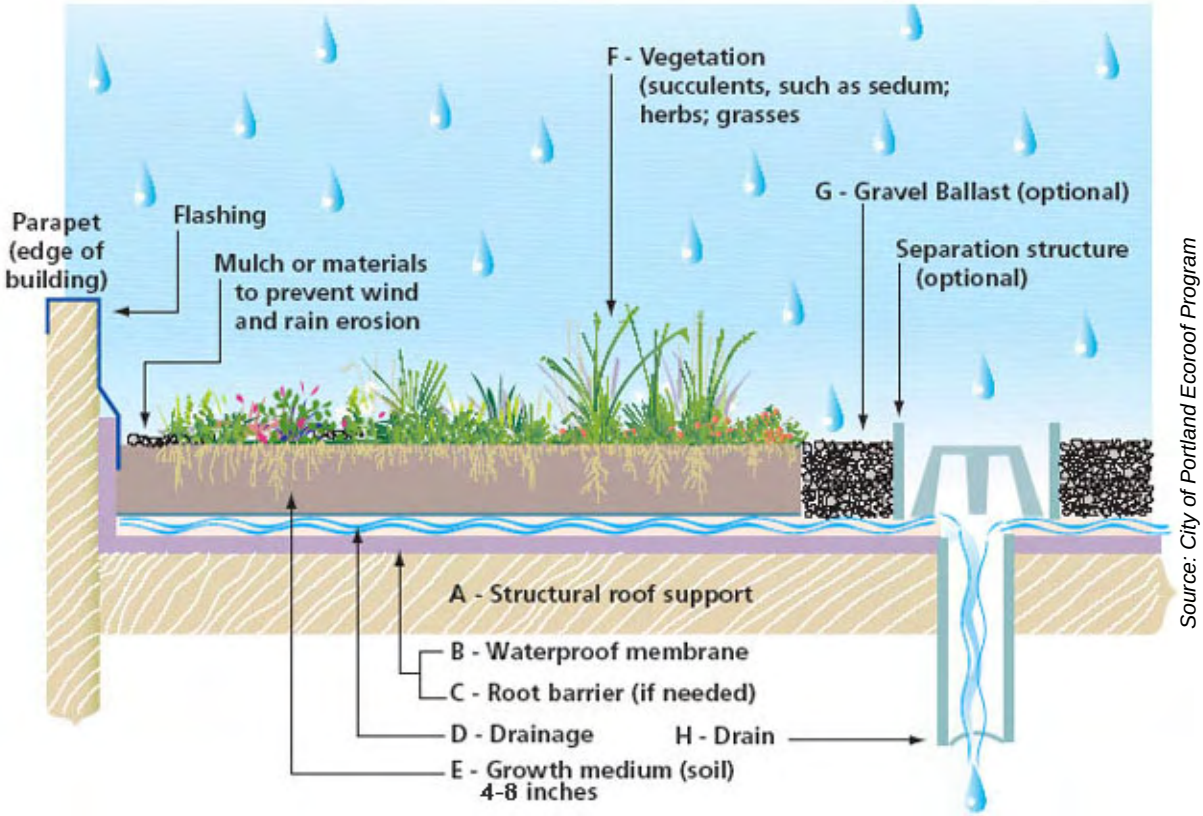

Figure 3-58: Green roof construction detail schematic.

Generally, a building's structure must be able to support an additional 10-25 pounds per square foot of saturated weight, depending on the growth media and vegetation used. For New construction, the load requirement of the Green Roof can be addressed as part of the building's design process. Additional structural support may be necessary for a re-roofing project; however, many existing buildings are structurally sound enough to accommodate a Green Roof.[13]

Green Roofs can be designed by architects, landscape architects, and building contractors. Since Green Roof systems include materials not found on convention roofs, it is recommended that qualified roofing contractor with Green Roof experience is chosen to install the design.[14]

Green Roofs may require maintenance beyond standard roof care, though such care is likely similar in cost. Long term management should be factored into appropriate siting of Green Roofs.

[13] City of Portland, Bureau of Environmental Services.
[14] Green Roofs for Healthy Cities

3.6 GREEN ROOFS

Inspection and Maintenance

- Upon installation, the Green Roof system should be inspected monthly for the first year and after each large storm event for erosion, plant survival, proper drainage and water proofing.
- Inspections can be reduced to a quarterly schedule once the Green Roof system has proven to work properly and vegetation is established.
- If necessary, irrigate in short bursts only (3-5 minutes) to prevent runoff. Irrigation frequencies should be established by the designer using an automated system.
- Clean out drain inlets as needed.
- Weeding and mulching may be necessary during the establishment period, depending on the planting design.
- Replace or fill in vegetation as needed.
- Inspect soil levels semi-annually to ensure plant survival and rainfall absorption.
- If the vegetation used is flammable during the dry season, it should be mowed or watered as needed to prevent fire.

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Rana Creek: www.ranacreek.com

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Infrastructures: www.infrastructures.com

3.7 STORM WATER PONDS AND WETLANDS

3.7 Storm Water Ponds and Wetlands

Storm water ponds and wetlands are constructed basins that have a permanent pool of water at least throughout the wet season. Storm water ponds are typically deeper and have less micro topography and wetland vegetation than storm water wetlands. They require a dependable source of water to sustain the wetland vegetation. These treatment control BMPs are among the most effective in terms of pollutant removal and can also offer aesthetic value. Storm water pollutant removal is achieved through settling and biological uptake within the pond or wetlands.

Description

Storm water ponds are also known as wet ponds, sediment retention ponds, or wet extended detention ponds. They are typically deeper, have more open water and contain less wetland vegetation than storm water wetlands. Storm water ponds contain a permanent pool of water and the excess capacity of the structure is used to collect and treat the water quality volume. Between storm events, pollutants are removed from the water through sedimentation, biological processes and chemical processes. Given proper design and maintenance, these ponds provide valuable wetland habitat, increase the aesthetic value of the area, and improve water quality.

Figure 3-59: Storm water wetlands designed to treat freeway runoff
(photos courtesy of Caltrans)

Applications and Advantages

Can be applied over a range of storm sizes, storm frequencies, and drainage areas. However, they can be limited in application in urban settings and arid climates because they require a perennial water source. Storm water ponds can be installed either on-line or off-line.

3.7 Storm Water Ponds and Wetlands

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Influent	Effluent
Total Suspended Solids (mg/l)	88.8 (48.9-156)	19.7 (16.6-23.4)
Total Copper (µg/l)	18.0 (7.4-43)	6.92 (4.7-10.3)
Dissolved Copper (µg/l)	8.87 (5.4-14.6)	5.09 (3.1-8.3)
Total Lead (µg/l)	33.3 (10.2-109)	6.68 (2.9-15.6)
Dissolved Lead (µg/l)	9.48 (0.9-101.4)	4.16 (2.0-8.9)
Total Zinc (µg/l)	75.3 (44-128.9)	28.6 (21.4-38.3)
Dissolved Zinc (µg/l)	57.4 (20.1-163)	16.9 (2.6-109)
Total Phosphorus (mg/l)	0.53 (0.3-0.9)	0.16 (0.12-0.21)
Total Nitrogen (mg/l)	1.49 (0.6-3.6)	1.17 (0.77-1.78)
TKN (mg/l)	1.06 (0.8-1.4)	0.84 (0.68-1.04)

Source: International BMP database, 2005

Limitations

- Unless a perennial baseflow is available to support a permanent pool, this technology is typically not practical in arid climates.
- May create a public health hazard and require fencing.
- Can create mosquito-breeding habitat.
- Increased water temperatures within the pond may lead to warming downstream.
- If not regularly maintained, permits may be required to perform necessary maintenance.
- May provide a habitat for waterfowl that may lead to increased nutrient loads.

Siting Criteria

- Apply in areas with high volumes of suspended sediments and dissolved contaminants.
- Areas having fairly consistent year-round base flow.
- Applicable to drainage areas greater than 25 acres.
- Must be sited in an area with available open space.
- Not to be located on steep unstable slopes.

3.7 STORM WATER PONDS AND WETLANDS

- If designed to infiltrate storm water into underlying soils, storm water ponds and wetlands are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design of storm water ponds.
- Storm water ponds should be sized to contain the permanent pool plus the Water Quality Volume (WQ_V).
- The WQ_V should be determined using the method outlined in Section 4.5.1.
- The permanent pool volume should be equal to twice the water quality volume.
- A sediment forebay can be installed to aid in the settling of coarse sediments.
- The forebay should be a minimum of 3 feet deep and should hold 15 to 25 percent of the permanent pool volume.
- An impermeable liner may be needed if the pond is located in an area with porous soils.
- Water depth in the pond should not exceed 8 feet and should range between 4 and 6 feet.
- The minimum length to width ratio of the pond should be 1.5:1.
- The basin should be narrow at the inlet and wide at the outlet.
- Ponds having a depth greater than 4 feet should have an aquatic bench extending around their perimeter. The aquatic bench should be 5 to10 feet wide and less than 18 inches deep.
- Side slopes above the permanent pool should be 4H:1V or flatter and should be stabilized with vegetation on slopes as long as it is kept 2 feet from the waters edge.
- Littoral zone side slopes should be 40H:1V or flatter.
- Wetland vegetation should not cover more than 25 percent of the ponds surface and should be maintained as isolated islands away from the pond's perimeter edge.
- The emergency spillway should be consistent with local flood control design standards (100 year peak flow, probable maximum flood (PMF), or standard project flood (SPF)).
- The outlet structure should be designed to drain the WQ_V within a minimum of 48 hours.
- Where permissible with local fish and game officials, stock pond with mosquito fish (Gambusia sp.) to aid in controlling mosquito populations.
- A pretreatment device, such as a hydrodynamic separator can be used to remove litter and debris before being discharged to the pond for further treatment.

3.7 STORM WATER PONDS AND WETLANDS

- The design of these ponds should include a meandering low-flow channel connecting all micro pools or place aerator(s) in these ponds with a two hour operation in the morning and evening.
- Vegetation can be installed on the bottom of the pond excluding 2 feet on both sides of the low-flow channel.

Inspection and Maintenance Requirements

- Biannual performance and maintenance inspections should be conducted.
- Cut and remove wetland plants every 5 - 15 years to remove nutrients and metals retained in the vegetation.
- Sediments may need to be removed from the pond every 5 – 20 years.
- To maintain an attractive pond, litter and debris must be regularly removed.
- A non-clogging outlet such as the reverse-slope pipe or a weir outlet with a trash rack should be installed in the pond.
- Properly maintain the access road as well as the shoreline vegetation.

References

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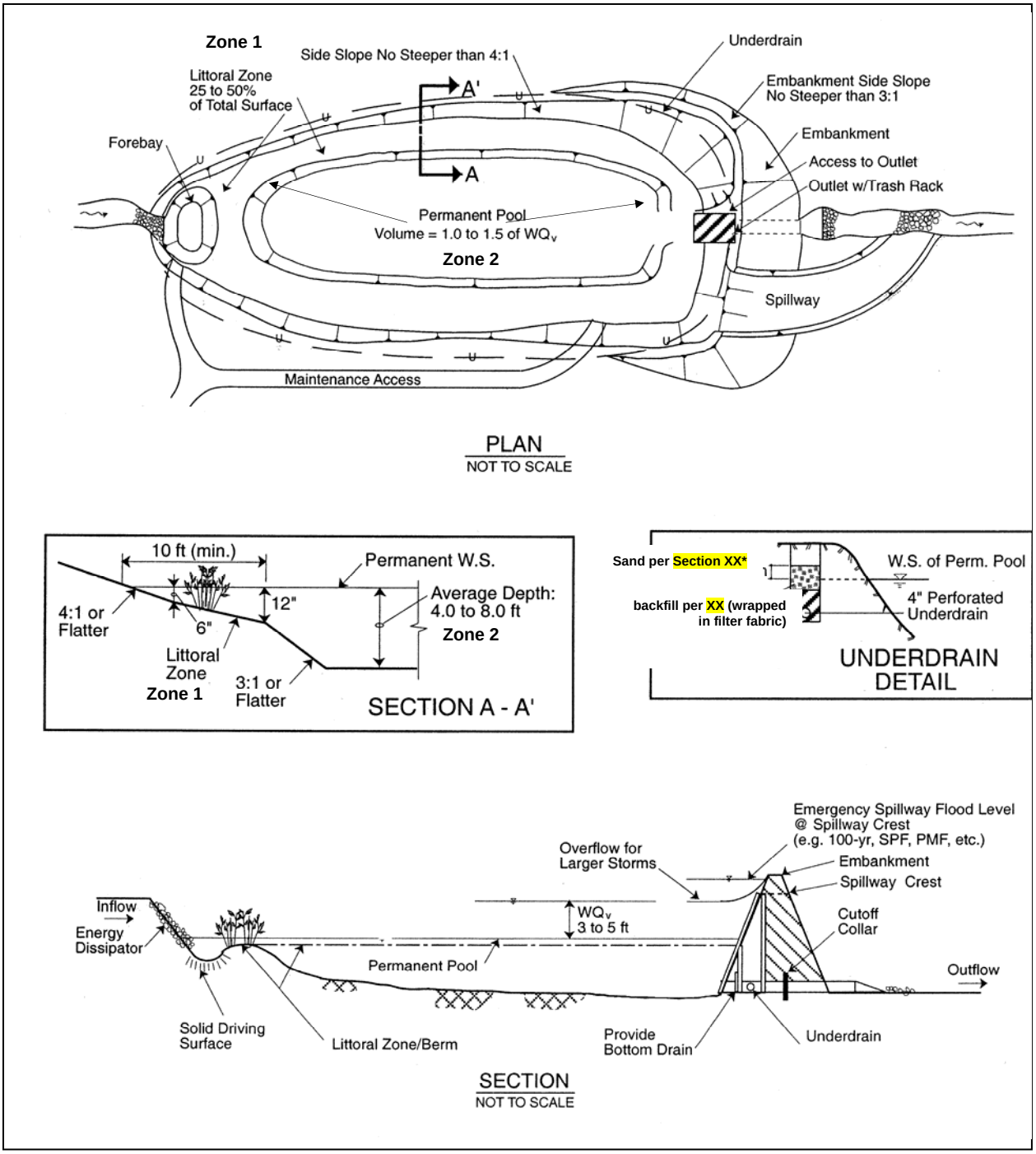
3.7 STORM WATER PONDS AND WETLANDS



* XX (aggregate specifications to be developed by the City of Salinas)

Figure 3-60: Example of a Storm Water Pond.
(modified from UDFCD, 1999)

3.7 STORM WATER PONDS AND WETLANDS

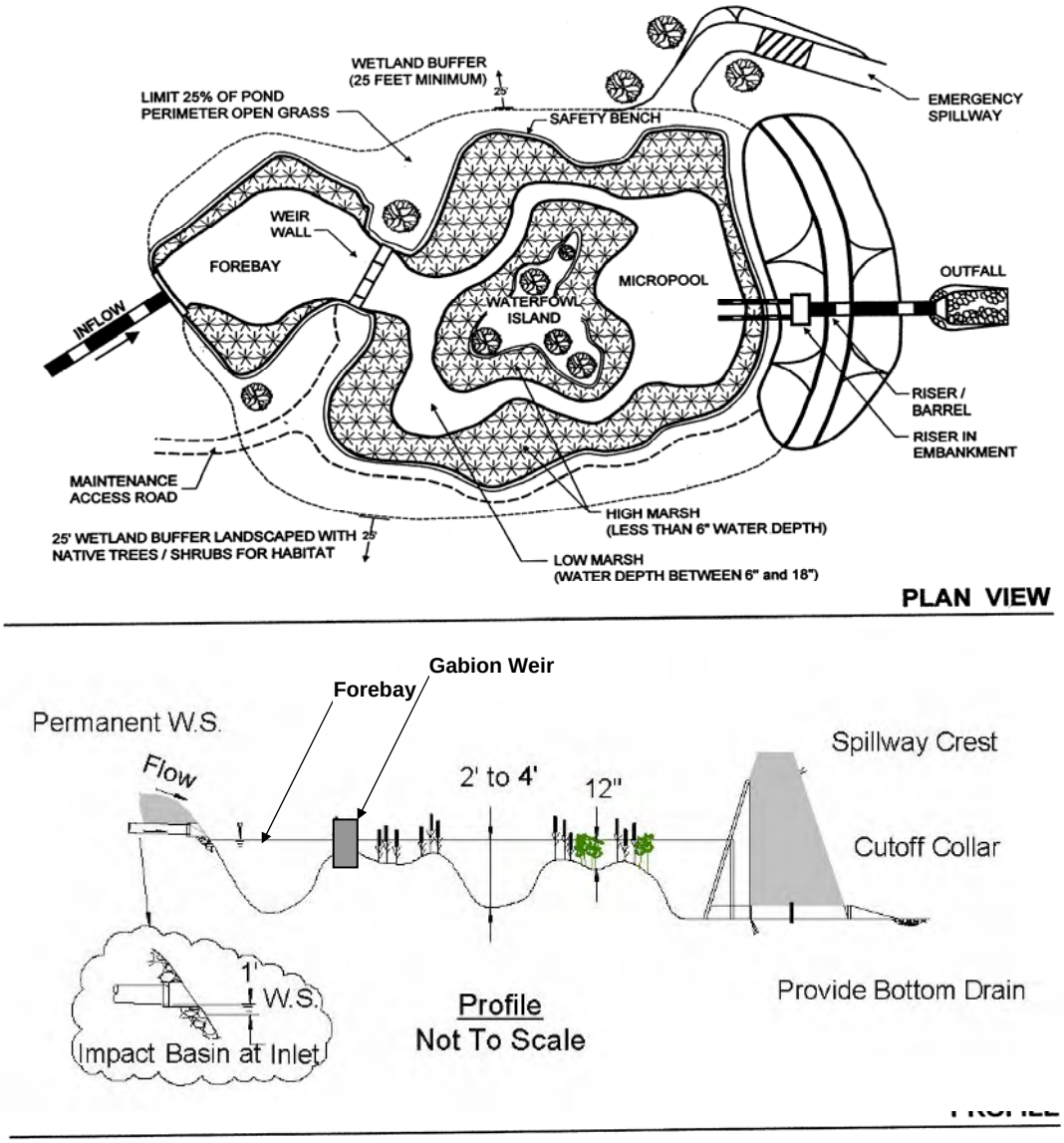


Figure 3-61: Example design of a Storm Water Wetland.
(from MDE, 2000 and CASQA, 2003).

Section 4: LID Design Considerations

4.0 Urban Storm Water Pollutants and Sources

Urbanization and industrial activities have significantly altered the natural landscape of our nation's watersheds. These activities have resulted in a decrease in the amount of stable and pervious land surfaces with native vegetation, an increase in the amount of erosion and sediment transport, and an increase in the rate, volume and pollutant loading of storm water discharges to receiving waters. Urbanization and industrial activities result in an influx of residential, commercial and industrial products and byproducts into urban and suburban areas. These materials are deposited on developed impervious surfaces by a variety of mechanisms and incorporated into storm water runoff as pollutants. Increased runoff and the transport of pollutants in storm water have adversely affected both the quantity and the quality of storm water runoff and have contributed to the chemical, physical, and biological impairment of the nations receiving waters. Studies, such as the Nationwide Urban Runoff Program (NURP) study (U.S. EPA, 1983), have shown that storm water from urban, suburban and industrial areas commonly contains elevated levels of heavy metals, synthetic organics, pesticides, fuels, waste oils, and pathogens. The U.S. EPA has determined that this type of pollution, known as nonpoint source pollution (NPS) or storm water pollution, is now the single largest cause of the deterioration of our nation's water quality (U.S. EPA, 1995). Table 4-1 provides a general list of the types of pollutants commonly found in urban storm water, the major sources and their potential environmental impacts.

Proper selection of source controls and structural treatment controls includes the identification of anticipated pollutants of concern for proposed new development and redevelopment projects. Table 4-2 provides a list of the anticipated and potential pollutants generated by several common urban land uses. To evaluate pollutants of concern and the appropriate source control BMPs, LID practices and/or structural treatment control BMPs, the project designer should reference Table 4-2 and consider the following:

- Receiving water quality and the pollutants for which those receiving waters are listed as impaired under Clean Water Act section 303(d),
- Land use type of the development project and pollutants associated with that land use type,
- Materials expected to be present on site that could become pollutants,
- Changes in storm water discharge flow rates, velocities, durations, and volumes resulting from the development project,
- Sensitivity of receiving waters to changes in storm water discharge flow rates, velocities, durations, and volumes.

The key to remember is that a pollutant need not be causing an immediate impairment when evaluating anticipated pollutants of concern. In addition, significant reductions in structural treatment BMP size and investment can often be realized by implementing LID and reducing runoff that needs to be captured, infiltrated, or treated, and, controlling sources of pollutants.

Table 4-1: Pollutants Commonly Found in Urban Runoff

Pollutant	Major Sources	Potential Effects
Nutrients • **Nitrogen** • **Phosphorus**	• Fertilizers • Animal Waste • Detergents • Atmospheric deposition • Leaking sewage pipes	• Lowers oxygen levels • Destroys habitat • Promotes algal blooms • Limits recreation • Interferes with navigation
Pathogens • **Bacteria** • **Viruses**	• Animal waste • Illicit connections between storm sewers and sewage lines • Leaking sewage pipes	• Poses human health risks • Closes beaches • Closes shellfish harvesting areas
Hydrocarbons • **Oil** • **Grease** • **Petroleum-based products** • **Polycyclic aromatic hydrocarbons (PAHs)**	• Parking Lots • Roads • Automobile emissions • Improper disposal of used motor oil • Illicit connections to drain systems	• Lowers levels of dissolved oxygen in receiving waters • Causes toxic impacts • Damages habitat
Toxic Organics • **Pesticides** • **Polychlorinated biphenyls (PCBs)**	• Lawn care • Agricultural lands • Industrial uses • Illicit connections to storm drain systems	• Causes toxic impacts • Leads to human and animal reproductive abnormalities • Increases animal mortality rates
Sediments	• Construction sites • Agricultural lands • Logged forest lands • Eroded stream banks	• Increases water turbidity • Alters water flows • Destroys benthic habitat • Blocks sunlight • Attracts particulate forms of metals and nutrients
Metals • **Lead** • **Copper** • **Cadmium** • **Zinc** • **Mercury** • **Chromium** • **Selenium** • **Nickel**	• Illicit storm drain connections • Automobile usage – emissions, brake pad residues • Atmospheric deposition • Industrial activities • Commercial activities	• Increases toxicity of sediment and water column • Adds toxics to food chain • Causes genetic defects, reproductive abnormalities and increased mortality rates among fish and wildlife • Increases risks of cancer, neurological disorders and birth defects among humans
Litter	• Human activities	• Aesthetic impacts • Impairs recreational uses • Threatens aquatic life
Chlorides	• Outdoor storage and use of salts on roads, driveways and sidewalks in cold areas	• Toxic to freshwater organisms
Elevated Temperatures	• Industrial sources • Removal of trees next to streams and rivers • Impervious surfaces and conveyances	• Threat to insects, fish and other temperature sensitive aquatic species

Sources: Terrene Institute, 1996; U.S. EPA, 1995.

Table 4-2: Anticipated and Potential Pollutants Generated by Land Use Type

Development Type	General Pollutant Categories								
	Pathogens	**Heavy Metals**	**Nutrients**	**Pesticides**	**Organic Compounds**	**Sediments**	**Trash & Debris**	**Oxygen Demanding Substances**	**Oil & Grease**
Detached Residential Development	X		X	X		X	X	X	X
Attached Residential Development	P		X	X		X	X	P(1)	P(2)
Commercial / Industrial Development >100,000 ft^2	P(3)		P(1)	P(5)	P(2)	P(1)	X	P(5)	X
Automotive Repair Shops		X			X(4)(5)		X		X
Restaurants	X						X	X	X
Hillside Development >5,000 ft^2			X	X		X	X	X	X
Parking Lots		X	P(1)	P(2)		P(1)	X	P(5)	X
Streets, Highways & Freeways		X	P(1)		X(4)	X	X	P(5)	X

X = Anticipated

P = Potential

(1) A potential pollutant if landscaping exists onsite.

(2) A potential pollutant if the project includes uncovered parking areas.

(3) A potential pollutant if land use involves food or animal waste products.

(4) Including petroleum hydrocarbons.

(5) Including solvents.

Source: CASQA, 2003

4.1 Salinas Shallow Soil and Groundwater Conditions

Six maps showing interpretations of soil physical and hydrologic properties, and shallow groundwater conditions, in and around the City of Salinas, are presented on Figures 4-1 through 4-6. From a general planning perspective, these maps can be used for storm water management planning as follows:

Figure 4-1: Soil Drainage Classifications - to qualitatively determine the frequency and duration of soil saturation periods and the removal of excess water from the soil.

Figure 4-2: Runoff and Infiltration - to qualitatively determine the general soil composition of shallow surface soils (within 5 feet below ground surface (bgs)).

Figure 4-3: Saturated Hydraulic Conductivity - to qualitatively determine the soils ability to transmit water under saturated conditions.

Figure 4-4: Depth to Restrictive Soil Layer - to estimate the approximate depth to the first shallow restrictive clay layer based on the nearest group of wells.

Figure 4-5: Available Soil Water Holding Capacity - to qualitatively determine appropriate plant species and irrigation requirements.

Figure 4-6: Soil Clay Content - to qualitatively determine type and amount of clay in the soil, the fertility of the soil, its potential ability of the soil to adsorb cations (e.g. pollutant removal potential), and its ability to retain moisture.

Soil physical and chemical properties can affect the selection and design of storm water management techniques and LID practices that need to be implemented in the City for NPDES permit compliance. Together, an assessment of these properties can allow planners, developers, engineers and designers to evaluate the soils in their project areas and their potential for storm water management. Design of actual facilities should be based on site-specific information.

Two main sources of soils information were used to create these figures; the soil survey records from the Natural Resource Conservation Service (NRCS) and water well log records from the Monterey County Water Resources Agency (MCWRA). The mapping methods used by NRCS is typically generalized and a significant amount of landscape interpretation is used in the mapping process. The NRCS soil survey is generally considered as a starting point by soil scientists and is supported by site specific soil data, including samples for physical and chemical analyses.

In addition, shallow groundwater data from the State Water Resource Control Board's Geotracker web database and the United States Geological Survey (USGS) were reviewed and applied where applicable. Soil properties related to water infiltration, storage, and runoff characteristics were compiled from the NRCS National Cooperative Soil Survey (NCSS). Areas mapped with shallow groundwater conditions, defined as approximately 20 feet below ground surface (bgs) or less, and potentially restrictive subsurface soil layers within 20 feet bgs, were also included in these figures to show areas that may require the collection of more site-specific information before soil infiltration is used as a storm water management technique. Well

completion reports obtained from the MCWRA and shallow groundwater data from the State Water Resource Control Board's Geotracker web database for Leaking Underground Fuel Tank (LUFT) monitoring wells were used to provide the "Probable Depth to Water" and "Reported Depth to Clay" data noted on these figures.

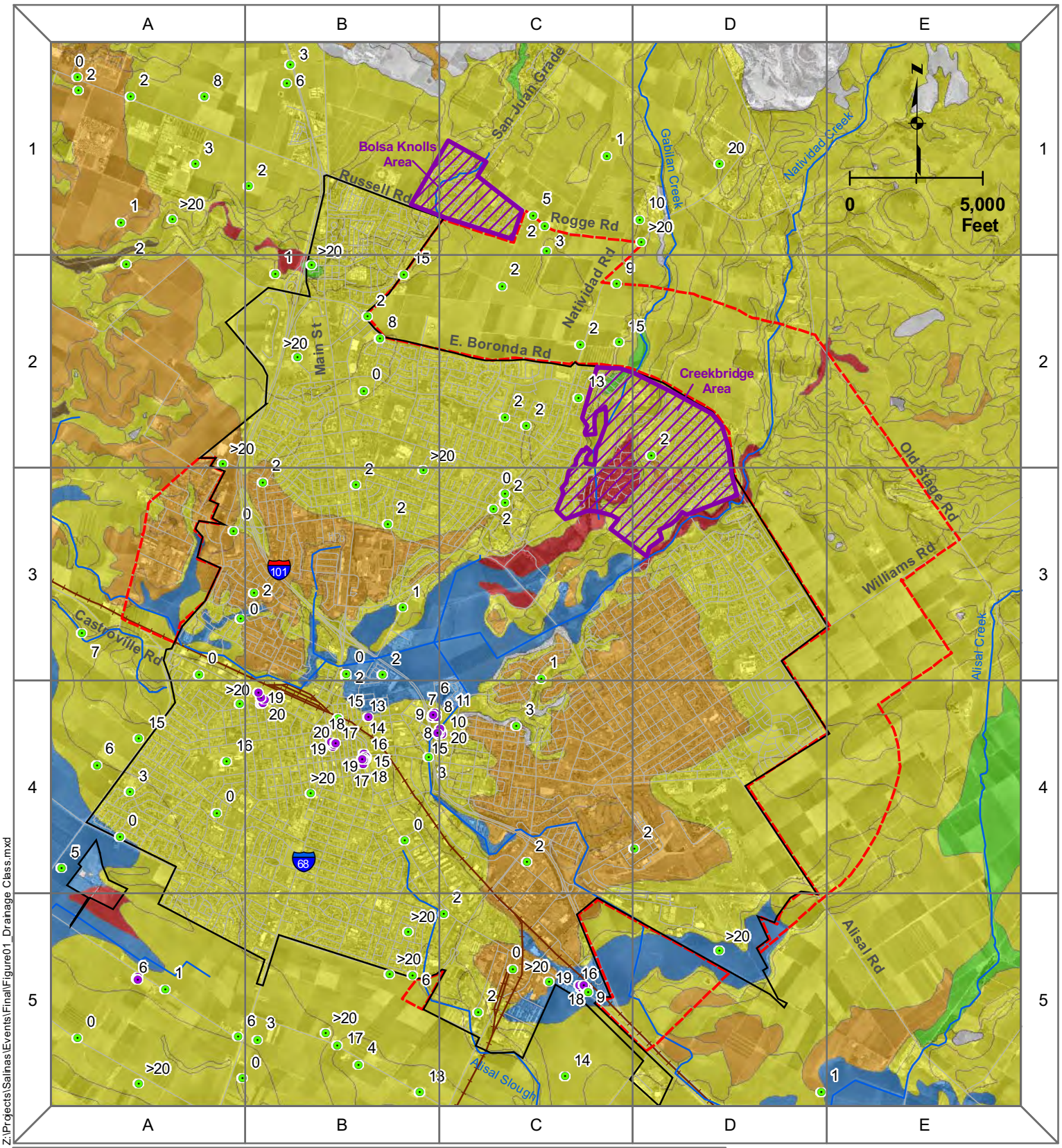
Figures 4-1 through 4-6 also include the approximate locations of MCWRA wells and LUFT monitoring wells. This information is important to the application of the separation and setback standards for storm water infiltration systems discussed in Section 4.2. It should be noted that the MCWRA well locations shown on these figures have been estimated based on street address information. Therefore well locations should be verified prior to the siting and design of storm water infiltration systems. GPS coordinates of well locations in the vicinity of storm water management practices should be provided to the City of Salinas during the City's plan review and permitting process.

Figures 4-1 through 4-6 indicate that there is a significant amount of heterogeneity (lack of consistency) in the shallow soils underlying the City. These figures indicate that the soils in the Salinas area are typical of an alluvial depositional environment with discontinuous (horizontal and vertical) layers and mixtures of sands, silts and clays. Soils in developed areas of the City have been mapped by the NRCS as varying from well to poorly drained, with moderate to high runoff potential and moderate to very slow infiltration/percolation rates (hydrologic soil group B, C and D soils). The MCWRA well logs indicate numerous areas with significant clay layers (1 foot or more thick) are present throughout the Salinas area within the first 20 feet bgs. Wells indicating relatively shallow clay areas occur in all soil types and are particularly notable in the northern portion of the City and the currently undeveloped area north of Boronda Rd. However, these soil properties represent a broad range of soil characteristics, and therefore, site-specific information should be used during specific storm water planning and design.

A discussion of each figure and its representation is presented following the figures. The discussion on each figure notes the soils in the City's Future Growth Area (see Figure LU-1 from the Salinas General Plan on the following page) as this is the area with the greatest potential for the planning and implementation of LID and storm water infiltration practices.

Soils information from both the NRCS and the MCWRA show general agreement concerning the soils occurring in the Future Growth Area, with many of the soils containing moderate textures (e.g., sandy loams, loams) at the surface and clayey textures in the subsurface (e.g., clay loams, clays) potentially restricting the transport of soil water to deeper depths. Both data sources indicate that significant shallow clay layers exist within the first 5 feet bgs throughout the developed portions of the City and in at least the northern portion of the Future Growth Area. Although NRCS soils mapping information is available for the entire planned Future Growth Area, MCWRA well log information was only available in northern portion of the Future Growth Area to corroborate the NRCS information. Therefore, there does not appear to be well log data for much of the eastern portion of the Future Growth Area which could be used to identify approximate depths to significant clay layers. However, it is likely that a number of significant shallow clay layers also exist in this area because shallow groundwater conditions have been observed by the MCWRA and the Monterey County Health Department (MCHD). Specifically MCHD personnel indicate that shallow groundwater conditions exist on the east side of the City in the vicinity of the "Creekbridge" and "Bolsa Knolls" areas.

City Boundary
Future Growth Area
Future Growth Area
Figure LU-1
Future Growth Area
City of Salinas
General Plan
LU-23
September 2002



Z:\Projects\Salinas\Events\Final\Figure01_Drainage Class.mxd

Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Soil Drainage Classification

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Undefined drainage type
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Drainage Classification Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

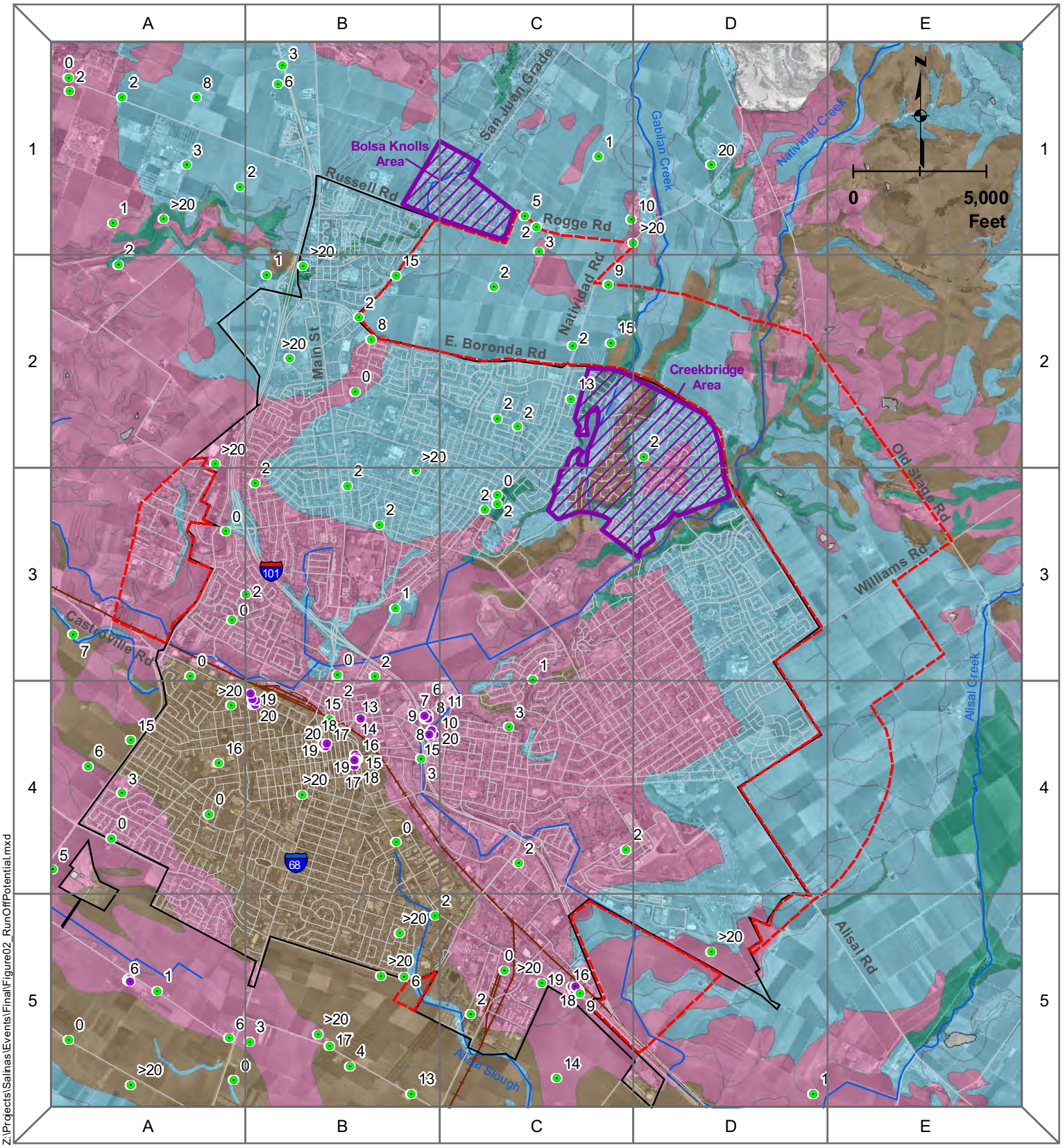
Kennedy/Jenks Consultants

City of Salinas, CA
Soil Drainage Classifications

K/J 06950006
July 2007

Figure 4-1

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Hydrologic Soil Group data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Hydrologic Soil Group

- A - Low Runoff Potential (High Infiltration Rate)
- B - Moderate Runoff Potential (Moderate Infiltration Rate)
- C - Moderate Runoff Potential (Slow Infiltration Rate)
- D - High Runoff Potential (Very Slow Infiltration Rate)
- Undefined runoff potential
- Soil Type Series/Grouping

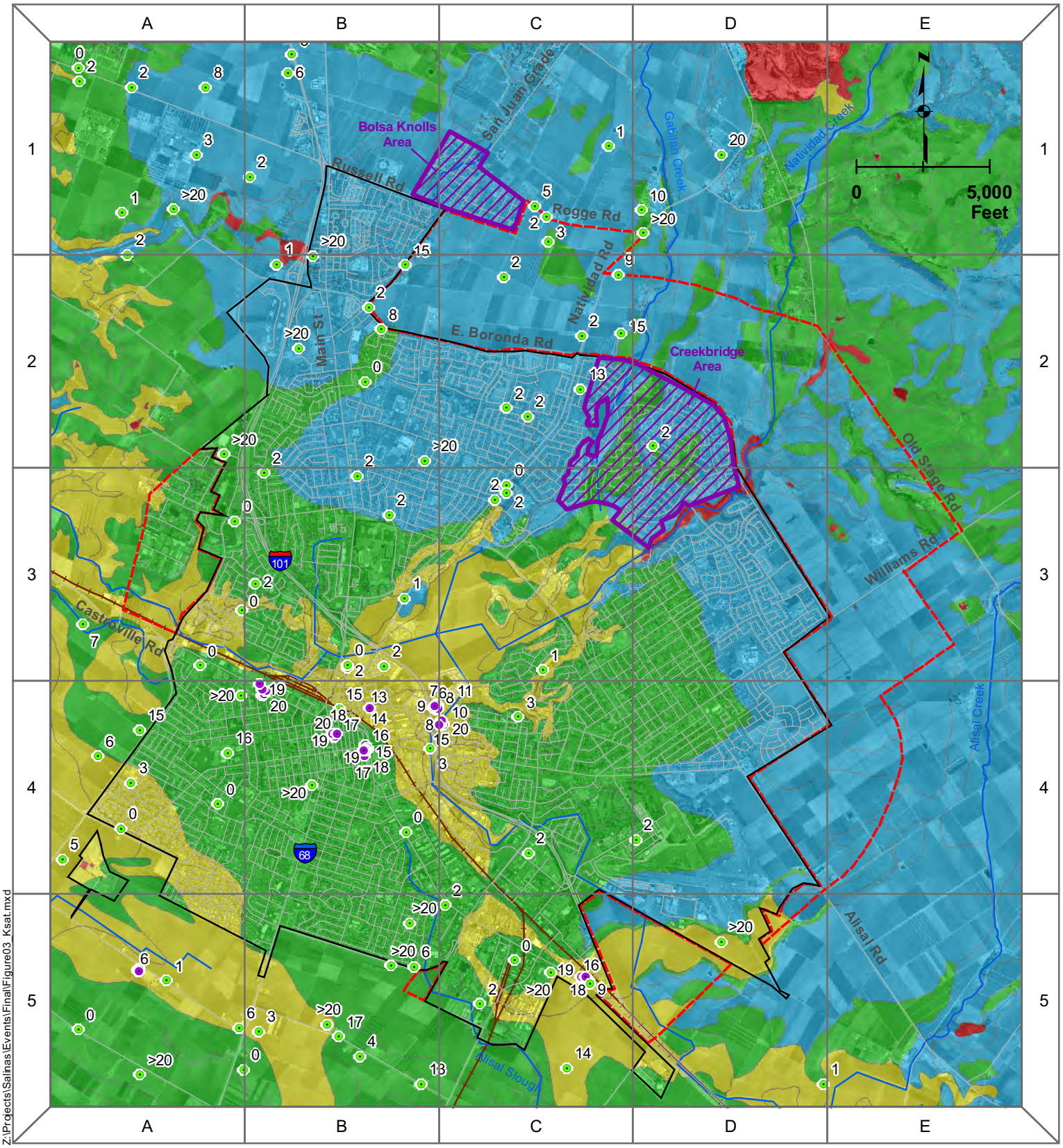
Kennedy/Jenks Consultants

City of Salinas, CA
Runoff and Infiltration Potential

K/J 06950006
July 2007

Figure 4-2

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs.
KSAT Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Saturated Hydraulic Conductivity

- Very low: 0.00 - 0.01 μm/s
- Low: 0.01 - 0.1 μm/s
- Moderately Low: 0.1 - 1.0 μm/s
- Moderately High: 1 - 10 μm/s
- High: 10 - 100 μm/s
- Very High: 100 - 705 μm/s
- Soil Type Series/Grouping

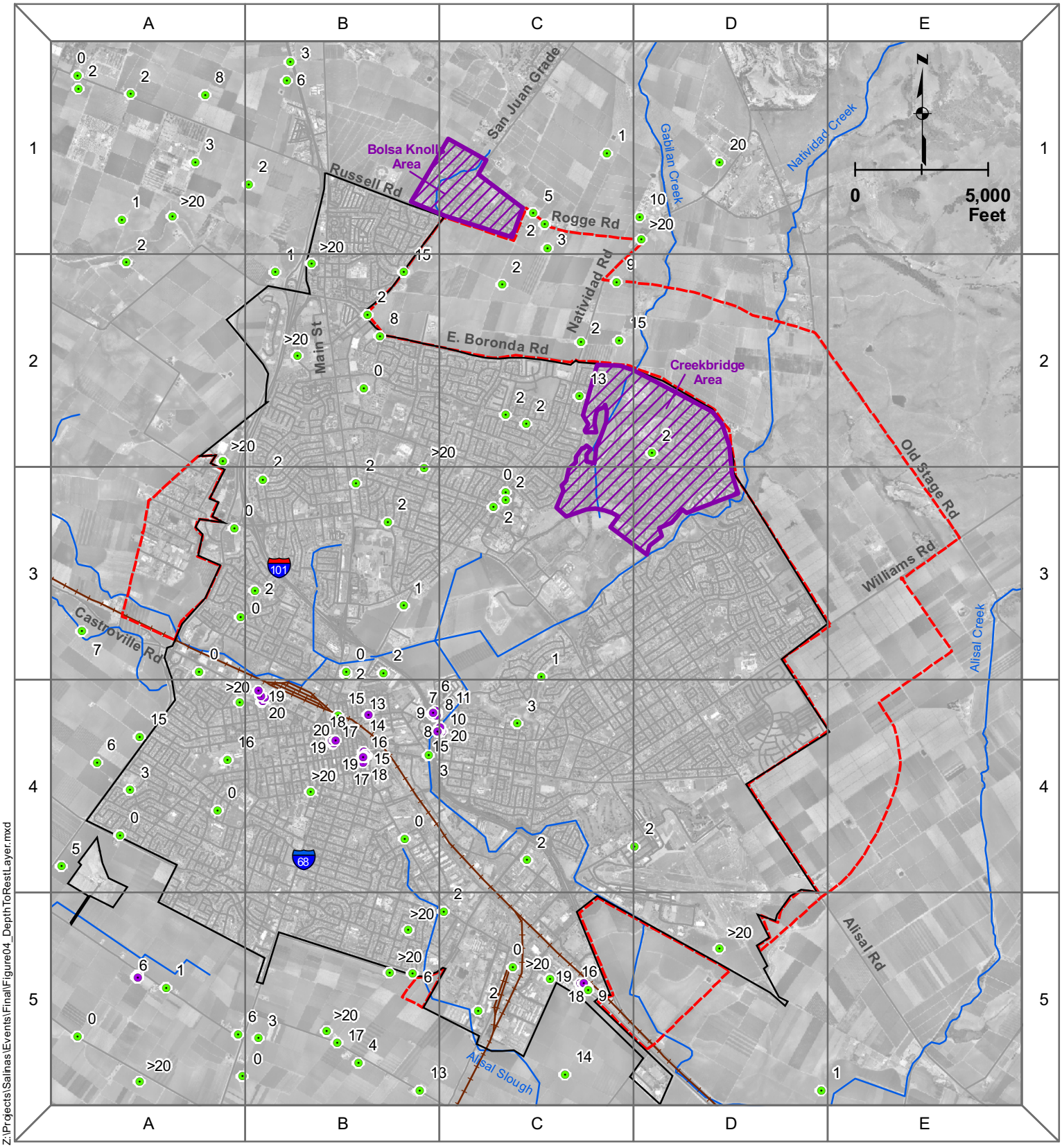
Kennedy/Jenks Consultants

City of Salinas, CA
Saturated Soil Hydraulic Conductivity

K/J 06950006
July 2007

Figure 4-3

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Restrictive Soil Layer Data

- 2 Reported Depth to Clay (ft below ground surface)
  * See text for explanation

Data Sources

Probable Depth to Groundwater: Geotracker website
Restrictive Soil Layer Data: MCWRA well logs
Aerial photo and City Boundary: City of Salinas May 2002

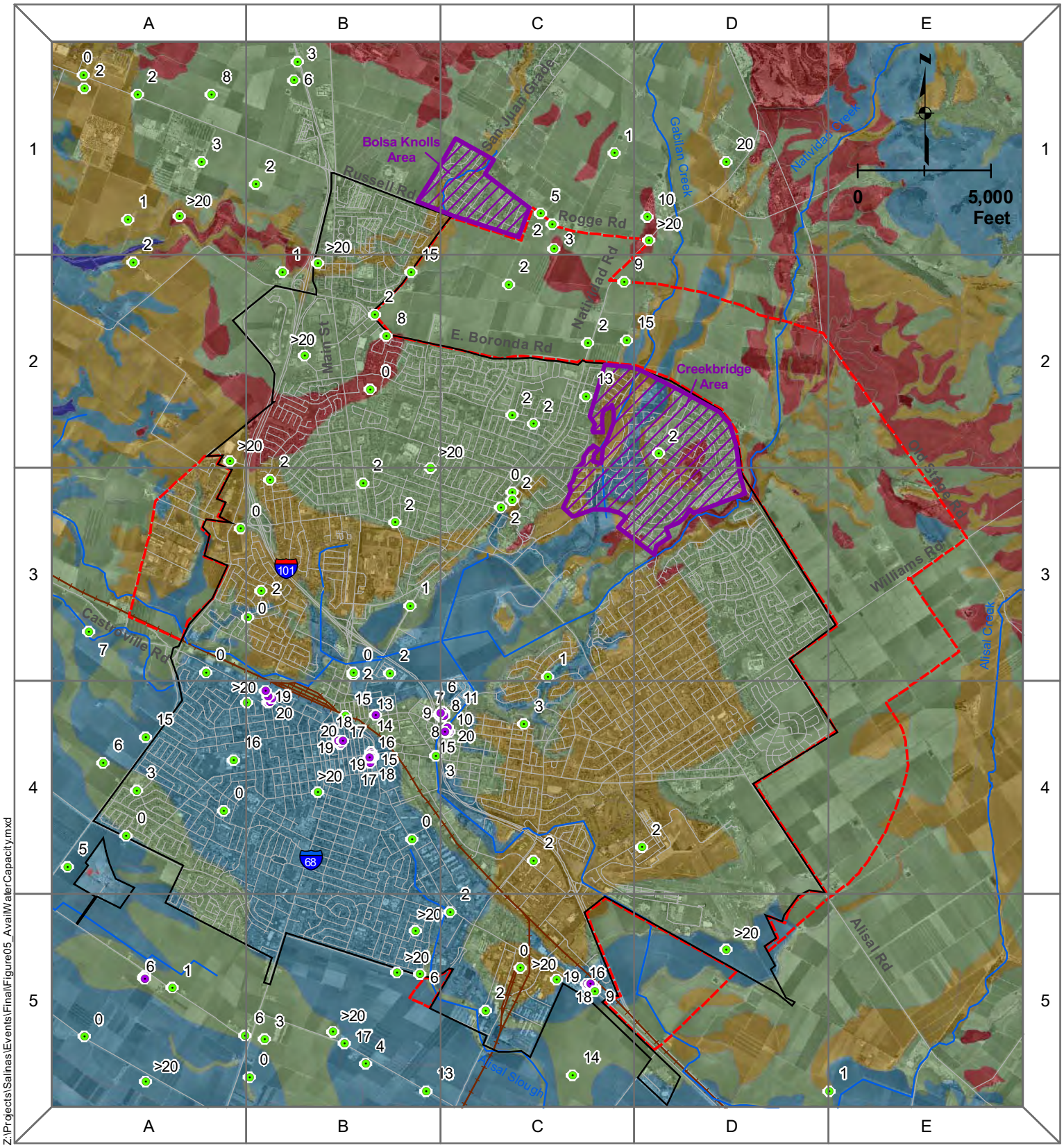
Kennedy/Jenks Consultants

City of Salinas, CA
Depth to Restrictive Soil Layer

K/J 06950006
July 2007

Figure 4-4

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Soil Water Capacity Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Available Water Holding Capacity (cm of water/cm of soil)

- 0 - 0.05
- 0.06 - 0.1
- 0.11 - 0.15
- 0.16 - 0.2
- >0.2
- Soil Type Series/Grouping

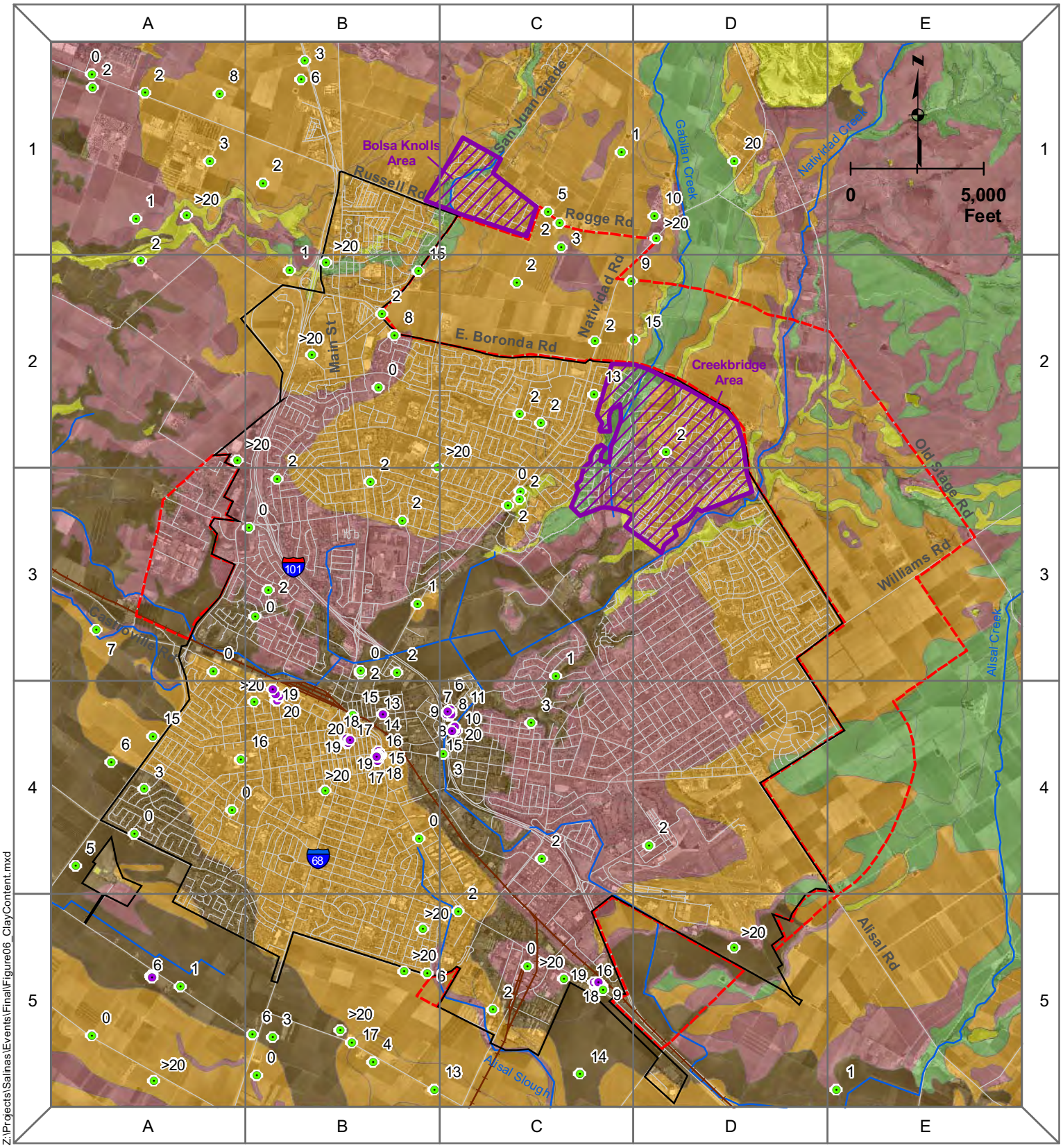
Kennedy/Jenks Consultants

City of Salinas, CA
Available Soil Water Holding Capacity (AWC)

K/J 06950006
July 2007

Figure 4-5

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.



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Legend

Boundaries/Features

- City of Salinas Boundary
- Future Growth Area
- Road
- Highway
- Railroad
- Waterway

Shallow Groundwater Data

- 16 LUFT Monitoring Well and Probable Depth to Water (ft below ground surface)
- Areas of reported shallow groundwater (MCHD)

Shallow Clay Layers

- 2 Reported Depth to Clay (ft below ground surface)

Soil Clay Content (%)

- 0 - 5
- 5 - 15
- 15 - 25
- 25 - 35
- >35
- Soil Type Series/Grouping

Data Sources

Probable Depth to Groundwater: Geotracker website
Reported Depth to Clay: Monterey County Water Resources Agency well logs
Soil Clay Content Data: NCSS-NRCS web soil survey
Aerial photo and City Boundary: City of Salinas May 2002

Kennedy/Jenks Consultants

City of Salinas, CA
Soil Clay Content

K/J 06950006
July 2007

Figure 4-6

NOTE: THE DATA PRESENTED ON THIS MAP ARE INTENDED FOR PLANNING PURPOSES ONLY. SITE SPECIFIC DATA SHOULD BE COLLECTED PRIOR TO DESIGN.

Figure 4-1: Soil Drainage Classifications

As defined by the NRCS, soil drainage class qualitatively refers to the frequency and duration of saturation periods and the removal of excess water from the soil. Drainage class does not generally incorporate changes to soil drainage from human activities such as grading and compaction, import of non native soils, and/or changes in natural drainage patterns from agricultural practices or urban development (e.g. crop irrigation and flood control). Seven qualitative soil drainage classes are recognized; excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. The majority of the Future Growth Area is mapped as having well drained soils, which implies that soil water will be present in the soil during most of the agricultural growing season, but will not pond at the surface for extended periods of time.

Figure 4-2: Runoff and Infiltration Potential

The NRCS has categorized all soils in the United States into four general Hydrologic Soil Groups (HSG - A, B, C, and D) according to their field-described infiltration, runoff, drainage, and soil texture characteristics. Soils are assigned to one of the four groups based on estimated infiltration and runoff rates for bare, saturated surface soils. Runoff potential qualitatively describes the amount of flow that occurs from precipitation that does not infiltrate the soil surface. It is generally estimated using soil texture information collected at the site. These Hydrologic Soil Groups do not account for anthropogenic alterations to the soil regime, and therefore, site-specific information should be used to make storm water management decisions. The HSG categories mapped for the Salinas area by the NRCS are generally in agreement with other soils information obtained from area well logs maintained by the MCWRA. However, City planners should not use these groupings as the only source of information since they are interpretations from soil mapping information collected in approximately 1978. In addition, the NRCS soil descriptions may only apply to the first two (2) feet of soil depth. Therefore, infiltration systems installed below this depth may encounter restrictive soil layers.

Figure 4-2 presents the soils mapped in the Salinas area by NRCS according to the general Hydrologic Soil Groups. The four groups are described below:

<u>Group A</u>: Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission and are typically classified as sands or gravels, loamy sands, or sandy loams.

<u>Group B</u>: Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission and are typically classified as silty loams and loams.

<u>Group C</u>: Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission and are typically classified as sandy clay loams.

Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission and are typically classified as clay loams, silty clay loams, silty clays or clays.

The majority of the City's Future Growth Area is mapped as having HSG-B soils with moderate runoff and infiltration potentials. Although these groups do not appear to include information accounting for the soil percolation, which describes the transport of soil water based on the most restrictive shallow soil layer, they can be used as a qualitative grouping of certain soil hydrologic properties.

Figure 4-3: Saturated Hydraulic Conductivity

Saturated hydraulic conductivity (K_{SAT}) refers to the soil's ability to transmit water in a saturated state, and is estimated by the NRCS using qualitative field observations of structure, porosity, and soil texture. The K_{SAT} parameter is important because it describes the entry of water into soil, the movement of water to plant roots, the flow of water to drains and wells, and the soils ability to evaporate water. Numeric K_{SAT} values, expressed in terms of micrometers per second (µm/s), have been grouped into the following classes:

Very low (0.00 - 0.01 µm/s)

Low (0.01 - 0.1 µm/s)

Moderately low (0.1 - 1.0 µm/s)

Moderately high (1 – 10 µm/s)

High (10 – 100 µm/s)

Very high (100 – 705 µm/s)

As an example, soils with very low K_{SAT} values transmit water at saturation to a lesser extent than those with very high K_{SAT} values, and therefore, this parameter is an important component to developing a comprehensive storm water management plan for the City. The majority of the Future Growth Area is mapped as having soils with high K_{SAT} values, which implies that this area may provide good storm water infiltration potential. However, the high K_{SAT} values may only be applicable for the first 1 to 2 feet of soil that is then underlain by clayey soils with relatively low K_{SAT} values. K_{SAT} information is typically not provided on soil borings or well logs. However, this information can be available if laboratory geotechnical testing was conducted on the associated soil samples.

Figure 4-4: Depth to Restrictive Soil Layer

According to the NRCS, a 'restrictive layer' is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restricts roots or otherwise provides an unfavorable

root environment. Examples are bedrock, cemented layers, and significant increases in clayey soil textures between surface and subsurface layers.

Soil information from both the MCWRA and NRCS data sources indicates that numerous significant clay layers occur in the Salinas area. In some areas, significant clay layers occur at the surface while in other areas they are present at depths of approximately 2 to 5 feet bgs. In addition, both information sources indicate that some locations of the City have soils with clayey textures throughout the profile. The MCWRA well locations and associated depth to shallow clayey layers, and the shallow groundwater data from Leaking Underground Storage Tank (LUFT) monitoring wells (discussed below) were superimposed on NRCS soils information for each figure to provide additional information for comparison.

The description of the shallow clay layers noted on the MCWRA well logs include Adobe, Yellow, Brown and Blue Clay, Sandy Clay and Gravelly Clay. The thickness of the significant clay layers in the well logs varied from 1 foot to more than 20 feet thick with an average minimum thickness of 3 feet.

There are approximately twelve wells located in the northern portion of the City's Future Growth Area in the MCWRA database. Information from the driller's logs for these wells indicates that significant shallow clay layers may occur at depths shallow enough to present a barrier to storm water infiltration. The moderate infiltration/percolation rates noted by the NRCS for much of the City's Future Growth Area values may only be applicable for the first 1 to 2 feet of soil that is then underlain by clayey soils with relatively slow infiltration/percolation rates.

Figure 4-5: Available Soil Water Holding Capacity

Available Water Holding Capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. AWC is qualitatively determined by the NRCS based on organic matter content, soil texture, bulk density, and soil structure. Per the NRCS, it is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Therefore Figure 4-5 may be useful to landscape architects in the selection of plant species.

AWC is controlled primarily by soil texture (the size and variation of soil particles) and the percentage of organic matter and gives an indication about the amount of water stored in soils that is available for plant uptake. A soil with a high percentage of silt and clay would have relatively high AWC, whereas a soil with only clay or only sand would have a relatively low AWC.

The majority of the City's Future Growth Area is mapped as having soils with moderate AWC values (0.11 to 0.15 cm of water/cm of soil or 11 to 15%). These AWC values are typical of soils consisting of mixes of sands, silts, and clay, which is consistent with the NRCS soil survey descriptions for this area. AWC values in this range may translate to between 7 and 9 inches of water (respectively) being held within the first 5 feet of soil (bgs). It may indicate that a significant percentage of this is being held at the boundaries between surface sandy soils and subsurface clayey soils. As noted above, understanding the AWC values in the soils located in the Future Growth Area may be

useful in the selection of appropriate plants and determining planning level landscape irrigation requirements for the new urban development planned for this area.

Figure 4-6: Soil Clay Content

Clay-sized particles, which are of inorganic soil particles with diameters less than 0.002 millimeters, influence the fertility and physical condition of the soil, the ability of the soil to adsorb cations, as well as its ability to retain moisture. In addition, soils containing different types of clay minerals also influence physical and chemical characteristics such as shrink-swell potential, plasticity, and soil dispersion. For the City's future development plans, the amount and type of soil clay content may affect the ease of tillage and earthmoving operations during construction, and may also influence storm water management planning by affecting the soil's ability to adsorb storm water pollutants. As a screening tool, Figure 4-6 shows the estimated surface soil layer clay content given as percent clay.

According to the NRCS, the majority of the City's Future Growth Area is mapped as having soils with approximately 15 – 25% clay, which indicates the soils with moderate textures such as loams, sandy loams, and clay loams. Having an understanding of soil textures, as well as the other soil physicochemical properties described above, may direct City planners to particular storm water management techniques. As noted above, soil clay content may also be useful in estimating the pollutant removal capacity of storm water infiltration systems.

4.2 Infiltration of Urban Storm Water

If site conditions allow, infiltration can be the most effective method to reduce the volume, rate, and pollutant loading of urban runoff. As a storm water management method, the term infiltration refers to practices that retain or detain urban runoff within existing or imported permeable materials (clean gravel and/or engineered soils – a mix of topsoil, sand and compost or peat). Pollutants within urban runoff are typically removed within storm water infiltration practices by a variety of physical, chemical and biological processes. Depending on the amount of runoff, the design of the storm water infiltration practice, and the permeability of the existing site soils, a portion of the treated runoff may recharge groundwater. Site planning and grading can minimize runoff and promote infiltration at almost any site.

LID practices such as filter strips, swales, bioretention systems (e.g. storm water planters, landscape detention, rain gardens, etc.), and porous paving systems can be used on sites with clayey soils, provided imported permeable soils, drain rock and underdrains are included in the design. Sites with more permeable existing soils may be able to install these devices without underdrains and realize a significant cost savings by reducing or eliminating the need to install expensive conventional underground storm drain infrastructure (e.g. reinforced concrete drop inlets and storm drain pipe). Direct storm water infiltration methods such as infiltration trenches and basins can also be used on sites with permeable existing site soils, provided the potential threat to groundwater quality is assessed and found to be very low. It should be noted that the potential threat to groundwater quality from direct infiltration of urban storm water typically can not be eliminated. Therefore the use of these systems should be limited and only considered where other storm water management practices (e.g. bioretention systems) can not be applied.

A variety of factors may limit or prevent the use of certain urban storm water infiltration methods. In addition to existing site soil infiltration/percolation properties, the factors that should be considered when assessing the feasibility of a particular site for storm water infiltration include: site slopes; depth to groundwater; expansive clays; land uses and practices within the drainage area; the proximity to water resources such as streams, wetlands and wells; proximity to structures and underground utilities; and proximity to septic systems, underground storage tanks, and areas of known soil and/or groundwater contamination. These factors should be evaluated during the design of storm water treatment devices and LID practices to prevent slope failures and settlement, storm water in foundations, basements and crawl spaces, groundwater contamination, and mosquito breeding.

Site Topography: Flatter sites typically provide the most feasible areas for storm water infiltration. Storm water routed to slopes may run off rather than soak into the ground. In addition, storm water infiltrated on hillsides may resurface a short distance down slope and may also cause geotechnical instability. For this reason direct storm water infiltration systems such as infiltration basins and trenches should never be placed on slopes greater than 15 percent. In addition, indirect storm water infiltration systems such as bioretention systems may need to incorporate impermeable liners and underdrain systems if sited near or on slopes.

Vegetated or grassy swales should have minimum and maximum longitudinal slopes and side slopes to slow runoff and maximize infiltration/percolation and storm water treatment potential. Per the design guidance provided in Section 3.2.0, vegetated or grassy swales should have minimum longitudinal slopes of 0.5 percent and maximum longitudinal slopes of 2.5 percent and adjacent side slopes should be a maximum of 5.0 percent.

Geotechnical Considerations: Infiltration of storm water can increase water pressure in soil pores, reducing soil strength and making slopes more susceptible to failure. It can also make foundations more susceptible to settlement. With the exception of bioretention systems designed with impermeable waterproof membranes and underdrains (or enclosed in a concrete box with an underdrain connected to the conventional storm drain system), storm water infiltration systems should be set back from slopes and foundations.

Depth to Groundwater: To protect groundwater quality, direct storm water infiltration methods such as infiltration trenches and basins should be designed with a minimum separation between the base of the imported permeable materials and the seasonally high groundwater level. The minimum separation noted in this manual for direct storm water infiltration is 10 feet. Indirect storm water infiltration methods, such as bioretention basins that filter urban runoff through amended surface soils and vegetation are allowed to have less separation (5 feet) between the base of the device and the seasonally high groundwater level because these devices provide a greater level of treatment and groundwater protection. The infiltration of storm water near the ground surface helps increase the separation to groundwater, providing a greater filtration layer and decreasing the risk of groundwater contamination.

Potential Groundwater Contamination: Direct storm water infiltration methods such as infiltration trenches and basins should not be used where there is a reasonably high potential for materials or liquids to spill and be transported in runoff. These devices should not be used at industrial or light industrial areas, near gas stations, automotive repair shops, car washes, fleet storage areas, nurseries, or other areas that provide outdoor storage, use or disposal of chemicals and materials. Direct storm water infiltration should also not occur adjacent to

roadways subject to high vehicular traffic. Indirect storm water infiltration methods, such as bioretention basins can potentially be used within the drainage area of the industrial and commercial land uses and roadways noted above if a pretreatment device such as an oil and water separator is included in the design to capture spills and/or the bioretention system includes an impermeable liner the prevents infiltration/percolation to underlying soils and an underdrain system that connects to the conventional storm drain system (to ensure proper drainage).

Areas with Existing Groundwater Pollution: Storm water infiltration should be avoided near areas of known groundwater contamination, such as the Leaking Underground Fuel Tank (LUFT) sites listed by the Regional Board. Infiltration of storm water near these sites can contribute to the movement and dispersion of pollutants in groundwater. Direct storm water infiltration methods such as infiltration trenches and basins should not be sited within 500 feet of underground storage tanks (USTs) that contain fuels or other hazardous materials. Indirect storm water infiltration methods such as swales and bioretention basins should also not be sited within 500 feet of these areas, unless they include an impermeable liner and an underdrain system that connects to the conventional storm drain system.

Underground Storage Tank (UST) Sites: A large percentage of UST sites are found to leak. The Central Coast RWQCB indicates that 60 - 65% of new (1998 or newer) UST sites are found to leak, even USTs with double-containment, improved installation techniques, and leak detection systems. Per the Central Coast RWQCB, the setback may be potentially reduced to 250 feet if the UST is located down gradient of the proposed storm water infiltration device, the infiltration flow patterns would not influence a pollution plume, and no utility conduits or trenches are located in the vicinity which could influence the pathway of UST contaminants or infiltration water.

Wells and Septic Systems: Wells (domestic and irrigation water supply and monitoring wells) can capture infiltrated storm water and become contaminated when infiltration trenches and basins are sited near the wellhead. In addition, direct storm water infiltration methods sited near septic system leach fields can promote the migration of nitrates and pathogens to groundwater. Therefore, direct storm water infiltration methods should be placed a minimum distance from wells and leach fields. The design guidance provided in a number of the storm water management manuals developed for the western states indicates the minimum distance from wells and leach fields should be 100 to 150 feet. They also note that direct storm water infiltration methods should not be sited within wellhead protection zones. Indirect storm water infiltration methods such as swales and bioretention basins are also not typically allowed to be located near wells and septic systems, unless they include an impermeable liner and an underdrain system that connects to the conventional storm drain system.

Mosquito Breeding and Vector Control: Direct and indirect storm water infiltration systems should be designed and maintained to ensure long-term performance and to prevent standing water for extended periods of time that allows mosquitoes and other vectors to breed. The design guidance provided in a number of the storm water management manuals developed for the western states varies and indicates direct and indirect storm water infiltration systems should not hold standing water for more than 48 hours in some areas and up to 7 days in other areas. The local Vector Control District typically sets this standard. For example, the Contra Costa Mosquito & Vector Control District (CCMVCD) requires that storm water infiltration systems should not hold standing water for more than 72 hours during the primary mosquito

breeding season (June through October). The CCMVCD notes that the mosquito production periods typically extend to 2 weeks during the months of December, January and February and storm water infiltration devices that hold standing water fewer than 5 days during these months rarely cause problems. A number of other design and maintenance considerations are also typically applied for vector control. They include measures to avoid the entry of fine sediment that may clog storm water infiltration systems and avoiding the use of loose riprap or concrete depressions that may retain standing water.

4.2.0 Setbacks for Storm Water Infiltration BMPs

Storm water infiltration BMPs include practices designed to directly and indirectly infiltrate urban runoff through surface soils to groundwater to prevent pollutants from entering surface waters. Direct infiltration practices include infiltration basins and trenches. Indirect infiltration practices include vegetated swales, bioretention systems and porous pavements. Anytime urban runoff is allowed to infiltrate to the subsurface, there is some potential for pollutant transport and groundwater contamination. In addition, if not designed correctly and maintained appropriately, storm water infiltration systems can hold standing water for extended periods of time, potentially creating mosquito breeding habitats. Therefore, to protect groundwater quality and assist with vector control in the Salinas area, Table 4-3 presents the allowable infiltration rates, limits on standing water, and separation and setback standards for storm water infiltration BMPs in the Salinas area. Table 4-3 also notes some of the similar standards that Monterey County has adopted for septic systems for comparison. This information is provided because design standards for storm water infiltration system should be similar to what is required for the permitting septic system leach fields. Although there is currently little available documentation about groundwater impacts from infiltration of storm water, there are a significant number of documented cases of nitrate contamination of aquifers by septic systems.

Table 4-3: Storm Water Infiltration System Policies and Procedures for the City of Salinas

Recommended Design Standards	Direct Infiltration Practices[1]	Indirect Infiltration Practices[2]	Agencies with Similar Design Standards	Monterey County Septic System Requirements[3]
Allowable Infiltration Rates[4]	min 1.0 in/hr (60 min/in) max 3.0 in/hr (20 min/in)	min 0.5 in/hr (120 min/in)[5] max 3.0 in/hr (20 min/in)	CASQA, CCCWP, CWP, TMSWMP	min 1.0 in/hr (60 min/in) max 12.0 in/hr (5 min/in)
Standing Water[6]	< 72 hrs	< 72 hrs	CASQA, CCCWP	NA
Groundwater Separation	≥ 10 ft	≥ 5 ft	Boise, CASQA, CCCWP, CWP, UDFCD, WDOE	≥ 10 ft
Bedrock Separation	≥ 10 ft	≥ 5 ft	Boise, CASQA, CCCWP, CWP, UDFCD, WDOE	≥ 10 ft
Water Well Setback	≥ 150 ft	≥ 100 ft[7]	Boise, CASQA, CCCWP, CWP, TMSWMP, WDOE	≥ 250 ft
Surface Water Setback	≥ 100 ft	≥ 50 ft[7]	Boise, CCCWP, TMSWMP	≥ 100 ft
Septic System Setback[8]	≥ 150 ft	≥ 100 ft[7]	CCCWP	NA
Groundwater Contamination Setback[9]	≥ 500 ft	≥ 500 ft[7]	CCCWP	Distance not specified[10]
Underground Fuel Tank Setback[11]	≥ 500 ft	≥ 500 ft[7]	CCCWP	Not specified
Building and Bridge Foundation Setback	≥ 100 ft up slope and ≥ 20 ft down slope	≥ 100 ft up slope and ≥ 20 ft down slope [7]	CASQA, IDEQ, TMSWMP, WDOE	≥ 10 ft
High Use Roadway Setback[12]	Prohibited	≥ 20 ft	CCCWP	NA
Basement and Crawl Space Setback	≥ 100 ft up slope and ≥ 20 ft down slope	≥ 100 ft up slope and ≥ 20 ft down slope[7]	IDEQ, TMSWMP, WDOE	≥ 10 ft
Property Line Setback[13]	≥ 5 ft	≥ 5 ft	PBES	≥ 10 ft
Slope Setback[14]	100 ft from the top of slopes >15%	50 ft from the top of slopes >15%	WDOE	Prohibited where slopes exceed 30%[15]

Abbreviations and Acronyms:

Boise – City of Boise, ID

CASQA – California Stormwater Quality Association

CCCWP – Contra Costa Clean Water Program, CA

CWP – Center for Watershed Protection

IDEQ – Idaho Department of Environmental Quality

PBES – Portland Bureau of Environmental Services, OR

TMSWMP – Truckee Meadows Storm Water Management Program (Reno, Sparks, Washoe Co, NV)

UDFCD – Urban Drainage and Flood Control District, Denver, CO

WDOE – Washington State Department of Ecology

Table 4-3 Notes

1. Direct infiltration practices include infiltration trenches, infiltration basins, and any structure designed to infiltrate storm water into the subsurface, and by design, bypasses the natural groundwater protection afforded by surface or near surface soils.
2. Indirect infiltration practices include swales, bioretention systems, and porous pavements. Vegetated swales and bioretention systems (e.g. rain gardens) typically maintain soil permeability with plant root systems. Porous pavements typically require periodic maintenance to maintain permeability. Vegetated swales and bioretention systems may require supplemental irrigation during extended dry periods. Storm water ponds and wetlands can be considered indirect infiltration practices if designed to infiltrate storm water into underlying soils. However many storm water ponds and wetlands are installed in low permeability soils, therefore infiltration testing requirements generally don't apply.
3. Monterey County Code 15.20.060 Septic tank system/gray water system permits and 15.20.070 Standards and Specifications.
4. If testing results indicate native soil infiltration rates are less than the minimum value, direct infiltration practices are not allowed and indirect infiltration systems are required to install underdrains or subdrains. If testing results indicate native soil infiltration rates are more than the maximum value, additional pretreatment and evaluation of potential impacts to groundwater should be conducted.
5. A lower minimum design infiltration rate is allowed for indirect infiltration practices such as swales, bioretention systems, storm water ponds and wetlands (if designed to infiltrate into underlying soils) because the roots of the vegetation incorporated into these practices generally maintain the permeability of native and imported soils. Whereas direct infiltration practices can clog if the storm water is not to remove fine sediment. Porous paving systems should consider underdrain systems when native soil infiltration rates are less than 1.0 in/hr (60 min/in).
6. Additional design standards and maintenance requirements apply for mosquito and vector control (see Monterey County Code for Mosquito Abatement and Vector Control).
7. Indirect infiltration practices may be placed within the setback limits or directly adjacent to the structures noted above, provided an impermeable surface and an underdrain system prevents infiltration to the underlying soils within the setback limits.
8. Setback applies to septic system leach fields.
9. Setback applies to areas of known groundwater contamination.

10. Monterey County Code 15.20.060 Section I: No septic tank/gray water system permit shall be issued in any area where continued use of on-site systems, constitutes a pubic health hazard, or where there is an existing or threatened condition of water pollution, contamination or nuisance.
11. Setback applies to known underground fuel tank sites.
12. Main roadways with 25,000 or greater average daily traffic (ADT) and 15,000 or greater ADT on any intersecting or minor roadways.
13. Variances may apply for infiltration systems located in the City right of way (ROW) or systems designed to treat more than one property.
14. A qualified geotechnical and/or structural engineer should determine site specific requirements whenever site slopes exceed 7 percent.
15. Monterey County Code 15.20.070: New septic tank systems are prohibited in areas where the natural ground slope exceeds thirty (30) percent unless a variance is granted by the RWQCB.

4.2.1 Site Screening and Infiltration Testing Requirements

If a storm water infiltration practice[15] is proposed as part of a development strategy to reduce the rate, volume and pollutant loading of urban runoff[16], the following site screening and testing procedures are recommended:

a) A boring or test pit should be installed at the location of the proposed storm water infiltration practice. The boring should be advanced to a minimum depth of 15 ft or to refusal. The boring or test pit should be used to identify seasonally high groundwater (e.g. staining) and potential shallow restrictive soil layers (e.g. bedrock or clayey soils).

b) If seasonally high groundwater or bedrock occurs more than 10 ft below the depth of the bottom of the proposed direct storm water infiltration practice (e.g. an infiltration basin or trench), proceed to step d). Direct storm water infiltration should not be allowed if seasonally high groundwater or bedrock occurs less than 10 ft below the depth of the bottom of a proposed direct storm water infiltration practice.

c) If seasonally high groundwater or bedrock occurs more than 5 ft below the depth of the bottom of a proposed indirect storm water infiltration practice (e.g. a swale, a bioretention system, or a porous pavement), proceed to step d). Indirect storm water infiltration should not be allowed if seasonally high groundwater or bedrock occurs less than 5 ft below the depth of the bottom of a proposed indirect storm water infiltration practice.

d) If the site meets the minimum criteria for separation from seasonally high groundwater and bedrock noted above (e.g. ≥ 5 ft for indirect infiltration BMPs and ≥ 10 ft for direct infiltration BMPs) infiltration/percolation testing should be conducted at the location of the proposed storm water infiltration practice. The test should be conducted at the depth of the bottom of the proposed storm water infiltration practice (e.g. at the interface between the bottom of the drain rock layer and the excavated site soils, where percolation into existing site soils will occur).

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[15] Storm water infiltration practices include direct infiltration systems such as infiltration basins and trenches and indirect infiltration practices such as swales, bioretention systems, and porous pavements.

[16] Per Regional Board Order No. R3-2004-0135, Priority Projects in the City of Salinas are required to reduce the rate, volume and pollutant loading of urban runoff to the Maximum Extent Practicable (MEP).

e) The minimum infiltration/percolation testing method acceptable for use in the City of Salinas is the method currently specified by the Monterey County Health Department (MCHD) for the permitting of septic system leach fields in the Salinas area. The infiltration/percolation test should be conducted in accordance with the MCHD procedures, using the appropriate data collection forms. The data forms and testing results should be supplied to the City of Salinas Development & Engineering Services Department for review and approval. Equivalent testing procedures may be allowed by the City upon the approval of the City Engineer.

f) The acceptable range of infiltration/percolation rates for storm water infiltration practices is 0.5 in/hr to 3.0 in/hr (120 min/in to 20 min/in).

- If testing results indicate infiltration/percolation rates are less than 0.5 in/hr (120 min/inch), an underdrain system should be incorporated into the design to prevent standing water for extended periods of time that may allow mosquitoes and other vectors to breed. Infiltration/percolation rates less than 0.5 in/hr typically indicate existing site soils are poorly drained clayey or silty soils that are prone to extended ponding.
- If testing results indicate infiltration/percolation rates are greater than 3.0 in/hr (20 min/inch), storm water should be fully pretreated prior to infiltration to prevent potential groundwater contamination. Addition of soil amendments to slow infiltration and allow adequate treatment and processing of storm water may also be considered. Infiltration/percolation rates greater than 3.0 in/hr typically indicate existing site soils are sandy soils with little to no silt and/or clay. Infiltration of storm water into soils with relatively high infiltration rates (≥ 5 in/hr), without proper pretreatment and/or the addition of soil amendments to slow infiltration can result in groundwater contamination.

g) Seasonally high groundwater levels, soil infiltration rates should, depth to bedrock and depth and thickness of shallow restrictive layers should be evaluated, verified and certified by a CA Registered P.E., Geotechnical Engineer, Geologist, Hydrogeologist, or other qualified professional as approved by the City Engineer.

h) A faster maximum design infiltration rate up to 12.0 in/hr (5 min/in) may be allowed for some storm water infiltration practices provided conditions exist such as the drainage area for the device has a low pollutant loading and spill potential and there is a low potential for groundwater contamination. Storm water infiltration into underlying soils with infiltration rates between 3.0 and 12.0 in/hr should be approved by the City Engineer. Storm water infiltration is not allowed into site soils that with infiltration rates greater than 12.0 in/hr.

i) Site conditions which might allow a slower or faster maximum design infiltration rate or a reduction in the separation to seasonally high groundwater or bedrock should be evaluated, verified and certified by a CA Registered P.E., Geotechnical Engineer, Geologist, Hydrogeologist, or other qualified professional and approved by the City Engineer.

Refer to Sections 3.3 and 3.4 of the Salinas DSP for additional information on swales, bioretention systems, and porous pavements. The BMP fact sheets in these sections provide numerous BMP design variations; the advantages and limitations of each BMP; siting, design

and construction criteria; inspection and maintenance requirements; and examples from other communities.

4.3 BMP Design and Selection Guidance

The following sections provide summarized information to assist planners and designers with the selection of appropriate LID practices and structural treatment control BMPs for proposed project sites. The BMP Design and Selection Matrices in the following section summarize a number of factors that should be considered when selecting LID practices and structural treatment control BMPs, including:

- Land Use
- Site Physcial Features
- Storm Water Management Capability
- Community and Environmental Factors
- Pollutant Removal Effectiveness

The next section provides presents a comparison of the Priority Project Categories that are required to implement BMPs to reduce the rate, volume and pollutant loading of urban runoff to pre-development conditions, and the potential applicability of the LID Practices presented in this document (Table 4-4). The Salinas NPDES Permit definitions of the Priority Project Categories are provided the notes of Table 4-4. Following this is a discussion on LID practices for high density urban developments.

4.3.0 BMP Design and Selection Matrices

Treatment Control Group	Treatment Control Design	Design Matrix 1. Land Use					
		Rural	Residential	Roads and Highways	Commercial/ High Density	Hotspots	Ultra Urban
Vegetative Treatment Systems	Vegetated Swales	S	S	S	S	S	S
	Vegetated Filter Strips	A	A	S	S	S	S
Infiltration Systems	Infiltration Trenches	A	A	A	A	X	S
	Infiltration Basins	A	A	A	A	X	S
Bioretention Systems	Landscape Detention, Tree Box Filters & Storm Water Planters	A	A	A	A	S	A
Extended Detention Basins	Sedimentation Basins	A	A	S	A	S	S
	Sand Filter Basins	A	A	S	A	S	A
Ponds and Constructed Wetlands	Storm Water Ponds	A	A	A	S	A	X
	Storm Water Wetlands	A	A	S	S	A	X
Media Filtration Systems	Surface Sand Filter	X	S	A	A	A	A
	Underground Sand Filter	X	S	S	A	A	A
	Porous Pavement	S	S	S	A	X	S

A = Applies under most conditions
S = Applies under some conditions
X = Not applicable

Treatment Control Group	Treatment Control Design	Design Matrix 2. Site Physical Features				
		Soils	Seasonal High Water Table	Drainage Area (AC)	Site Slope	Head (ft)
Vegetative Treatment Systems	Vegetated Swales	Native or engineered soils	>5 feet	10 max	No more than 5%	3 to 5 ft
	Vegetated Filter Strips			5 max	No more than 10%	NA
Infiltration Systems	Infiltration Trenches	Min infiltration rate 0.5 inch/hr	>10 feet	10 max	Generally no more than 20%	~ 1 ft
	Infiltration Basins			5 to 50	Generally no more than 15%	3 to 5 ft
Bioretention Systems	Landscape Detention, Tree Box Filters & Storm Water Planters	Imported soil	>5 feet	1 max	Generally no more than 20%	~ 5 ft
Extended Detention Basins	Sedimentation Basins	Native or engineered soils	>5 feet	5 min	Generally no more than 20%	~4 ft
	Sand Filter Basins			10 max	Generally no more than 20%	~4 ft
Ponds and Constructed Wetlands	Storm Water Ponds	HSG A soils may require liner	NA	25 min	Generally no more than 15%	6 to 8 ft
	Storm Water Wetlands				Generally no more than 8%	3 to 5 ft
Media Filtration Systems	Surface Sand Filter	Native or engineered soils	>5 feet	5 max	Generally no more than 6%	~ 5 ft
	Underground Sand Filter			1.5 max		5 to 7 ft
	Porous Pavement			No Limit	Generally no more than 5%	NA

Treatment Control Group	Treatment Control Design	Design Matrix 3. Storm Water Management Capability			
		Water Quality	Recharge	Channel Protection	Flood Control
Vegetative Treatment Systems	Vegetated Swales	A	S	S	S
	Vegetated Filter Strips	A	S	A	X
Infiltration Systems	Infiltration Trenches	A	A	S	S
	Infiltration Basins	A	A	S	S
Bioretention Systems	Landscape Detention, Tree Box Filters & Storm Water Planters	A	S	S	S
Extended Detention Basins	Sedimentation Basins	A	S	S	A
	Sand Filter Basins	A	S	S	A
Ponds and Constructed Wetlands	Storm Water Ponds	A	S	S	A
	Storm Water Wetlands	A	S	S	A
Media Filtration Systems	Surface Sand Filter	A	X	S	S
	Underground Sand Filter	A	X	S	S
	Porous Pavement	A	S	S	S

A = Practice generally meets storm water management goals
S = Practice can provide some benefit depending on site constraints
X = Practice can rarely be used to meet this goal

Treatment Control Group	Treatment Control Design	Design Matrix 4. Community and Environmental Factors				
		Ease of Maintenance	Affordability	Community Acceptance	Safety	Habitat
Vegetative Treatment Systems	Vegetated Swales	M	H	H	H	L
	Vegetated Filter Strips	M	H	H	H	L
Infiltration Systems	Infiltration Trenches	M	M	M	H	L
	Infiltration Basins	M	M	M	H	L
Bioretention Systems	Landscape Detention, Tree Box Filters & Storm Water Planters	M	M	H	H	M
Extended Detention Basins	Sedimentation Basins	M	M	H	M	L
	Sand Filter Basins	M	M	H	H	L
Ponds and Constructed Wetlands	Storm Water Ponds	M	M	M	M	H
	Storm Water Wetlands	M	M	M	M	H
Media Filtration Systems	Surface Sand Filter	M	L	M	M	L
	Underground Sand Filter	M	L	H	H	L
	Porous Pavement	M	M	H	H	L

H = High benefit and/or low limitations
M = Medium benefit and/or limitations
L = Low Benefit and/or high limitations

Treatment Control Group	Treatment Control Design	Design Matrix 5. Pollutant Removal Effectiveness						
		Sediment	Nutrients	Trash	Metals	Bacteria	Oil and Grease	Organics
Vegetative Treatment Systems	Vegetated Swales	M	L	L	M	L	M	M
	Vegetated Filter Strips	H	L	M	H	L	H	M
Infiltration Systems	Infiltration Trenches	H	H	H	H	H	H	H
	Infiltration Basins	H	H	H	H	H	H	H
Bioretention Systems	Landscape Detention, Tree Box Filters & Storm Water Planters	H	M	H	H	H	H	H
Extended Detention Basins	Sedimentation Basins	M	L	H	M	L	L	L
	Sand Filter Basins	H	M	H	M	L	L	M
Ponds and Constructed Wetlands	Storm Water Ponds	H	M	H	H	H	H	H
	Storm Water Wetlands	H	M	H	H	H	H	H
Media Filtration Systems	Surface Sand Filter	H	M	H	H	M	M-H	M-H
	Underground Sand Filter	H	L	H	H	M	M-H	M-H
	Porous Pavement	H	M	L	M	M	M-H	M-H

H = High pollutant removal effectiveness
M = Medium pollutant removal effectiveness
L = Low pollutant removal effectiveness

4.3.1 LID Practices for Priority Project Categories

Table 4-4: Priority Project Categories and Potentially Applicable LID Designs and Practices

	LID Designs and Practices							
Priority Project Categories	LID Planning Techniques	Minimizng and Disconnecting Impervious Surfaces	Swales and Filter Strips	Bioretention Systems	Porous Paving Systems	Rainwater Catchment Systems	Green Roofs	Storm Water Ponds and Wetlands
Residential developments[1]	A	A	A	A	A	A	S	A
Commercial developments[2]	A	A	A	A	A	A	A	A
Automotive repair shops[3]	A	A	S	S	S	S	S	S
Restaurants[4]	A	A	S	A	A	S	S	S
Hillside developments[5]	A	A	S	S	S	S	S	X
Parking lots[6]	A	A	S	A	A	X	X	S
Streets, roads, highways, and freeways[7]	A	A	A	A	A	X	X	S
Retail gasoline outlets[8]	A	A	S	X	X	S	X	X

Notes:

A = applies under most conditions, S = applies under some conditions, X = typically does not apply

1 - Home subdivisions with ten housing units or more. This category includes single-family homes, multi-family homes, condominiums, and apartments.

2 - Commercial developments are defined as any development on private land that is not for heavy industrial or residential uses where the impervious land area for development is 100,000 square-feet or more. The category includes, but is not limited to, hospitals, laboratories, medical facilities, educational institutions, recreational facilities, commercial nurseries, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses, and other light industrial facilities.

3 - Automotive repair shops are defined as a facility that is categorized by one of the following SIC codes: 5013, 5014, 5541, 7532-7534, or 7536-7539, where the total impervious area for development is 5,000 square feet or more.

4 - Restaurants are defined as facilities that 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) and have 5,000 or more feet of impervious area.

5 -Hillside developments are defined as any development that creates 5,000 square feet of impervious surface in an area with known erosive soil located in an area with natural slopes having a twenty-five percent or greater grade.

6 - Parking lots exposed to rainfall that are 5,000 square feet or more, or with 25 or more parking spaces, including uncovered impervious areas used for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.

7- Streets, roads, highways, and freeways, including paved surface five acres or greater used by automobiles, trucks, motorcycles, and other vehicles.

8 - Retail gasoline outlets are defined as any facility engaged in selling gasoline with 5,000 square feet or more of impervious surface area.

4.3.2 LID Practices for High Density Urban Developments

High density urban developments can present a challenge to designers due to lack of open spaces. However, LID practices such as Green Roofs, Rainwater Catchment Systems, and Bioretention Systems can be designed into most high density urban developments. In addition, where codes allow, buildings can be expanded vertically to reduce the overall impervious surface exposed to rainfall and runoff. Additional information on BMPs for high density urban developments can be found in a report from the U.S. EPA titled, ”Protecting Water Resources with Higher-Density Development” (U.S EPA, 2006). This report can be used to help communities better understand the impacts of high- and low-density development on water resources. It features four communities (Portland, Oregon; Tacoma, Washington; Boca Raton, Florida; and Emeryville, California) that have used a combination of higher densities and innovative site-specific storm water strategies to create great places and reduce their storm water runoff.

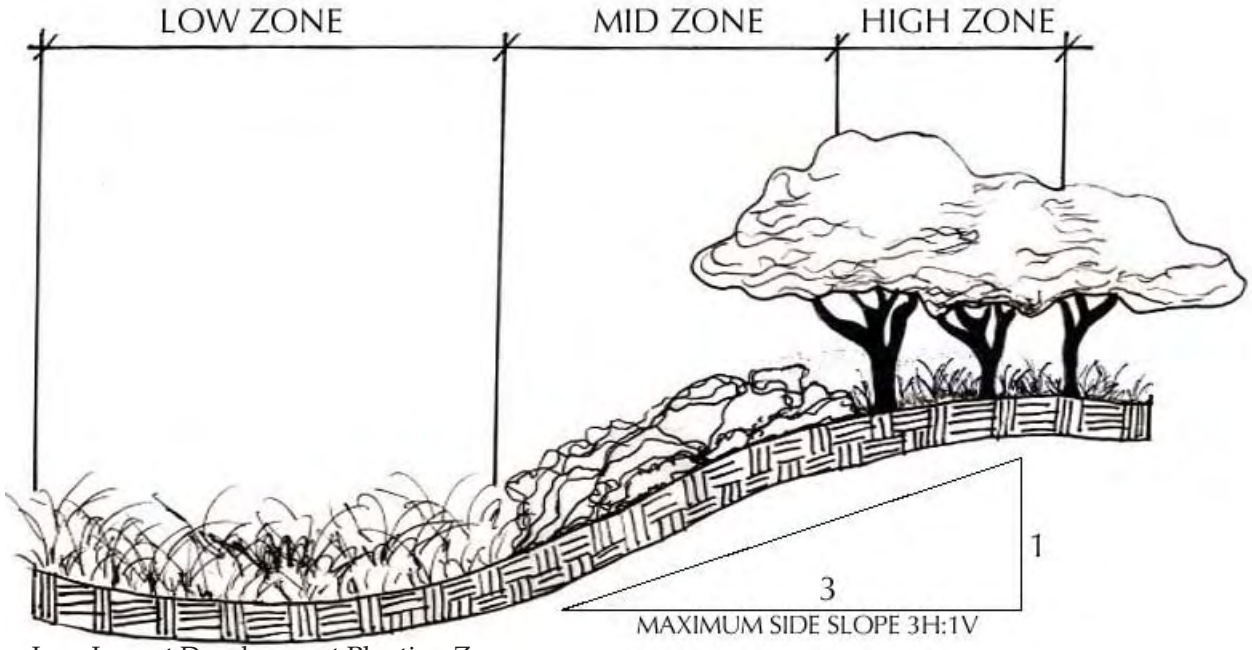
4.4 Salinas Planting Zone and Plant List for LID Practices

The following pages (4-30 to 4-35) present planting guidelines for vegetated LID practices such as preferred species for the different zones within swales and bioretention basins and the zones within conventional flood control detention basins. Design criteria, plant layout and soil testing, mulching and maintenance requirements are also presented. Finally the process for developing the LID Plant list for the City of Salinas is also discussed.

Low Impact Development Planting Zones

Planting zones refer to the planted areas in drainage features of Low Impact Development (LID) practices and flood control detention basins. LID practices include vegetated swales and bioretention basins. Plants are an integral element of their function. The plants in these zones facilitate natural infiltration of surface runoff, increase evapotranspiration, reduce the heat-island effect of urbanized areas, and reduce the rate, volume, and pollutant loading of urban runoff that ultimately ends up in local streams, rivers, estuaries, and the Monterey Bay. For the drainage features to function optimally, numerous plant characteristics have been considered in indicating the appropriate plant species for the three plant zones such as: water requirements, tolerance for inundation, root and leaf structure and a species' ability to filter pollutants. The plant zone guidelines and planting list can also be utilized for the revegetation, restoration , and bank stabilization of local streams, rivers, and estuaries.

In all instances, native plant species are recommended since they are adapted to the Cenral Coast climate and generally require less water and fertilization. Non-native invasive plant species are discouraged as water can quickly spread their occurrence and alter downstream habitats. Likewise turf grasses are discouraged for LID drainage features since they require large amounts of supplemental water, fertilizers and regular maintenance.



Low Impact Development Planting Zones

LOW ZONE – The low zone is an area where runoff temporarily ponds in response to a rain event or dry weather flows such as upgradient washing or irrigation activities The low zone should be designed to drain and not hold standing water for more than 72 hours. However, it may be inundated for extended periods of time during the rainy season. Water tolerant plants with dense root structure and/or vegetative cover provide maximum pollutant filtration, discourage erosion and slow water runoff velocities (in drainage features that cross-drain, such as bioswales). Native grasses and groundcovers are recommended for these areas.

MID ZONE – The mid zone is an area that slows the storm water runoff as it flows into the drainage feature. Water passes through and saturates this area, but will not stand there for extended periods of time during typical storm events. The plants for this zone must tolerate periods without water *and* periodic inundation. The plants in the mid zone should provide a root structure to prevent erosion of the side slope.

HIGH ZONE – The high zone is an area that creates the top of the bank of the drainage facility. Water will not stand in this zone. Deep roots give natural base structure to the edge of the drainage facility. These plants must be tolerant of extended periods without water and occasional saturation.

Low Impact Development (LID) Plant List

Developed for the City of Salinas, California

Botanical Name	Common Name	Low Zone**	Mid Zone**	High Zone**	Small planting Strips (< 5' wide)	Large planting areas (> 5' wide)	Green Roofs	Tolerates Prolonged Saturation	Tolerates Periodic Flooding	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Wind Tolerant	Notes
TREES														
Acer cercinatum	Vine maple		X	X	X	X			X	X				Needs some shade
Acer macrophyllum	Big-leaf maple		X	X		X		X	X				X	Clay tolerant
Aesculus californica	Buckeye			X		X		X	X	X			X	Clay tolerant
Alnus rhombifolia	White alder		X	X		X		X	X					Keep protected from prevailing winds
Alnus rubra	Red alder		X	X		X		X	X					
Cercis occidentalis	Western redbud		X	X	X	X			X	X	X			
Fraxinus latifolia	Oregon ash		X	X		X			X					
Juglans californica var. hindsii	Black walnut			X		X		X	X	X				
Populus fremontii	Western cottonwood			X		X		X					X	Water loving, aggressive roots, fast growing
Prunus lyonii	Catalina cherry			X	X	X		X	X	X			X	Clay tolerant
Pseudotsuga menziesii ssp menziesii	Coast Douglas fir			X		X			X	X			X	
Salix coulteri	Coulter willow	X	X	X		X		X	X				X	
Salix laevigata	Red willow	X	X	X	X	X		X	X				X	
Salix lasiolepis	Arroyo willow	X	X	X	X	X		X	X				X	
Sambucus mexicana	Elderberry		X	X	X	X		X	X	X			X	Clay tolerant
Umbellularia californica	California bay laurel			X		X		X	X				X	Needs large scale planting area
SHRUBS														
Baccharis douglasii	Marsh baccharis	X	X	X	X	X		X	X	X				
Baccharis pilularis	Coyotebrush			X	X	X			X	X			X	
Bachharis salicifolia	Mulefat		X	X		X		X	X	X			X	
Cornus stolonifera	Red-twig dogwood	X	X	X	X	X		X	X				X	Clay tolerant
Fremontodendron californica	Flannelbush			X		X					X	X		High zone, needs to dry between waterings
Garrya elliptica	Silk tassle			X	X	X				X				Clay tolerant with drainage
Gaultheria shallon	Salal				X	X			X					Prefers shade
Mimulus aurantiacus	Stickey monkey flower		X		X	X	X			X				
Mimulus cardinalis	Scarlet monkey flower	X	X		X	X	X	X	X				X	Clay tolerant
Rhamnus californica	Coffeeberry		X	X		X	X			X	X		X	Low water requirements
Ribes sanguineum	Pink-flowering currant		X	X	X	X		X	X	X			X	Clay tolerant
Ribes speciosum	Fuchsia-flowering gooseberry		X		X			X	X				X	Clay tolerant, prefers shade
Ribes viburnifolium	Catalina perfume		X	X	X	X		X	X	X			X	Extremely drought tolerant in clay soils
Rosa californica	California wild rose		X	X		X		X	X	X				Can be invasive, likes moisture
Rubus parvifolius	Thimbleberry					X			X	X			X	

** Plant species are considered native to California. California native selections are suggested to limit impact on native habitats downstream.*
***Refer section drawing for planting zones.*

Prepared by Joni L. Janecki & Associates, Inc

Low Impact Development (LID) Plant List

Developed for the City of Salinas, California

Botanical Name	Common Name	Low Zone**	Mid Zone**	High Zone**	Small planting Strips (< 5' wide)	Large planting areas (> 5'wide)	Green Roofs	Tolerates Prolonged Saturation	Tolerates Periodic Flooding	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Wind Tolerant	Notes
GRASSES, GROUNDCOVERS, FERNS, & BULBS														
Achillea millefolium	Yarrow		X	X	X	X	X				X		X	Clay tolerant
Aquilegia formosa	Western coulmbine	X			X	X		X	X	X				Clay tolerant with drainage and organic matter
Bromus carinatus	California brome		X	X	X		X			X				
Calamagrostis Karl Foerster	Feather reed grass	X	X		X	X		X	X	X			X	
Calamagrostis nutkentensis	Calamagrostis nutkaensis		X		X	X	X		X	X			X	
Calochortus albus	Globe lilies		X		X	X			X	X			X	
Carex globosa	Globe sedge	X	X		X	X	X	X	X				X	
Carex obnupta	Slough sedge	X	X		X			X	X				X	Needs moisture
Carex pansa	Sand dune sedge	X	X		X	X	X		X		X		X	Needs sandy soil
Carex tumulicola/ Carex divulsa	Berkeley sedge/ Gray sedge	X	X	X	X	X	X	X	X	X		X	X	Clay tolerant
Castilleja miniata	Indian paintbrush		X	X	X	X	X			X	X		X	
Deschampsia caespitosa	Tufted hair grass		X		X	X	X		X	X	X		X	Needs irrigation
Dudleya caespitosa	Dudleya		X	X	X		X			X	X		X	
Eleocharis macrostachya	Common spike rush	X	X		X	X	X	X	X				X	Sand to clay tolerant
Eschscholzia californica	California poppy		X	X	X	X	X			X	X		X	
Festuca californica	California fescue		X	X	X	X	X		X	X			X	Do not plant in low zone
Festuca idahoensis	Western fescue	X	X	X	X	X	X		X	X			X	Do not plant in low zone
Festuca rubra	Red fescue	X	X		X	X	X	X	X	X	X	X	X	Needs irrigation
Fragaria chiloensis	Beach strawberry		X		X		X		X	X	X		X	
Heuchera micrantha	Coral bells		X	X	X	X	X		X	X	X		X	
Iris douglasiana	Douglas iris		X		X	X	X		X		X		X	
Juncus effusus	Common rush	X	X		X	X		X	X	X			X	
Juncus patens	California grey rush	X	X		X	X		X	X	X			X	
Leymus triticoides	Creeping wildrye	X	X		X	X	X		X	X		X	X	Fast spreading, clay tolerant
Melica imperfecta	California melic		X	X	X		X		X				X	
Mulhenbergia rigens	Deer grass		X	X	X	X	X		X	X			X	Clay tolerant
Polystichum minutum	Sword fern		X		X	X			X					Prefers shade or part shade
Salvia ssp.	Sage		X	X	X	X	X		X	X			X	Higher zones, predominantly dry zones
Scirpus cernuus	Fiber optic grass	X	X		X	X	X	X	X	X			X	Prefers sandy soil
Sedum ssp.	Stonecrop		X		X		X			X	X		X	
Sisyrinchium bellum	Blue-eyed grass		X	X	X	X	X			X		X	X	
Satureja douglasii	Yerba buena	X	X		X		X		X				X	Clay tolerant, part shade
Vines														
Clematis ligusticifolia	Clematis	X	X		X	X		X	X	X	X			
Lonicera involucrata	Twinberry honeysuckle		X	X	X	X			X				X	
Vitis californica	California wild grape	X	X	X	X	X			X	X	X		X	Needs partial sun, do not plant at low point

** Plant species are considered native to California. California native selections are suggested to limit impact on native habitats downstream.*

***Refer section drawing for planting zones.*

Prepared by Joni L. Janecki & Associates, Inc

Low Impact Development Planting Guidelines

DESIGN CRITERIA

There are numerous conditions to consider when choosing plant species to be used in LID drainage features. Many of the criteria are found in species that tolerate the various and (sometimes) disparate conditions in their native habitats. For example, the plant species need to tolerate periods of flooding as well as extended dry periods without supplemental irrigation. California native plant species are highly recommended as they are best adapted to the local climate.

The LID plant palette is intended to serve as a baseline for plant species selection for LID drainage features. Other plant species may be proposed for use in LID drainage features; the City will have the right to permit or deny their use. The following planting criteria and characteristics are to be considered when proposing other species for LID drainage features:

- The planting zones where the plant species are to be planted (Low, Mid, High, see Planting Zones)
- The size of the planting area and the size of the plant species at maturity
- California native or easily naturalized plant species are preferred
- Non native invasive species should not be used
- Drought tolerant / low-supplemental irrigation requirements
- Tolerant of season flooding/inundation
- Low maintenance requirements
- Adaptability

As an element of a drainage feature, LID plant selections should aim to control erosion and wick water from soils. Accordingly, groundcovers and grasses that quickly cover exposed soils are the best choices for the low zone (see Planting Zones). Trees and large shrubs are best planted in the high zone where their roots can absorb the infiltration. Low shrubs, grasses and groundcovers may be used in the mid zone depending on the slope, soil type, and drainage patterns (sheet flow vs. concentrated flow, or flooding).

If a planted LID drainage feature receives a concentrated flow, energy dispersion devices will be required at the entry point to deter damage or erosion to the planted areas. Examples of erosion protection/energy dissipation designs include cobblestones, gabions, small hardscaped areas, or other approved devices.

Gabbion for Energy Dispersion (i.e. erosion control)

PLANT LAYOUT

The following shall be considered when planting LID drainage features:

- The smallest practical area of land should be exposed at any one time during development. Mulching or other protective erosion control measures should be used temporarily to protect exposed areas.
- Vegetation should be installed as soon as possible in the development after the land is exposed.
- Plants should be planted in staggered rows to ensure that plants grow together for maximum soil coverage.

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Low Impact Development Planting Guidelines

SOIL TESTING

A soils report shall be prepared prior to planting . The report shall be prepared by a qualified soils specialist or laboratory. The report shall be submitted to the City as part of the landscape and irrigation plans for final approval. Soil samples should be collected after grading operations are complete. Since surface soils are highly variable in the alluvial plain of the Salinas Valley, a sufficient number of soils samples shall be collected to account for variations that may be present in the areas to be planted. The report should include:

- Native soil composition
- Infiltration rates
- A texture test
- Cation exchange capacity
- An agricultural suitability analysis
- Recommended amendments for planted species to thrive

The following list includes some qualified soil testing laboratories in the region:

Perry Soil Laboratory, 424 Airport Blvd., Watsonville, CA 95076, T: (831) 722-7606

Soil and Plant Laboratory, Inc., 352 Matthew Street, Santa Clara, CA 95052, T: (408) 727-0330

AMENDMENTS

Prior to planting the recommended amendments shall be added as described in the soils report. A copy of the soils report shall be attached to the irrigation schedule provided to the owner and/or operator of the project.

MULCH

After planting, exposed soils shall be covered with mulch to discourage erosion. Mulch should only be maintained until plant growth has covered the majority of the exposed soil. Biodegradable erosion control mats and materials may also be used to provide same function as mulch.

Mulch should be large enough in size to be easily cleaned away from drain inlets and not fit through the openings of drain grates. Mulch shall be free of sticks and other debris. Always hold mulch away from root crown. Acceptable mulch types include:

- Nitrogen fortified bark (1″ to 2″ diameter)
- Redwood bark (1″ to 2″ diameter)
- Chipped gravel, crushed stone, or cobbles (1/2″ – 2 1/2″ diameter)
- 50/50 blend of top soil and aged compost

"Gorilla Hair" (shredded redwood bark) will not be permitted by the City of Salinas as it causes an impervious layer that encourages mold growth in Salinas's soils.

MAINTENANCE

Native plant species naturally reduce the need for maintenance. These species will minimize pests and disease problems, require less fertilizer, reduce the need for excessive pruning and conserve water. Woody plants require less maintenance once established while perennials adjust to their new environment quickly but may require more care over the long run.

Care requirements should be considered when choosing plant species for LID drainage features. Trash and debris should be cleaned out of LID planting areas periodically, especially after large storm events. Drain inlets shall be cleaned out periodically.

Bioretention basin along an urban roadway.

Prepared by Joni L. Janecki & Associates, Inc

Low Impact Development Plant List Development

PROCESS

The LID plant list was developed through a research process. Characteristics of LID drainage features such as bioswales, bioretention basins, rain gardens and tree filters were considered. Key local factors such as the climate, soils, and biodiversity of Salinas, California provided further parameters for development of appropriate plants. Preference was given to plants native to the Central Coast region for their compatibility with sensitive downstream habitats and to keep exotics form spreading and invading those habitats. Documents and conversations with and documents from other municipalities such as the Cities of Livermore, Oakland, and Santa Monica, California, The City of Seattle, Washington and The City of Portland, Oregon provided valuable guidance and insight towards successful implementation, operations and maintenance of LID drainage features.

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4.4.0 Bioretention System Design Criteria

If a bioretention system[17] is proposed as part of a development strategy to reduce the rate, volume and pollutant loading of urban runoff[18], the following design criteria should be applied:

5. Bioretention should consist of the following components:

   - A depressed ponding area located below the grade of an adjacent impervious surface[19];
   - Planted vegetation and a mulch layer;
   - A layer of engineered soil mix consisting of clean sand, certified compost or peat moss, and topsoil with a minimum thickness of 18 inches;
   - Depending on underlying soil conditions, an underdrain system[20] may be required to drain the ponding area within 72 hours.
   - An optional permeable filter fabric liner[21] or an impermeable liner[22] that separates existing site soils from the engineered soil mix.

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[17] Bioretention systems include landscape detention basins, tree box filters, and storm water planters. See Section 3.3 for additional information on these LID practices.

[18] Per Regional Board Order No. R3-2004-0135, Priority Projects in the City of Salinas are required to reduce the rate, volume and pollutant loading of urban runoff to the Maximum Extent Practicable (MEP).

[19] Storm water planters designed to treat runoff from elevated impervious surfaces such as roofs and parking structures may be placed above the grade of an adjacent impervious surface such as sidewalks and driveways.

[20] The requirement to include an underdrain system as part of the design of a bioretention system depends on the infiltration/percolation rates of the underlying soils determined during the initial site screening procedures outlined in the "Site Screening / Infiltration Testing Requirements" (Section 4.2.1**)**. As noted in this section, an underdrain system consisting of a perforated pipe in the gravel sub-base layer (e.g. drain rock, pea gravel, and filter fabric) is required if testing results indicate infiltration/percolation rates in existing site soils underlying the proposed infiltration practice are less than 0.5 in/hr (120 min/inch). Underdrains are also required in closed bioretention systems (e.g. bioretention systems that do not drain to underlying site soils) such as tree box filters and storm water planters enclosed within concrete boxes without drain holes.

[21] To allow infiltration and prevent clogging, the filter fabric shall be a woven geotextile fabric layer, such as SI Corporation Geotex 117F or an approved equivalent. However, filter fabrics have been observed to clog in bioretention systems, therefore pea gravel should be used wherever possible to prevent clogging. In particular, pea gravel should be used to separate the engineered soil mix from underlying site soils, and at the interface between the engineered soil mix and the drain rock layer (if included in the design). Although typically not necessary, filter fabric can be placed along the side walls of bioretention basins. However, filter fabric is not recommended at the bottom of bioretention basins.

[22] An impermeable liner may be required in some circumstances to protect groundwater quality, to prevent storm water from migrating under structures or into utility corridors, and to separate storm water from expansive clays.

2. The depressed ponding area or “Low Planting Zone” should allow urban runoff to temporarily pond for 72 hours or less at a depth of approximately 6 to 12 inches. The depressed area should be sized to capture and treat the Water Quality Volume (WQ_V) using the method outlined in Section 4.5. Vegetation planted in the “Low Planting Zone” should be capable of being inundated for extended periods of time.

3. The vegetation selected for bioretention systems should follow the guidelines outlined in the “Salinas Planting Zone and Plant List for LID Practices” presented in Section 4.4. The plant list provides appropriate local plant species for the ‘Low’, ‘Mid’ and ‘High Planting Zones’ of bioretention systems, vegetated swales and flood control detention basins.

4. The engineered soil mix should be well mixed and contain the following:

   - 50-60% clean sand,
   - 5-20% certified compost or peat moss, and
   - 20-30% topsoil

   a) The sand should be clean washed ASTM C-33 sand free of deleterious material. The sand should be rinsed with potable water prior to installation and construction of the bioretention system. Recycled wash water from concrete ready mix operations and other sources should not be used to wash the sand because it typically has a high pH.

   b) The definitions of materials that qualify as certified compost and peat moss are as follows:

      Compost is produced by the controlled biological decomposition of organic material. Certified compost[23] is a form of compost that has been sanitized through the generation of heat and ‘processed to further reduce pathogens’ (PFRP), as defined by the U.S. EPA (Code of Federal Regulations Title 40, Part 503, Appendix B, Section B). It is further stabilized to the point that it is beneficial to plant growth and does not contain any pathogens harmful to human health. Certified compost is an organic matter source that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer. Certified compost should be tested regularly with a frequency based on production volumes and applicable State and/or Federal regulations.

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[23] Compost made from leaves collected during the fall season is preferable for urban runoff pollutant removal because the nutrient content in the leaves is typically low (the compost has a low P-index). During the fall, nutrients in the leaves are transferred to the branches and roots of trees in anticipation of winter. The low nutrient content effectively prevents the leaching of excess nutrients into the bioretention system effluent. Other compost types, particularly those that include animal manure, have been observed to leach nutrients into the effluent of bioretention systems, resulting in increased concentrations of Nitrogen and Phosphorous, greater than observed in the urban runoff influent.

Certified compost should be analyzed for the following properties:

- pH
- Soluble salts
- Nutrient content (total N, P_2O_5, K_2O, Ca, Mg)
- Moisture content
- Organic matter content
- Bioassay (maturity)
- Stability (respirometry)
- Particle size (report only)
- Pathogens (Fecal Coliform or Salmonella)
- Trace metals (Part 503 regulated metals)

Peat Moss or Sphagnum is a genus of between 150-350 species of mosses commonly called peat moss, due to its prevalence in peat bogs. Members of this genus can hold large quantities of water inside their cells; some species can hold up to 20 times their dry weight in water. This water retention property is one reason why peat moss is commonly sold as a soil amendment. Peat moss can acidify surrounding soils by taking up cations such as calcium and magnesium and releasing hydrogen ions. This property makes peat moss effective at urban runoff pollutant removal.

c) The topsoil should be a sandy loam or loamy sand of uniform composition, containing no more than 5% clay, free of stones, stumps, roots, or similar objects greater than one inch, brush, or any other material or substance which may be harmful to plant growth, or a hindrance to plant growth or maintenance. The topsoil should be free of plants or plant parts of Bermuda grass or others as specified by the City of Salinas Urban Forester. The soil mix should also contain no toxic substances harmful to plant growth or that can be leached into the bioretention system effluent and detected at a concentration greater than observed in the urban runoff influent.

5. The Engineered Soil Mix should be well mixed and consist of 50-60% clean sand, 5-20% certified compost or peat moss, and 20-30% topsoil per specifications 4. a), b), and c) noted above. In addition, the Engineered Soil Mix should conform to the testing specifications noted in the following Section (4.4.1).

6. If a gravel sub-base layer is incorporated into the design, it should consist of clean coarse aggregate (drain rock and/or pea gravel). Recycled wash water should not be used to wash the aggregate because it typically has a high pH. The aggregate should be rinsed with potable water prior to installation and construction of the bioretention system.

7. Bioretention systems can function in a “2-step” fashion. Urban runoff can be conveyed to the first stage of a bioretention system with a minimum capacity to capture and treat a 0.6-

inch rain event from the basin drainage area (e.g. the Water Quality Volume or WQ_V). Overflow from the first stage bioretention system can be conveyed into a larger detention or retention basin during larger storm events for flood control. The bioretention features noted above Imay not be required for larger flood control detention or retention basins. However, when practicable or where necessary to provide adequate treatment, these bioretention features should be considered in larger detention or retention basins and may be required in some areas.

4.4.1 Testing Requirements for Engineered Soils for Bioretention Systems

The characteristics of the soil mix in bioretention systems (Section 3.3) play a critical role in the improvement of urban runoff water quality. The soil is a three-phase system composed of gas, liquid, and solid, each of which in the proper balance are essential pollutant removal through bioretention. The soil anchors the plants and provides nutrients and moisture for plant growth. Microorganisms inhabit and proliferate within the soil solution, and the unsaturated pore space provides plant roots with the oxygen necessary for metabolism and growth. The microorganisms in the soil decompose pollutants such as the petroleum hydrocarbons, which are commonly found in urban runoff. To be effective, the planting soil mixture of bioretention systems (e.g. engineered soil mix) should be permeable to allow infiltration of runoff and provide adsorption of organic nitrogen and phosphorus. Therefore, bioretention systems require specialized engineered soils for pollutant removal, which require testing to confirm an appropriate mix has been developed.

The engineered soil mix of bioretention systems should be tested prior to installation for pH, organic matter, P-index, and other chemical constituents. The engineered soil mix should meet the following criteria:

pH range: 5.5 – 6.5

Organic matter: Greater than 1.5

P-index: 4 to 12

Magnesium (Mg): 100+ ppm

Phosphorus (P_2O_5): 150+ ppm

Potassium (K_2O): 120+ ppm

Soluble salts: not to exceed 900 ppm/.9 MMHOS/cm (soil)
not to exceed 3,000 ppm/2.5 MMHOS/cm (organic mix)

A minimum of one test for the above constituents should be performed per borrow source or for every 90 cubic yards of engineered soil mix. The laboratory name and address, soil testing method(s), and dates of testing should be provided on the soil test results, which should be provided to the City of Salinas prior to installation. The testing criteria for engineered soils noted above should not be confused with the analyses required for certified compost presented in the previous section. If certified compost is to be used in an engineered soil mix, it should truly be “certified” and should have been tested previously per the U.S. EPA standards presented on the previous page.

4.5 Numeric Sizing Criteria

The Salinas NPDES Permit requires numeric sizing criteria for both volume- and flow-based treatment control BMPs. Examples of volume-based treatment control BMPs include extended detention basins, infiltration basins and trenches, and bioretention basins. Examples of flow-based treatment control BMPs include swales and filter strips. The following sections discuss an analysis of local rainfall records and the methods to be used to size volume- and flow-based treatment control BMPs in the Salinas area, and the rainfall depth and intensity to be applied to these methods, respectively.

4.5.0 Salinas Design Storm Criteria

A precipitation frequency analysis was conducted using hourly precipitation data for the Salinas Municipal Airport obtained from the National Climatic Data Center (NCDC). Hourly data was only available for this station from 1948 to 1951, and 1998 to 2006[24] (e.g. the period of record). Runoff producing storm events were assumed to be 0.05 inches or greater in depth, with a minimum 6 hour dry period between storms[25]. Based on these parameters, there were a total of 354 runoff producing storms during the period of record. As presented in Figure 4-7, the 85th percentile storm has a rainfall depth of 0.6 inches, which is the value to use when calculating the water quality volume (WQ_V) for volume-based treatment control BMPs in the Salinas area. A similar analysis of rainfall intensity was conducted (Figure 4-8). The analysis indicates that the 85th percentile hourly rainfall intensity for the City of Salinas is 0.11 inches/hour. Since the Salinas NPDES Permit requires flow-based treatment control BMPs to be designed to infiltrate or treat the maximum flow rate produced by a rain event equal to two times the 85th percentile hourly rainfall intensity, the value to use in the Salinas area is 0.22 inches/hour.

4.5.1 Volume-based Treatment Control BMPs

The Salinas NPDES Permit indicates that volume-based treatment control BMPs must be designed to infiltrate or treat the calculated volume obtained using one of the following methods:

a. The volume of runoff produced by the 24-hour 85th percentile storm event (based on local rainfall records) using the maximized storm water quality capture volume method (WEF/ASCE method, 1998);

b. The unit basin storage volume equivalent to 80% of the volume of annual runoff (CASQA method, 2003); or,

c. An approved equivalent numeric sizing criteria.

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[24] According to the Western Regional Climate Center (WRCC), the record ended in 1951 when the gauge was removed. The station was reportedly inactive between 1952 and 1998, and became active again in September 1998 when new automated equipment was installed. The 2006 data utilized for this analysis was from January to June

[25] Precipitation analyses in the United States typically assume a 6-hour dry period (a.k.a. Minimum Inter-event Time or MIT) to separate individual storm events (Driscoll et. al., 1989). Analyses of runoff producing storm events also typically assume a minimum of 0.05 inches of precipitation is required to produce runoff. They assume that any precipitation less than 0.05 inches that occurs during a period of time that is preceded by a minimum 6-hour dry period will not produce runoff because this small amount of rainfall will be retained in depression storage, infiltrated, and/or lost to evaporation.

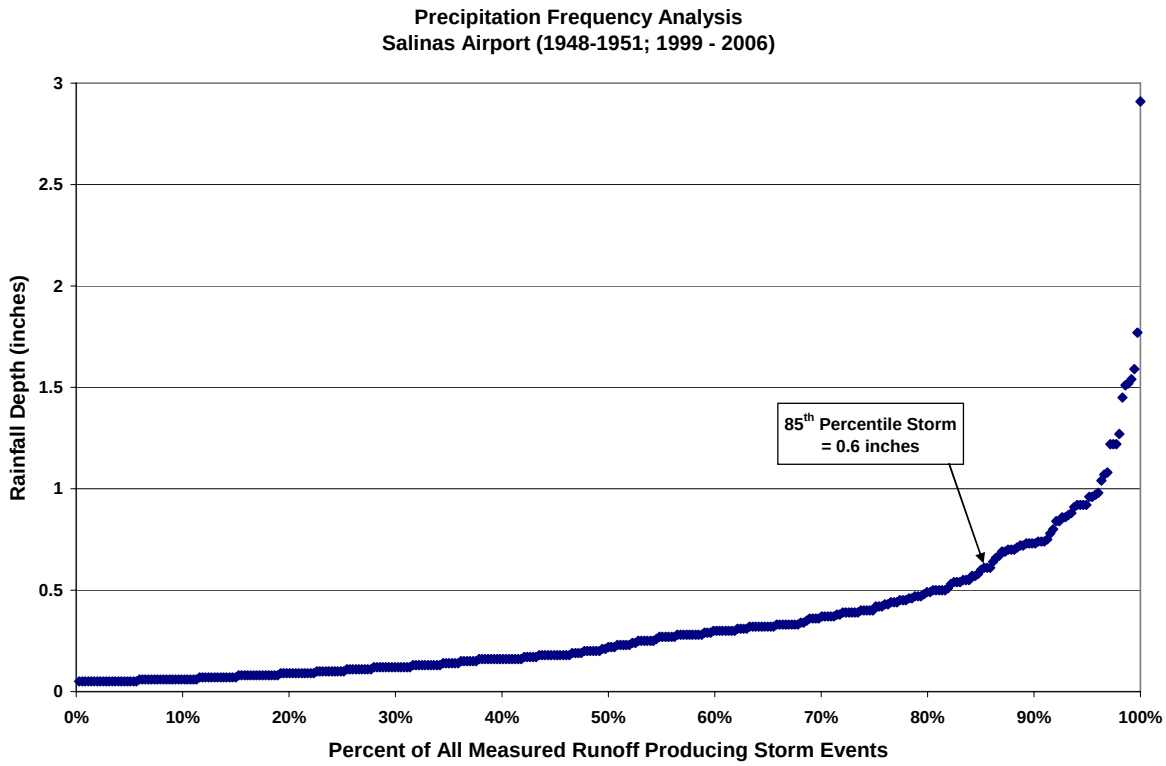


Figure 4-7: Precipitation frequency analysis indicating the 85th percentile runoff producing storm event for the Salinas area. (Source: Kennedy/Jenks Consultants)

4.5.1.0 WEF/ASCE Method (24-hour 85th Percentile Volume)

To determine the volume of runoff that must be infiltrated or treated in the Salinas area, use a rainfall of 0.6 inches (see previous section for discussion). The maximized storm water quality capture volume (WEF/ASCE method, 1998) for volume-based treatment control BMPs is as follows:

$$C = 0.858i^3 — 0.78i^2 + 0.774i + 0.04$$

$$P_o = (aC)P_6 = WQ_V$$

Where

C = the runoff coefficient

i = watershed imperviousness ratio

P_o = maximized detention volume (inches) = WQ_V

a = regression constant for BMP draw down time (for 24 hours a = 1.582, for 48 hours a = 1.963)

P_6 = mean annual runoff producing rainfall depth based on local rainfall records (inches). As noted above P_6 = 0.6 inches for the City of Salinas.

4.5.1.1 CASQA Method (Unit Basin Storage Volume)

To determine 80% of the volume of annual runoff (CASQA method, 2003):

1. Determine BMP drainage area (in ft^2)
2. Calculate the composite runoff coefficient "C" for the drainage area using Rational Method "C" values
3. Select the appropriate curve from Appendix D of the CASQA BMP Handbook (e.g. San Jose, 48-hr)
4. Calculate required water quality capture volume (WQ_V) by multiplying BMP drainage area by Unit Basin Storage Volume.

Additional information about calculating the WQ_V can be found in Section 5.5.1 of the California Stormwater BMP Handbook for New Development and Redevelopment (www.cabmphandbooks.com)

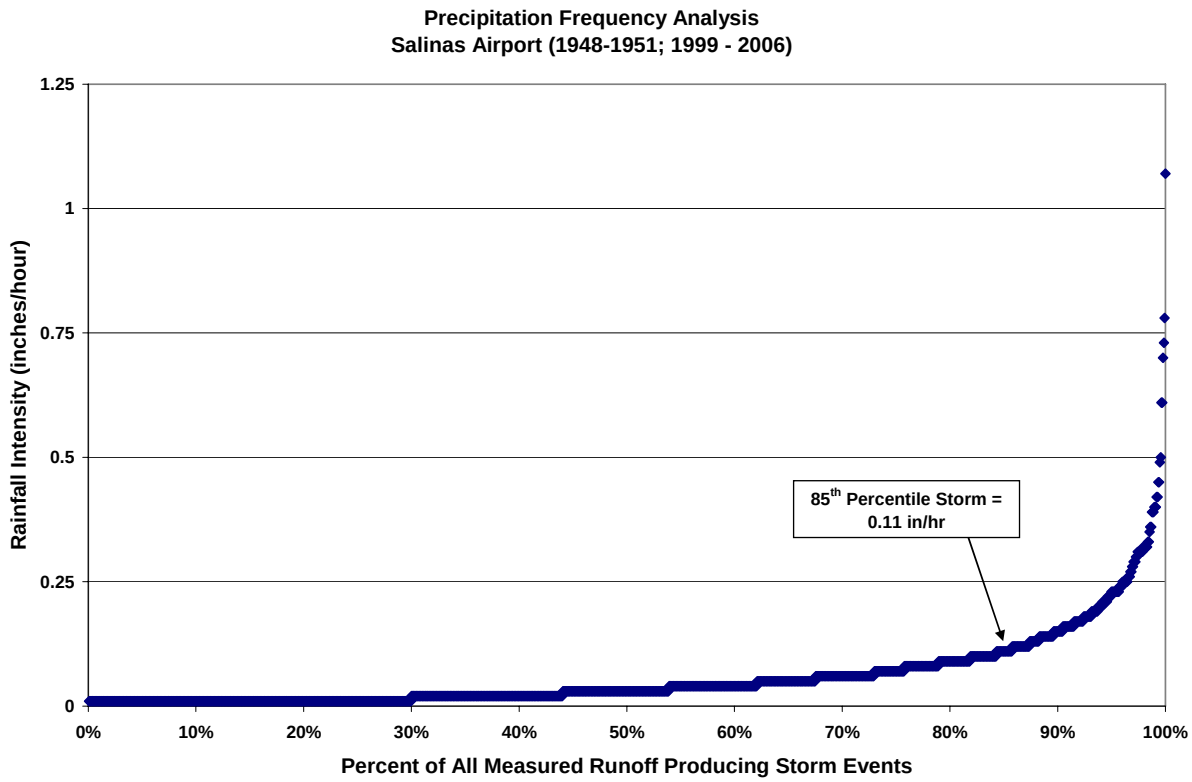


Figure 4-8: Precipitation frequency analysis indicating the 85th percentile rainfall intensity for the Salinas area. (Source: Kennedy/Jenks Consultants)

4.5.2 Flow-based Treatment Control BMPs

The Salinas NPDES Permit indicates that flow-based treatment control BMPs must be designed to infiltrate or treat the maximum flow rate produced by a rain event equal to two times the 85th percentile hourly rainfall intensity based on local rainfall records (CASQA method, 2003). An approved equivalent numeric sizing criteria can also be adopted by the City.

The CASQA method utilizes the commonly applied Rational Formula ($Q = CIA = WQ_F$):

Where

WQ_F = flow rate (ft^3/sec)

C = the runoff coefficient

I = rainfall intensity (inches/hour)

A = drainage area (acres)

As discussed in Section 4.5.0 (and shown above on Figure 4-8), the rainfall intensity associated with the 24-hour 85th percentile storm is 0.11 inches/hour. Therefore two times the 85th percentile hourly rainfall intensity is 0.22 inches/hour.

Additional information about calculating the WQ_F can be found in Section 5.5.2 of the California Stormwater BMP Handbook for New Development and Redevelopment (www.cabmphandbooks.com)

4.6 Diversion Structures

Implementing one or both of the following techniques typically accomplishes capture or isolation of the water quality flow (WQ_F) or water quality volume (WQ_V):

- Use of diversion structures, such as weirs, orifices or pipes, to divert the WQ_F or WQ_V into an off-line structural treatment control. The diversion structure is typically located at or upstream of the inlet to the BMP (Figures 4-9 and 4-10).

- Bypassing flows in excess of the WQ_F or WQ_V using weirs, orifices or pipes within in-line structural treatment controls and routing these flows to the conventional storm drain system or another treatment control BMP (Figures 4-11 and 4-12).

Since conventional storm drainage systems are typically constructed to convey flows from the larger storm events (the 5-year up to the 100-year peak flow) without regard for treatment, the design engineer should ensure there is sufficient capacity in the diversion structure to accommodate overflows. Therefore, the engineer should establish the design capacity of the storm drain system when designing diversion structures and structural treatment controls for storm water quality enhancement. The following figures provide examples of diversion structures and the following discussion provides the recommended procedures for sizing various diversion structures for flow and volume-based treatment controls BMPs.

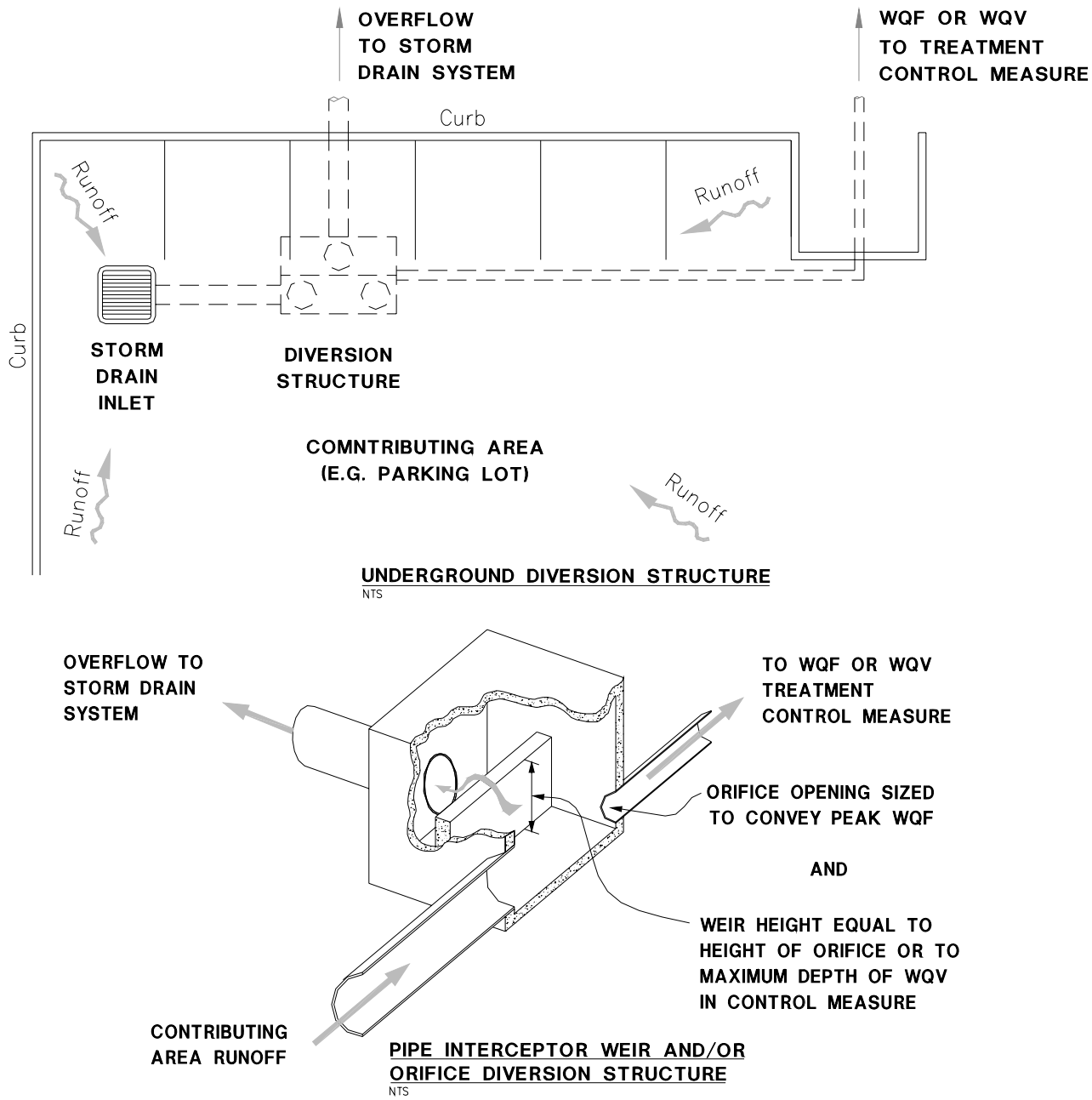
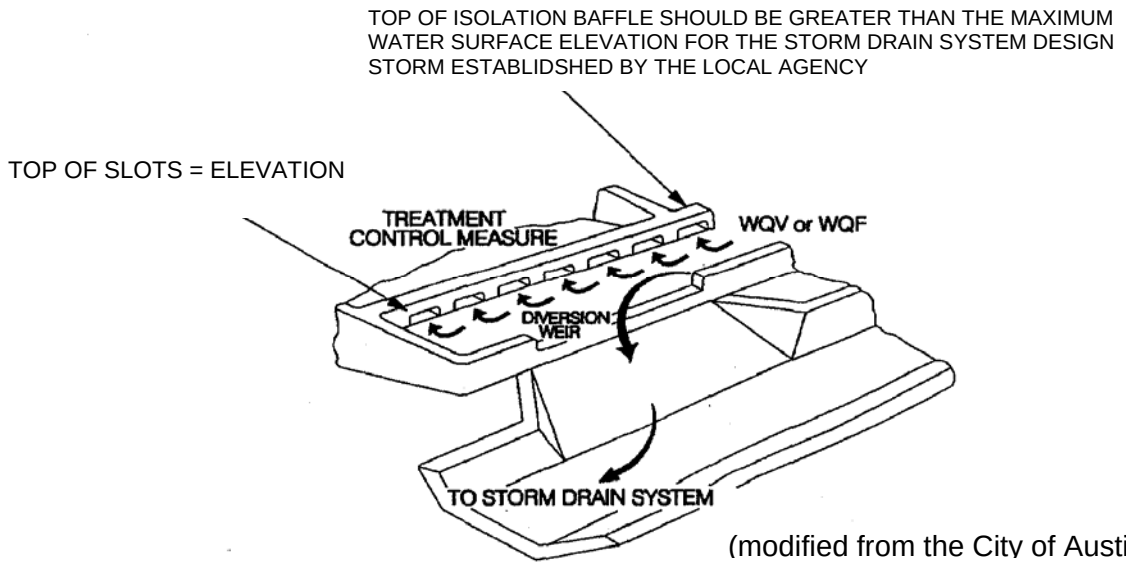


Figure 4-9: Example of an underground pipe interceptor weir and/or orifice diversion structure for WQ_F or WQ_V treatment control measures. (Modified from City of Sacramento, 2000)



(modified from the City of Austin, 2003)

Figure 4-10: Example of a surface channel diversion structure for flow or volume based treatment controls.

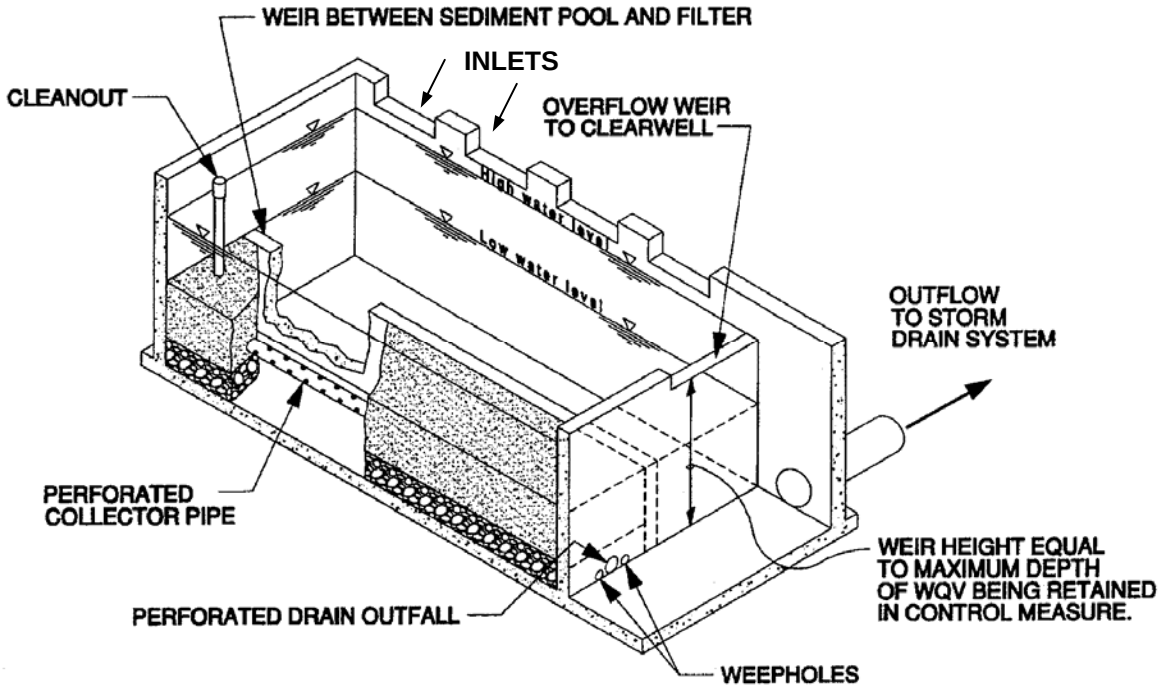
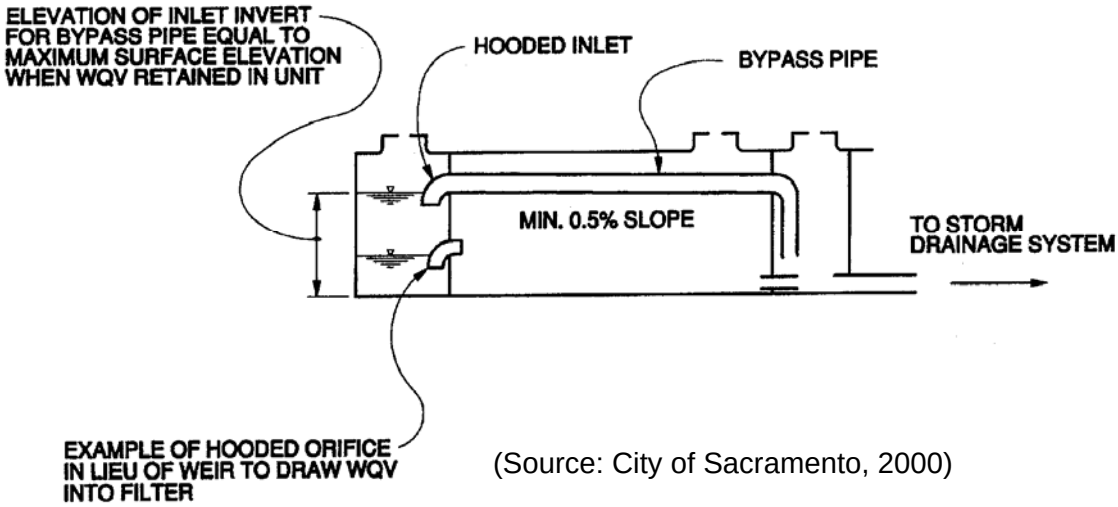


Figure 4-11: Example of an in-line underground sand filter with an overflow weir. (modified from the City of Sacramento, 2000)



(Source: City of Sacramento, 2000)

Figure 4-12: Example of an in-line treatment control measure with a bypass pipe.

4.6.0 Weirs for Flow-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_F for the proposed LID practice or structural treatment control BMP using the equations noted in Section 4.5.1.

3) Determine the depth of flow in the storm drain system at the WQ_F using the Manning's equation.

$$WQ_F = (1.49/n)AR^{2/3}S^{1/2}$$

Where: WQ_F = water quality peak flow rate (cfs)

1.49 = conversion factor for English units

n = Manning roughness coefficient (dimensionless)

A = cross sectional area of the storm drain pipe or channel (ft^2)

R = hydraulic radius of the storm drain pipe or channel (ft)

S = slope of the pipe or channel (ft/ft)

Nomographs or computer programs can also be used to determine the depth of flow.

4) Set the weir height (H) at the flow depth determined in step 3.

5) Use the following equation for a rectangular broad-crested weir to determine weir length (L).

$$Q_{SD} = CLh^{1.5}$$

Where: Q_{SD} = the peak flow rate for the storm drain system (cfs)

C = the weir coefficient

L = the effective horizontal length of the weir (ft)

h = the depth of flow above the crest of the weir (ft)

6) Ensure sufficient head is available in the design of the weir structure to accommodate overflow from the larger storm events.

The weir or discharge coefficient "C" for a broad-crested weir accounts for factors such as the flow approach velocity. It has been determined experimentally to range between 2.67 and 3.05. A value of C = 3.0 is typically used for the design for the design of detention overflow structures, spillways and diversion structures (Stahre and Urbonas, 1990). Table 4-5 provides a list of Manning roughness coefficients (n) for various channel-lining materials.

4.6.1 Weirs for Volume-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_V for the proposed LID practice or structural treatment control BMP using the equations noted in Section 4.5.1.

3) Using the design and construction criteria provided in the BMP fact sheets; determine the water level height in the treatment control measure when the entire WQ_V is retained within the structure.

4) Set the weir height (H) at the water level height determined in step 3.

5) Use the equation for a rectangular broad-crested weir (noted above) to determine weir length (L).

6) Design weir with low-flow capabilities so that no ponding occurs behind the weir.

Ensure sufficient head is available in the design of the weir structure to accommodate overflow from the larger storm events.

4.6.2 Orifices for Volume-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_V for the proposed LID practice or structural treatment control BMP using the equation in Section 4.5.1.

3) Using the design and construction criteria provided in the BMP fact sheets; determine the water level height in the treatment control measure when the entire WQ_V is retained within the structure.

4) Set the invert elevation of the orifice at the water level height determined in step 3.

5) Establish the size of the orifice opening using the following equation:

$$Q_{SD} = C_d A(2gh_d)^{1/2}$$

Where: Q_{SD} = capacity of the storm drain system from step 1 (cfs)

C_d = orifice coefficient = 0.65 (dimensionless)

A = orifice area (ft^2)

g = acceleration of gravity (32.2 ft/sec^2)

h_d = height of water above mid-point of orifice (ft)

6) Ensure sufficient head is available in the treatment control BMP to accommodate flows from larger storm events through the orifice.

In addition to providing a bypass for the amount of water that exceeds the WQ_V, orifices can be used within volume based treatment controls in place of weirs or pipes to prevent floatables from entering the conventional storm drain system.

4.6.3 Bypass Pipes for Volume-Based Treatment Controls

1) Repeat steps 1 through 3 under Designing Orifice Diversions for Volume-Based Treatment Controls.

2) Size the bypass pipe to the design capacity of the storm drain system (Q_{SD}). Assuming the bypass pipe flows full at Q_{SD}, use the following version of the Manning's equation:

$$D = \left(\frac{2.159 Q_{SD} n}{S^{1/2}} \right)^{3/8}$$

Where: D = diameter of the bypass pipe (ft)

Q_{SD} = capacity of the storm drain system (cfs)

n = Manning's roughness coefficient (dimensionless)

S = slope of the pipe or channel (ft/ft)

Ensure sufficient head is available in the treatment control BMP to accommodate flows from larger storm events through the bypass pipe.

Table 4-5: Manning's Roughness Coefficients
(from Chow, V.T., Open Channel Hydraulics, 1959)

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

	TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
EXCAVATED OR DREDGED				
a.	Earth, straight and uniform			
1.	Clean, recently completed	0.016	0.018	0.020
2.	Clean, after weathering	0.018	0.022	0.025
3.	Gravel, uniform section, clean	0.022	0.025	0.030
4.	With short grass, few weeds	0.022	0.027	0.033
b.	Earth, winding and sluggish			
1.	No vegetation	0.023	0.025	0.030
2.	Grass, some weeds	0.025	0.030	0.033
3.	Dense weeds or aquatic plans in deep channels	0.030	0.035	0.040
4.	Earth bottom and rubble sides	0.028	0.030	0.035
5.	Stony bottom and weedy banks	0.025	0.035	0.040
6.	Cobble bottom and clean sides	0.030	0.040	0.050
c.	Dragline-excavated or dredged			
1.	No vegetation	0.025	0.028	0.033
2.	Light brush on banks	0.035	0.050	0.060
d.	Rock cuts			
1.	Smooth and uniform	0.025	0.035	0.040
2.	Jagged and irregular	0.035	0.040	0.050
e.	Channels not maintained, weeds and brush			
1.	Dense weeds, high as flow depth	0.050	0.080	0.120
2.	Clean bottom, brush on sides	0.040	0.050	0.080
3.	Same as above, but highest state of flow	0.045	0.070	0.110
4.	Dense brush, high state	0.080	0.100	0.140
NATURAL STREAMS				
Minor Streams (top width at flood stage <100 ft)				
a.	Streams on plain			
1.	Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2.	Same as above, but more stones and weeds			
3.	Clean, winding, some pools and shoals	0.030	0.035	0.040
4.	Same as above, but some weeds and stones	0.033	0.040	0.045
5.	Same as above, but lower stages, and more	0.035	0.045	0.050
	ineffective slopes and sections	0.040	0.048	0.055

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravel, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
Floodplains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.105	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
Major streams (top width at flood state 100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	--	0.060
b. Irregular and rough section	0.0.5	--	0.100

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
LINED OR BUILT-UP CHANNELS			
a. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Gunite, good section	0.016	0.019	0.023
4. Gunite, wavy section	0.018	0.022	0.023
b. Concrete bottom float finished with side of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Dry rubble or riprap	0.020	0.030	0.035
c. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
d. Asphalt			
1. Smooth	0.013	0.013	--
2. Rough	0.016	0.016	--
e. **Mixed Vegetation**	0.030	0.040	0.050

4.7 Preventative Measures

If not sited, designed and maintained properly, structural treatment controls and LID practices have the potential to contaminate groundwater, cause water to seep into the basements and crawlspaces of homes and other structures, and create favorable breeding habitat for mosquitoes. The following sections provide guidance on design techniques and methods that should be considered to avoid these undesirable consequences.

4.7.0 Groundwater Contamination

Any time surface water from developed areas is infiltrated into the soil, there is a potential for pollutant transport and groundwater contamination. Structural treatment controls and LID practices that allow for infiltration of polluted runoff can be of concern if sited incorrectly. If there is a high potential for spills that may be conveyed directly to a structural treatment control or a LID practice, such as from an industrial site with outdoor storage of chemicals, infiltration systems should not be implemented. In this case, chemical storage areas should not be exposed to rain water and any runoff that occurs should be routed to the sanitary sewer system or to another type of treatment control measure that does not allow for infiltration. If sited in areas where there is a low potential for spills, BMPs designed to infiltrate storm water are typically very effective at removing pollutants and numerous studies have shown that they presents only a minor risk of contaminating either groundwater or soil (Barraud et al., 1999,

Dierkes and Geiger, 1999, Legret et al., 1999, Pitt et al., 1994). These studies indicate that natural and amended surface soils are very effective at removing pollutants from urban storm water runoff because concentrations are typically low and surface soils utilize a number of natural processes such as physical filtering, ion exchange, adsorption, biological processing, conversion, and uptake by plants.

Infiltration systems are not recommended in drainage areas where runoff can be expected to contain significant concentrations of hydrocarbons, metals or toxicants. Therefore infiltration systems should **not** be located in drainage areas with industrial or vehicle service activities where outdoor storage or use of toxic or hazardous materials could result in spills. As discussed in Section 4.2, infiltration systems also should not be installed within 150 feet of drinking water wells or in areas where the seasonally high groundwater table would be within 5 to 10 ft feet of the bottom of a proposed system. In areas where existing site soil infiltration rates exceed 3.0 in/hr (20 min/inch), storm water should be fully pretreated by some other device, or soil amendments added to slow infiltration rates to 3.0 in/hr or less. Storm water infiltrating directly into existing site soils that have infiltration rates exceeding 3.0 in/hr, generally do not provide adequate treatment prior to transport to groundwater, particularly in sandy soils with little to no organic matter. If a bioretention system, swale, filter strip or porous pavement system is proposed and there is a potential for spills or highly polluted runoff to be conveyed to the LID practice, it should be relocated or an impermeable liner and underdrain system should be incorporated into the design to prevent infiltration and groundwater contamination.

4.7.1 Dry Wells and Class V Injection Wells

Shallow dry wells, infiltration galleries, and subsurface drain fields that release storm water or other fluids directly below the land surface are considered Class V injection wells and may be subject to regulation by the U.S. EPA. By definition, a Class V injection well is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension. A pipe that conveys storm water to an underground infiltration gallery is also considered a Class V injection well. These types of facilities are considered storm water disposal systems, not treatment systems, and have impacted groundwater quality in a number of communities across the nation. The U.S. EPA is concerned that there may be a dramatic increase in the use of Class V injection wells as a result of NPDES storm water permit requirements to implement BMPs. When not allowed to filter through surface soils and plant roots, storm water contaminated with sediments, hydrocarbons, nutrients, metals, salts, fertilizers, pesticides, bacteria, or other pollutants can contaminate groundwater supplies, resulting in costly treatment alternatives and the closure of drinking water wells. However, when storm water is allowed to temporarily pond in an open basin that is exposed to the atmosphere, is wider than it is deep, and infiltrates storm water through engineered soils and gravel, the system is not considered a Class V injection well and typically presents little risk to groundwater quality. The LID practices and structural treatment control BMPs presented in this document are not considered Class V injection wells and should not present a threat to groundwater quality if sited and designed correctly.

4.7.2 Storm Water in Crawl Spaces

Shallow groundwater, storm water, and water from landscape irrigation, if not properly managed, can penetrate foundations and seep into the basements and crawl spaces of homes and other structures. Since many types of building materials contain organic matter, mold can

occur in the favorable environment created in these areas. Mold in crawl spaces and basements is a concern because several species can present health risks. Commonly, storm water and water from landscape irrigation creates mold problems in basements and crawlspaces when homeowners re-grade their property for landscaping improvements, creating a drainage pattern that redirects moisture towards the foundation of the home.

Landscaping should be graded to direct moisture away from the foundation. A grade of at least six inches fall over the first ten feet from the foundation wall is recommended to keep moisture away from foundations. In addition, foundation drains can reduce the potential for water in basements and crawl spaces. Foundation drains that extend and drain to LID practices such as swales can be expected to provide better drainage than foundation drains surrounded by native soils. Additional measures include the installation of a vapor barrier (a plastic cover over the exposed dirt of crawlspaces) to prevent moisture from coming in from the ground. Crawl spaces and basements should also incorporate adequate cross ventilation so air will circulate freely.

Based on a literature search and an Internet list serve poll of storm water professionals across the nation, no reported cases of water or mold in crawl spaces and basements have occurred from implementing LID practices or structural treatment control BMPs that infiltrate storm water. However, this could occur if a storm water infiltration system were improperly designed or sited directly up gradient of and/or adjacent to the foundation of a home or other structure. Conformance with local building design standards and the design standards presented in this document are necessary to keep storm water out of crawl spaces and basements in new development and redevelopment. Public education about the importance of maintaining proper grades, directing moisture away from foundations, and providing good ventilation for crawlspaces and basements should also help to minimize the potential mold problems.

4.7.3 Mosquito Breeding and Vector Control

Stagnant pools of shallow water that contain organic matter from plants and debris can provide an ideal habitat for mosquitoes and other vectors to breed. Mosquitoes that spread diseases such as West Nile Virus and other diseases are present in the Salinas area. Developed areas can increase breeding habitats for mosquitoes and other vectors when water ponds for extended periods of time. Therefore LID practices and structural treatment control BMPs should not hold standing water for more than 72 hours during the primary mosquito breeding season (June through October). A number of other design and maintenance considerations should also be considered for vector control.

To prevent mosquito breeding in LID practices and structural treatment control BMPs, the following design and maintenance standards are required:

- Locate and design facilities to avoid entry of fine sediment, which may cause systems to clog and fail and may also result in standing water.

- Select locations that will allow flow by gravity to, through, and away from the facility. Pumps are not recommended because they are subject to failure and often require sumps.

- Design distribution piping and containment basins with adequate slopes to drain fully and prevent standing water. Take into consideration the buildup of sediment between maintenance periods.

- Compaction during grading may be needed to avoid slumping and settling, which can create depressions that will hold water. However, avoid compaction of infiltration/percolation areas.

- Avoid the use of loose riprap or concrete depressions that may hold standing water for more than 72 hours.

- Avoid barriers, diversions, or flow spreaders that may retain standing water for more than 72 hours.

LID practices and structural treatment control BMPs that permanently retain water, such as storm water ponds and wetlands, should be designed and maintained based on the standards presented in this document. These standards include rock lining and steep slopes along the edge of storm water ponds and wetlands and periodic removal of debris and vegetation. Mosquito fish (Gambusia sp.) that eat mosquito larvae may also be introduced to storm water ponds and wetlands to provide an additional method of control. However, the California Department of Fish & Game should be consulted first regarding any potential restrictions to the introduction of species which might be considered non-native.

Nationally, LID practices and structural treatment control BMPs that include landscaping and depressed areas that temporarily pond water have only been shown to breed mosquitoes when these facilities were not designed correctly, not properly planted, not maintained adequately, or were not infiltrating properly. In bioretention basins, proper infiltration rates are attained through the use of engineered soils with good permeability and proper plant composition. Proper design and routine maintenance will prevent ponding for periods long enough to allow for mosquito breeding. Routine maintenance is necessary to ensure proper infiltration rates and discourage invasion of species such as cattails, which can increase the chances of standing water and, therefore, mosquito breeding potential. Vegetated swales and extended detention basins that include rock lined low flow channels and underdrain systems typically prevent the development of stagnant pools of water, particularly in areas that receive persistent runoff from turf and landscaping irrigation. Low flow channels should be designed with a minimum continuous grade of 0.5 percent. Those that do not include underdrain systems may require more frequent maintenance to prevent ponding water from standing longer than 72 hours.

4.8 References

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Section 5: Source and Structural Treatment Control BMPs

5.0 Introduction

This section presents the related source and structural treatment control BMPs that can be applied to construction sites, and residential, commercial and industrial land uses to support LID and protect water resources and habitats. Construction BMPs are required to reduce erosion and sediment transport at construction sites, manage construction site materials and wastes, and manage maintenance, fueling and cleaning activities in order to protect water resources and reduce or eliminate discharges to receiving waters. Post-construction source control BMPs are non-structural operational practices and management measures that can be used to prevent or reduce the source pollutants in urban runoff. They include measures intended to reduce dry weather flows from activities such as landscape irrigation and outdoor washing. They also include measures intended to reduce sources of pollutants that can come in contact with rain and runoff from outdoor storage, work and maintenance areas.

Structural treatment control BMPs are permanent engineered facilities designed to treat urban runoff where source control measures alone cannot be used to meet water quality objectives. Structural treatment control BMPs can be considered public domain treatment control BMPs or manufactured (proprietary) treatment control BMPs. Public domain treatment control BMPs are those that can be designed by an engineer and constructed of locally available materials. Manufactured (proprietary) treatment control BMPs are patented devices that have been engineered and constructed by private companies. They typically consist of prefabricated units that can be ordered from vendors who assist with the design and installation.

5.1 Construction BMPs

Erosion and sediment transport are natural processes that form landscapes and provide the bedloads required to maintain stable streams and rivers. Sediment and gravel transported from undeveloped land surfaces also provides important fish spawning medium and is critical to support other aquatic, riparian and terrestrial habitats. However, disturbances within watersheds from activities such as construction, agriculture, mining and overgrazing can greatly accelerate the process of erosion and sediment transport, resulting in excessive deposition of sediments in streams and rivers, and other negative environmental impacts.

To protect local water resources from negative environmental impacts during construction activities, temporary BMPs should be implemented for planning, runoff control, erosion control, sediment control, drainageway protection, and general site and materials management. BMPs for each of these construction project elements are briefly discussed below. Detailed information on the purpose, application, limitations, standards and specifications, inspection and maintenance requirements of these and other related construction BMPs can be obtained from the following online sources:

- The California Stormwater Quality Association (CASQA), Stormwater Best Management Practice (BMP) Handbooks, Construction Handbook: http://www.cabmphandbooks.com/Construction.asp

- The State of California, Department of Transportation (Caltrans) Construction Site Best Management Practices (BMPs) Manual: http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm

- The Truckee Meadows Construction Site Best Management Practices Handbook: http://www.cityofreno.com/gov/pub_works/stormwater/bmp/construction/

5.1.0 Principles of Erosion and Sediment Control

Erosion control BMPs focus on protecting soil surfaces and preventing the particles from being detached by wind or rain, whereas sediment control practices trap the soil particles after they have been dislodged and moved by wind or water (CA RWQCB, 1999[26]). Erosion control BMPs are generally considered more efficient and cost effective than sediment control BMPs because they keep soils in place and do not require costly sediment removal maintenance procedures. The combined use of erosion and sediment control BMPs is often required at construction sites to reduce and eliminate pollution in storm water discharges.

Natural drainage (preservation of vegetation and grade) is the most effective means of filtering sediment and pollution and regulating the volume of runoff from land surfaces adjacent to streams (CA RWQCB, 1999). When it is not possible to maintain a natural state, sediment runoff from disturbed surfaces can be reduced significantly through the use of soil stabilization practices, sediment barriers and controls, and the stabilization of vehicle access roads. Some of these practices are temporary and only remain in effect during construction. Others can be designed to be permanent and remain after construction is completed or until the site is stabilized or re-vegetated. Figure 5-1 provides a comparison of sediment concentrations in storm water runoff discharged from sites with various levels of controls in place.

Limiting the amount of disturbed soil area is also a critical component of an effective storm water management program. Some agencies place limitations on the amount of total disturbed soil area each project can expose until either temporary or permanent erosion control measures are in place. For example, the Standard Specifications for Caltrans state that "Unless otherwise approved by the Engineer in writing, the Contractor shall not expose a total area of erosible earth, which may cause water pollution, exceeding 70,000 m^2 (approximately 17.3 acres) for each separate location, operation or spread of equipment before either temporary or permanent erosion control measures are accomplished" (Caltrans, 2000[27]).

Limitations on the amount of continuous disturbed soil area are particularly important on exposed slopes. Slope length and inclination are considered the most important criteria for soil stabilization and sediment controls, because these two factors have the largest potential impact on erosion rates. Slope lengths can be limited by installing measures that effectively break up the slope length, reduce runoff velocities and trap sediments. Terraces and linear sediment barriers such as fiber rolls can be implemented for this purpose.

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[26] California Regional Water Quality Control Board, 1999. *Erosion and Sediment Control Field Manual*, San Francisco Bay Area Region, 3rd Edition, July 1999.

[27] Caltrans, 2000. *Construction Site Best Management Practices (BMPs) Manual*. State of California, Department of Transportation, November 2000.

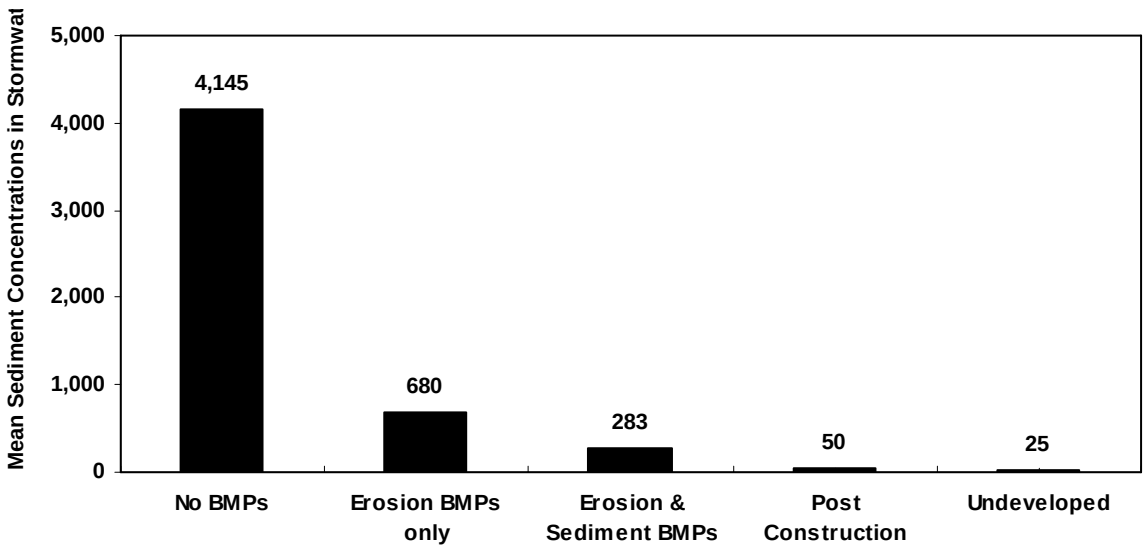


Figure 5-1: Effects of erosion and sediment control measures on suspended sediment concentrations from construction sites. (Schueler and Lugbill, 1990[28])

Different soil types and soil surface conditions also influence erosion potentials. Table 5-1 presents the erodiblity classification of several different basic soil types. Soil erodibility is the propensity for soil particles to become detached by the erosive actions of water and wind. It is also a function of soil texture, organic matter content, soil structure and permeability.

Table 5-1: Basic Soil Types and Erosion Potentials

Soil Type	Erodibility Classification
Low-Plasticity Silt	Most Erodible
Silty Sand	↓
Clayey Sand	↓
High-Plasticity Silt	↓
Low-Plasticity Organic Soil	↓
Low-Plasticity Clay	↓
High-Plasticity Clay	↓
Silty Gravel	↓
Well-Graded Sand	↓
Poorly Graded Gravel	↓
Well-Graded Gravel	Least Erodible

Source: Fifield, 2002[29]

[28] Schueler, T. and J. Lugbill. 1990. *Performance of Current Sediment Control Measures at Maryland Construction Sites.* Occoquan Watershed Monitoring Lab and Metropolitan Washington Council of Governments. Washington, DC. 90 pp.

Table 5-2 presents a comparison of soil surface conditions at construction sites and the impact on increasing or reducing erosion potentials. Land management practices or techniques that roughen soil surfaces and disrupt sheet flow effectively act to reduce the velocity of runoff waters, reduce erosion potentials, enhance infiltration and promote the establishment of vegetation. Shielding soil surfaces with covers, such as mulches, enhances soil roughening effectiveness, protects disturbed soils and helps to preserve soil moisture, further enhancing the revegetation success.

Table 5-2: Soil Surface Conditions at Construction Sites

Soil-Surface Condition	Impact on Erosion
Compacted and Smooth	+30%
Track walked along contours	+20%
Track walked up and down slope	-10%
Sparse crimped straw	-10%
Loose to 12-inches in depth	-20%

Reference: Goldman et al., 1986[30]

5.1.1 Planning BMPs for Construction Sites

The planning concepts that can be incorporated into construction sites to support LID and provide temporary and permanent erosion and sediment control, as well as long-term water quality benefits, include the following:

- Site Design
- Scheduling
- Phased Construction
- Topsoil Reuse
- Employee Training

Site design BMPs include the LID techniques that are discussed in detail in Section 3 of this manual. Scheduling BMPs include the minimization of earth disturbing activities during the rainy season. Phased construction includes the development of a schedule for the installation and maintenance of BMPs that is compatible with the general construction schedule. Reuse of topsoil can be a critical factor to the success of revegetation efforts, particularly when attempting to reestablish native vegetation. Topsoil reuse includes the salvaging, stockpiling and reapplication of topsoil and other selected materials for reuse during revegetation activities. Training is important to ensure that contractors, subcontractors and government review and

[29] Fifield, J. S., 2002. *Field Manual on Sediment and Erosion Control Best Management Practices for Contractors and Inspectors*, Forester Press, Santa Barbara, CA.

[30] Goldman, S., K. Jackson, and T. Bursztynsky, 1986. *Erosion and Sediment Control Handbook*. McGraw-Hill Book Company, New York, NY.

inspection staff are able to identify activities that may potentially impact storm water quality, identify possible solutions, and implement the appropriate BMPs.

5.1.2 Runoff Control BMPs for Construction Sites

Temporary and permanent BMPs are sometimes required at construction sites to intercept, divert, and convey concentrated flows away from disturbed soil areas. These facilities can be constructed onsite or upstream of the site. Runoff control BMPs can be used alone or in combination with erosion control BMPs to direct run-on around or through the project in a non-erodible fashion. Runoff control BMPs include the following:

- Permanent Diversions
- Temporary Diversion Dikes and Ditches
- Check Dams
- Temporary Slope Drains

5.1.3 Erosion Control BMPs for Construction Sites

As noted previously, erosion control BMPs are those that can be applied directly to disturbed soils to reduce erosion by wind, rain and runoff. They are typically the most effective method of controlling discharges from construction sites. Preservation of existing vegetation, both landscaped and native, can reduce the amount of erodible area and provide buffer zones that assist in filtering runoff. This BMP is discussed in detail in Section 3.0 and can also be considered a planning BMP. Erosion control BMPs include the following:

- Preservation of Existing Vegetation
- Slope Terracing and Tracking
- Mulching
- Soil Binders
- Wind Erosion and Dust Control
- Rolled Erosion Control Products
- Riprap
- Revegetation

5.1.4 Sediment Control BMPs for Construction Sites

Sediment control BMPs for construction sites are typically temporary measures that can be used to control sediment transport and reduce or eliminate sediment discharges offsite and into receiving waters. These devices do not control erosion, but can help to reduce erosion by reducing flow velocities and diverting flows away from erodible soils. They are also intended to intercept and slow or detain storm water runoff to allow sediment to settle and be trapped. Sediment control BMPs include the following:

- Fiber Rolls
- Brush and Rock Filters

- Sand Bag Barriers
- Gravel Filter Berm
- Silt Fences
- Temporary Sediment Traps
- Sediment Retention Basins
- Construction Site Entrances and Exits
- Construction Exit Tire Wash
- Stabilized Construction Roadway

Linear sediment barriers such as Fiber Rolls and Gravel Filter Berms function to break up slope lengths, reduce runoff velocities and trap sediments. Slope length and inclination are the two most important factors controlling erosion rates. The following specifications apply to all BMPs that function to break up slope lengths, reduce runoff velocities and trap sediments:

- For slopes with inclinations less than 2H:1V and greater than 20H:1V: BMPs should be placed on slope surfaces 100 feet in length and greater at intervals no greater than 50 feet.

- For slopes with inclinations 2H:1V or greater: BMPs should be placed on slope surfaces 50 feet in length and greater at intervals no greater than 25 feet.

BMPs such as Brush and Rock Filters, Sand Bag Barriers, Silt Fences should be placed at the top or toe of slopes, <u>not</u> across the face of slopes. These BMPs as well as Temporary Sediment Traps and Sediment Retention Basins function to trap sediments onsite and should be maintained at regular intervals. BMPs such as Construction Site Entrances and Exits, Construction Exit Tire Washes and Stabilized Construction Roadways function to minimize the amount of sediments that are tracked offsite by construction vehicles.

5.1.5 Drainageway Protection BMPs for Construction Sites

Drainageway protection BMPs for construction sites include measures that can be temporarily used to protect streams and drainages located on or adjacent to construction sites. They include the following:

- Temporary Stream Crossings
- Stormdrain Outlet Protection
- Stormdrain Inlet Protection
- Catch Basin Inlet Filters

Temporary Stream Crossing BMPs are required to protect streams and drainages that will be crossed by vehicles. Stormdrain Outlet Protection BMPs are necessary at all locations where discharge from an outlet my cause erosion. Stormdrain Inlet Protection BMPs and Catch Basin Filters are the control measures that can be temporarily used to protect stormdrain inlets from receiving sediment-laden runoff during construction activities. With the exception of permanent stormdrain outlet protection, these measures should be removed when construction activities are complete and final site stabilization has been accomplished.

5.1.6 General Site and Materials BMPs for Construction Sites

General site and materials BMPs can be used to manage construction site materials and wastes and manage maintenance, fueling and cleaning activities in order to reduce or eliminate discharges on and offsite and into receiving waters. Proper management of materials and wastes at construction sites can significantly reduce pollution in storm water. General site and materials BMPs include the following:

- Water Conservation Practices
- Stockpile Management
- Solid and Demolition Waste Management
- Dewatering Operations
- Street Sweeping
- Spill Prevention and Control
- Vehicle and Equipment Cleaning
- Vehicle and Equipment Maintenance and Fueling
- Handling and Disposal of Concrete and Cement
- Material Delivery, Handling, Storage and Use
- Paints and Liquid Materials
- Pavement Construction Management
- Liquid Waste Management
- Sanitary/Septic Waste Management
- Landscaping Management
- Contaminated Soil and Water Management
- Hazardous Waste Management
- Illicit Discharges and Connections - Detection and Reporting

As noted previously, detailed information about the BMPs listed above, and other related construction BMPs, can be obtained from the online sources noted in Section 5.1.

5.2 Post-Construction Source Control BMPs

The BMPs presented in this section discuss the general non-structural operational practices and low technology management measures that can be used to prevent or reduce pollutants at the source on developed urban land uses. They typically can be implemented in a low cost and time effective manner and primarily involve good housekeeping practices (spill prevention, proper outdoor storage methods, and proper cleanup procedures). Implementation of adequate and appropriate source control measures at residential, commercial and industrial developments can reduce or eliminate the need for higher cost structural treatment control BMPs.

In order to select appropriate source control BMPs, the outdoor activities that are conducted at a particular site should be carefully evaluated. The activities that have the potential to contribute significant pollutant loads to storm water and non-storm water discharges (e.g. dry weather flows) are commonly referred to as "activities of concern." If not managed adequately, these activities may provide sources of pollutants that come in contact with rain and runoff as it drains over the area where the activities are being or have been conducted. These pollutants then leave the site when runoff drains into the municipal storm drain system, resulting in polluted storm water ultimately being discharged to the local water resources.

The source control BMPs presented in this section address the more common activities of concern at residential, commercial and industrial developments. There may be other activities of concern at a particular site that are not covered in the fact sheets presented in the following sections that may also need to be addressed. Additional information about these and other related source control BMPs can be obtained from the California Stormwater Quality Association (CASQA), Stormwater Best Management Practice (BMP) Handbooks (http://www.cabmphandbooks.com the New Development and Redevelopment Handbook, the Industrial and Commercial Handbook, and the Municipal Handbook).

5.2.0 General Urban Area Source Control BMPs

Two source control measures that can be applied to most urban land uses include efficient irrigation techniques on landscaping and storm drain labeling on catch basins and storm drain inlets. Application of efficient irrigation technologies helps to minimize the waste of water resources and reduces runoff and dry weather flows from transporting pollutants to the storm drain system. To reduce the illegal disposal of wastes such as used motor oil into the storm drain system; signs, stencils, markers or labels can be applied catch basins and storm drain inlets to educate the public that the storm drain system typically discharges directly to local water resources untreated. In communities with ethnic diversity, stenciling may have to be multi-lingual and/or accompanied by other educational materials to prevent illegal dumping.

5.2.0.0 EFFICIENT IRRIGATION

5.2.0.0 Efficient Irrigation

Description

Application of efficient irrigation techniques minimize the waste of water resources and reduce the volume of dry weather flows discharging to the storm drain system. Efficient irrigation techniques include rain and wind-triggered shutoff devices, automatic line break detection shutoff valves and soil moisture sensors. These devices automatically regulate the amount and frequency of irrigation based on climatic conditions and function to provide only the amount water required to sustain vegetation requirements.

Applications

Appropriate at any location that includes irrigated landscaping, including residential, commercial, and industrial sites that are either being developed or redeveloped.

Limitations

- Installation of rain-triggered shutoff devices and automatic shutoff valves involve an initial additional expense; however these costs can be offset through water savings.
- May require additional inspection and maintenance to insure the irrigation system is functioning as efficiently as designed. Education of landscape maintenance personnel is critical to proper operation of irrigation systems.

Siting Criteria

- Applicable at any location that includes an irrigation system for landscaping.

Design and Construction Criteria

- Install rain-triggered shutoff devices to prevent automatic irrigation during and following precipitation events.
- Install flow reducers or automatic shutoff valves which will shut off the flow in case of a broken line or sprinkler head.
- Customize the irrigation system and watering schedule to the actual water requirements of the vegetation used.
- Set irrigation timing and duration to minimize runoff and to comply with any local watering restrictions.
- Choose plant types that are appropriate for local climatic conditions.
- Choose plants that require little to no application of fertilizers or pesticides for healthy growth.
- Minimize runoff by covering areas of bare soil with mulch.
- Provide vegetative buffers along property lines and channel banks to filter out sediments.

5.2.0.0 EFFICIENT IRRIGATION

Inspection and Maintenance Requirements

- Monitor and maintain the irrigation system to minimize runoff.
- Repair or replace broken pipes, nozzles, or other devices as soon as possible.
- Use alternative environmentally friendly fertilizers or pesticides.

References

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

5.2.0.1 STORM DRAIN LABELING

5.2.0.1 Storm Drain Labeling

Description

Illegal dumping of wastes into storm drain inlets is a significant problem in some areas. Many times this occurs because polluters are unaware that the storm drain system conveys storm water and wastes directly to rivers, streams and lakes without treatment. To educate the public and reduce the disposal of wastes such as used motor oil and painting supplies into the storm drain system; signs, stencils, markers or labels can be applied as a source control. Storm drain labels can be applied with paint and a stencil, secured with an adhesive, heat applied, stamped into concrete or cast into iron of manufactured drop inlets. Storm drain labels stating educational messages and prohibitions should be placed above or next to storm drain inlets.

Applications

Appropriate at all storm drain inlets including residential, commercial, and industrial sites. Reflective materials may help to decrease the occurrence of illegal nighttime dumping in some areas.

Limitations

- Storm drain stencils tend to weather and fade over time. However some jurisdictions prefer their use because they can be used during multiple public participation events.
- If not properly attached with a secure adhesive, storm drain signs, markers or labels may become detached or be subject to vandalism.
- Multi-lingual stenciling may be required in areas of ethnic diversity.

Siting Criteria

- Storm drains inlets within new development projects should be clearly marked with storm drain signs, stencils, markers or labels.
- May be applied either on the top of or at the face of curbs, above or directly adjacent to storm drain inlets.
- The message should be visible from all angles.

Design and Construction Criteria

- Inquire with local agencies as to whether specific design criteria and language for storm drain labeling is required.
- Image and wording on the label should be clearly stated.
- Storm drain signs, stencils, markers or labels should be permanent.
- A durable, long lasting adhesive should be used to apply all storm drain signs, markers and labels.
- When stamped into concrete or cast into iron drop inlets, the label should be a minimum of 0.25 inch deep and have a minimum letter height of 1.5 inches.
- Figure 5-2 provides examples of some of the storm drain labels typically used.

5.2.0.1 Storm Drain Labeling

- Bilingual storm drain labels should be used in neighborhoods where English is a second language.

Inspection and Maintenance Requirements

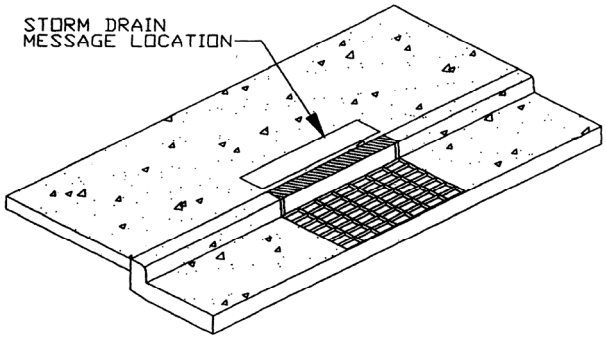
- Storm drain labels should remain readable at all times.
- Inspect storm drain labels every two years and replace or reapply as necessary.

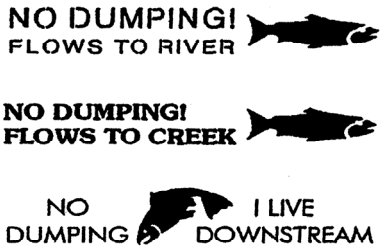
References

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

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

5.2.0.1 STORM DRAIN LABELING





NOTES:

1. STORM DRAIN MESSAGE SHALL BE APPLIED IN SUCH A WAY AS TO PROVIDE A CLEAR, LEGIBLE IMAGE.
2. STORM DRAIN MESSAGE SHALL BE PERMANENTLY APPLIED DURING THE CONSTRUCTION OF THE CURB AND GUTTER USING A METHOD APPROVED BY THE LOCAL AGENCY.
3. FOR AREA DRAIN INLETS, STORM DRAIN MESSAGE SHALL BE PLACED ADJACENT AND PARALLEL TO THE LONG AXIS OF THE DRAIN.
4. LETTERS SHALL BE 1-1/2" IN HEIGHT. DIMENSIONS OF STORM DRAIN MESSAGE SHALL NOT EXCEED 12" X 33".
5. IF THE MESSAGE IS STAMPED IN CONCRETE, THE DEPTH SHOULD BE APPROXIMATELY 0.25".
6. IF AN ALTERNATIVE STORM DRAIN MESSAGE IS PROPOSED, IT SHALL BE APPROVED BY THE LOCAL AGENCY.

Figure 5-2: Examples of storm drain labels.
(Sources: City of Sacramento, 2000;
www.dasmanufacturing.com/storm/storm.html; http://basmaa.org/index.cfm)

5.2.1 Mutli-Family Area Source Control BMPs

The BMP fact sheets presented in this section discuss the practices and measures that can be implemented at multi-family areas to prevent or reduce pollutants from the following common activities of concern:

- Vehicle Wash Areas
- Waste Handling Areas

5.2.1.0 VEHICLE WASH AREAS

5.2.1.0 Vehicle Wash Areas

Description

Wash waters commonly contain high concentrations of sediments, oils and grease, cleaning chemicals, phosphates, antifreeze and heavy metals and have a negative impact on storm water quality if wash waters are not prevented from entering the storm drain system.

Applications

To be applied in multi-family developments or mobile home parks.

Limitations

- None Known

Siting Criteria

- Wash area should have a paved access.

Design and Construction Criteria

- Wash areas should be paved, bermed, and sloped toward the sanitary sewer or treatment system.
- Wash areas should have a minimum width of 15 feet and a minimum length of 25 feet.
- Place a covered waste container within the wash area.
- Surrounding areas should be sloped away from the wash areas.
- The entire wash area should be covered with a roof to reduce rainwater flows to the storm sewer.
- Clearly mark wash areas with posted signs stating that vehicle fluids should not be dumped in the area.

Inspection and Maintenance Requirements

- None Available

Additional Information

- Contact the local sewer authority to determine if treatment of wash waters is required.

References

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures, Sacramento Stormwater Management Program.

5.2.1.1 WASTE HANDLING AREAS

5.2.1.1 Waste Handling Areas

Description

Residential waste products can have a negative impact on storm water quality. Oils, anti-freeze, batteries, fuels, paints, cleaning agents, weed killers, fertilizers, as well as many other products may contaminate storm water runoff if not properly managed.

Applications

Wastes should be properly managed and maintained in all multi-family or mobile home park areas.

Limitations

- None Known

Siting Criteria

- Follow local codes or ordinances for the design of multi-family waste handling areas.
- Storm drains should not be located within the waste handling area.

Design and Construction Criteria

- Waste handling areas should be underlain by an impervious material such as concrete.
- A barrier (concrete pad or berm) should be constructed around the waste collection area and the area should be graded such that spills or wastes will move toward a dead-end sump.
- Dumpsters should be lined and covered to reduce waste spills and leaks.
- Signs should be posted restricting disposal of hazardous wastes.
- Recyclables should be stored indoors or under an overhang.

Inspection and Maintenance Requirements

- Spills should be cleaned up immediately.
- Wastes should be collected regularly.

Additional Information

- Provide appropriate instruction and signage regarding waste disposal.
- Local, state, and federal regulations should be followed when disposing of wastes.

References

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #8 – Spill Prevention and Control. http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp08.asp

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

5.2.2 Commercial/Industrial Area Source Control BMPs

Source control BMPs act to prevent storm water pollution by ensuring that potential pollutant sources are maintained in a manner that reduces exposure. Storm water pollution prevention is less expensive than treatment control and thus should be applied whenever possible. Source control BMPs should be applied in storage areas, fueling areas, maintenance, and work areas, wash areas, waste handling areas, and should also include the labeling of storm drains. To reduce the volume of storm water run-on to these areas, berming, grading, and roofing techniques can be applied.

The BMP fact sheets presented in this section discuss the practices and measures that can be implemented at commercial and industrial areas to prevent or reduce pollutants from the following common activities of concern:

- Outdoor Material Storage
- Outdoor Material Loading/Unloading
- Fueling Areas
- Outdoor Work, Maintenance and Wash Areas
- Spill Prevention, Containment and Cleanup
- Waste Handling and Disposal

5.2.2.0 OUTDOOR MATERIAL STORAGE

5.2.2.0 Outdoor Material Storage

Description

Improper outdoor storage of materials can provide a source of pollutants for storm water and can have undesired impacts on receiving waters. Material types range from raw materials to finished products depending on the industry involved. Examples may include toxic compounds, oils and grease, heavy metals, nutrients, and suspended solids. Proper containment and coverage of materials stored outdoors can prevent or reduce contamination of storm water runoff and receiving waters.

Applications

Toxic and hazardous materials should be stored in a manner to prevent exposure to rain and storm water runoff. Significant amounts of non-toxic or non-hazardous materials may also have a deleterious effect on receiving waters and should be considered for outdoor material storage controls.

Limitations

- Can potentially create additional impervious surfaces.
- Berms can potentially create drainage management issues.

Siting Criteria

- Materials can be contained and stored using the following: shelving, stacking, tanks, and containers.
- Materials should be covered and/or waters should be captured or diverted around the material storage area.

Design and Construction Criteria

- Storage areas should be sloped toward a dead-end sump.
- Storage areas should be underlain with pavement.
- Other runoff should be directed away from storage areas.
- The roof of the storage area should extend beyond the footprint of the storage area.
- A berm or other secondary containment should be installed around the material storage area to confine any spills or leaks.

Inspection and Maintenance Requirements

- If materials are covered with tarpaulins, frequent inspection may be necessary.

Additional Information

- Spill prevention plans shall be in place where required by local, NDEP, or Federal environmental control regulations.

5.2.2.0 Outdoor Material Storage

References

California Stormwater Quality Association, 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment.

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

5.2.2.1 OUTDOOR MATERIAL LOADING/UNLOADING

5.2.2.1 Outdoor Material Loading/Unloading

Description

The loading and unloading of materials occurring on docks, trucks, or around storage areas introduces the risk of spilling or leaking materials. The accumulation of spilled materials around the loading area may be washed away during cleaning or by runoff thereby introducing contaminants into the storm drain system. Certain precautions should be taken to reduce the risk of polluting storm water runoff from material loading/unloading areas.

Applications

- Applicable in industrial and commercial areas undergoing development or redevelopment. Can be applied on maintenance bays, docks, staging areas, and around outside storage areas.

Limitations

- None Known

Siting Criteria

- To be applied on maintenance bays, docks, staging areas, and around outside storage areas.

Design and Construction Criteria

- Loading/unloading areas should be constructed from impermeable surfaces such as concrete or asphalt.
- An overhead cover that extends 3 feet beyond the loading dock is recommended.
- Depressed loading docks should not drain directly into the storm drain system.
- Below-grade loading docks should drain runoff through an infiltration system where practicable. However, limitations exist where toxic, hazardous, or other deleterious materials are being loaded/unloaded.
- A berm to prohibit storm water from surrounding areas from draining onto loading/unloading areas is recommended.
- Downspouts should be directed away from loading/unloading areas.
- A permit may be required prior to connecting a pretreatment system (e.g. oil and water separator) to the sanitary sewer system.

Inspection and Maintenance Requirements

- Inspect loading/unloading areas regularly, clean up litter and wastes as soon as possible, and keep spill prevention, containment and cleanup supplies available at all times.

5.2.2.1 Outdoor Material Loading/Unloading

Additional Information

- Follow local codes when designing loading/unloading areas and associated drainage/pretreatment systems.

- Properly dispose of storm water and non-storm water runoff in accordance with local codes and policy. Do not dispose of waters directly into the storm drain system or receiving waters.

References

California Stormwater Quality Association, 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment.

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

5.2.2.2 FUEL STORAGE AND FUELING AREAS

5.2.2.2 Fuel Storage and Fueling Areas

Description

The potential exists for oils, greases, solvents, car battery acids, and coolants to impact storm water quality at fueling stations. Accidental spills during fueling or during the delivery of fuels as well as rainwater and wash waters running over fueling areas can have a significant impact on the water quality of runoff. Heavy metals and toxic substances in fuels are not easy to remove by storm water treatment devices and thus spill prevention is paramount.

Applications

Can be applied in commercial or industrial areas where fuels are dispensed. This includes gasoline stations and automotive repair shops.

Limitations

- None known

Design and Construction Criteria

- Fueling areas should be paved with a smooth impervious surface such as Portland cement concrete. Asphalt should not be used in the vicinity of fuel dispensers because fuels can dissolve and/or destroy the structural integrity of asphalt.
- The concrete surface should extend a minimum of 6.5 feet from the corner of each fuel dispenser or the length of the hose plus 1 foot, whichever is less.
- An overhanging roof or canopy structure should cover the entire fueling dispensing area and it should not drain onto or toward the fueling area.
- Fueling areas should be separated from the rest of the site by grade breaks and should be on a slight slope to prevent the ponding of water. The dimensions of the overhanging roof or canopy structure should be equal to or greater than the area within the grade break.
- A dead-end sump or an oil and water separator should be used to collect wash runoff and/or spills from fueling dispensing areas and the wastewater contained in the sump or separator should be disposed of properly.
- A permit may be required prior to discharging wastewater from a dead-end sump or connecting an oil and water separator to the sanitary sewer system.
- Storm drains should not be located directly down slope or next to fueling areas.
- Fueling areas should be designed according to local codes and regulations.
- Storm drain seals (drain covers, plugs, or isolation valves) should be provided in case of a spill and/or emergency to prevent pollutants from entering the storm drain system.

Inspection and Maintenance Requirements

- Inspect dead-end sumps quarterly, or at the appropriate interval to ensure they do not overflow.
- Pump and properly dispose of wastewater contained in the sump at regular intervals.

5.2.2.2 Fuel Storage and Fueling Areas

- Spill cleanup materials should be maintained on site and be readily accessible.
- Any spills should be cleaned up as soon as possible.
- Spills are not cleaned up until the absorbent is picked up and disposed of properly.

References

California Stormwater Quality Association, 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment.

Los Angeles County, 2002. A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado

5.2.2.3 Outdoor Work, Maintenance, and Wash Areas

5.2.2.3 Outdoor Work, Maintenance, and Wash Areas

Description

Contaminants such as oils, grease, metals, phosphates, suspended solids, and nutrients present in work areas and resulting from equipment and automotive maintenance and washing can impact water quality if storm water runoff is not properly conveyed to the sanitary sewer. Sources of contaminants include: cleaning of parts, equipment and vehicles, cleaning of the work area, spilled or dripped fuels, oils or other chemical agents, and the disposal of rags, filters, batteries, and other wastes. Wastes and runoff should be collected and not allowed to infiltrate.

Applications

Applicable in commercial and industrial areas. Includes restaurants, gasoline stations, and automotive repair shops.

Limitations

- Some locations may be required to pre-treat and monitor wash waters entering the sanitary sewer.

Siting Criteria

- Do not locate work, maintenance, or wash areas near storm drains.

Design and Construction Criteria

<u>Work and Maintenance Areas</u>

- Use a prefabricated metal drip pan or underlay the work area with Portland cement concrete.
- Maintenance/work areas should be covered with a roof or canopy.
- Establish a berm around the work area to prevent run-on or runoff.
- Berm and/or cover areas where vehicle parts with fluids are stored.
- Certain regulated industrial activities may require pre-treatment with a structural control prior to discharge to the sanitary sewer.

<u>Equipment and Vehicle Wash Areas</u>

- Wash areas should be self-contained, have a pre-treatment device and properly connected to the sanitary sewer.
- The entire wash area should be covered with a roof to prevent contact with rainwater.
- Wash areas should be paved with Portland cement concrete, bermed, and sloped toward the sanitary sewer or treatment system.
- A permit may be required prior to discharge wastewater or to connect an oil and water separator to the sanitary sewer system.

5.2.2.3 Outdoor Work, Maintenance, and Wash Areas

- Wash areas for vehicles should have a minimum width of 15 feet, a minimum length of 25 feet and a paved access.
- Clearly mark wash areas with posted signs.
- Use biodegradable and phosphate-free detergents when possible.
- Use hoses that have nozzles that turn off automatically when not in use.

Inspection and Maintenance Requirements

- Train employees on proper cleaning and maintenance techniques as well as wastewater handling procedures.
- Pre-treatment devices will require inspection and maintenance appropriate to the device (refer to TC fact sheets).

Additional Information

- Contact the local sewer authority to determine if treatment of wash waters is required.
- Wash waters are not considered to be storm water.
- Hazardous and toxic wastes should not enter the storm drain system.
- Accumulated wastewaters should be disposed of according to local codes and regulations.
- Provide drain plugs or valves to prevent spilled materials from entering the storm drain system.

References

California Stormwater Quality Association, 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment.

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

5.2.2.4 Spill Prevention, Containment, and Cleanup

5.2.2.4 Spill Prevention, Containment, and Cleanup

Description

Containment berms, curbing, and drip pans are methods for controlling and containing spills on commercial and industrial sites. These methods prevent spilled materials from entering the storm drain system. Berming can be either a temporary or permanent feature at a site and can be constructed from a variety of materials including concrete, metal, synthetic liners, or earthen materials.

Applications

To be applied on any commercial or industrial site having the potential to spill materials that will introduce pollutants to the storm drain system.

Limitations

- Containment dikes may be too expensive for small sites.
- Curbing is not effective for holding large spills.
- Drip pans are only applicable for small leaks.

Siting Criteria

- Drip pans should be located where they are easy to remove, clean, and maintain.
- Do not place drip pans next to sidewalks or on uneven surfaces where they have a potential for being overturned.
- Firmly secure drip pans to prevent heavy winds from moving or damaging them.

Design and Construction Criteria

- The floor of the spill area should be sufficiently impermeable. Suggested materials include asphalt or concrete.
- Containment dikes should be capable of containing a spill from the largest storage tank within the potential spill area.
- Curbing should be sized to route spill materials down gradient from the largest container within the spill area to a collection basin.
- Curbing is typically constructed from earth, concrete, metal, asphalt, or other impervious materials.
- Containment dikes may be equipped with normally closed valves to assist with management of retained storm water.

Inspection and Maintenance Requirements

- Drip pans should be inspected and cleaned frequently.
- Drip pans should be secured in bad weather conditions.

5.2.2.4 Spill Prevention, Containment, and Cleanup

- Containment dikes and berm should be inspected after significant storm events and spills to check for leaks or overflows.
- Closely inspect the overflow system to control leaks.
- Visually inspect snowmelt and rainwater present in the spill containment area prior to release. Storm water present in the spill containment area may need to be treated or collected and disposed of properly.

Additional Information

- Sorbents or gelling agents are effective means of controlling spilled materials.
- The type of berm selected will determine the costs of installation and maintenance.
- Local, state, and federal codes and regulations should be followed when removing spilled materials from a site.

References

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #8 – Spill Prevention and Control. http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp08.asp

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

5.2.2.5 Waste Handling and Disposal

Description

Storage areas for industrial or chemical wastes need to be properly maintained to prevent or reduce pollutants from entering the storm water system. Wastes should be stored, treated, or disposed of in a safe and responsible manner consistent with applicable regulations. Pollutant and waste sources may include dumpsters, waste piles, storage of treatment chemicals or residuals, or process wastes. Any wastes spilled or lost from work areas may build-up in soils to later be released during precipitation events effecting storm water quality. Thus, proper management of facilities is vital in preventing storm water pollution.

Applications

Wastes should be properly managed and maintained on all commercial and industrial sites.

Limitations

- None Known

Siting Criteria

- Specific sites should be selected onsite for waste collection and handling.
- Storm drains should not be located within the waste handling area.
- Areas should be elevated if practicable.

Design and Construction Criteria

- Waste handling areas should be underlain by an impervious material such as concrete.
- A barrier (concrete pad or berm) should be constructed around the waste collection area and the area should be graded such that spills or wastes will move toward a dead-end sump.
- Provide overflow protection devices around tanks and the storage area.
- The waste containment area should be covered and is preferably located indoors.
- Waste containers should be covered to prevent rainwater exposure or materials from being blown away.
- Dumpsters should be lined and covered to reduce waste spills and leaks.
- Signs should be posted on dumpsters restricting disposal of hazardous wastes.

Inspection and Maintenance Requirements

- Assure that wastes will be collected before overflowing occurs.
- Spills should be cleaned up immediately.

Additional Information

- Provide appropriate instruction and signage regarding waste storage and management.

5.2.2.5 WASTE HANDLING AND DISPOSAL

- Local, state, and federal regulations should be followed when disposing of accumulated wastes.

References

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #8 – Spill Prevention and Control. http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp08.asp

Sacramento Stormwater Management Program, 2000. Guidance Manual for On-Site Stormwater Quality Control Measures.

Urban Drainage and Flood Control District, 1999. Drainage Criteria Manual (V.3). City and County of Denver, Colorado.

5.3 Public Domain Structural Treatment Control BMPs

This section describes the structural treatment control measures that can be incorporated into new public and private developments, as well as retrofitted into existing developments to assist with meeting federal, state, and local storm water management objectives. The structural treatment control BMPs presented in this section are the more common public domain measures being implemented throughout the country. Numerous studies have shown these control measures to be effective if properly designed, installed and maintained. Therefore, a registered professional civil engineer should design all public domain treatment control measures using the design criteria presented in this manual. In addition, they should be properly operated and maintained in order to function as designed. Failure to properly operate and maintain a structural treatment control BMPs can result in no treatment, a discharge of pollutants from the measure into the storm drain system, and possible fines by state or local agencies.

Structural treatment control BMPs are engineered facilities designed for the treatment of storm water runoff. They use infiltration, filtering, retention/detention, settling, and microbial decomposition to reduce the concentration of pollutants in urban runoff. Structural treatment control BMPs can be considered public domain treatment control BMPs or manufactured (proprietary) treatment control BMPs. Public domain treatment control BMPs are those that can be designed by an engineer and have been implemented and tested by numerous communities throughout the nation. Manufactured (proprietary) treatment control BMPs are patented devices that have been engineered and constructed by private companies.

The BMP fact sheets presented in this section discuss the structural treatment control BMPs that can be implemented at a wide variety of land uses. They are grouped into the following general categories:

- Infiltration Trenches
- Infiltration Basins
- Surface Sand Filters
- Underground Sand Filters
- Sedimentation Basins
- Sand Filter Basins
- Oil and Water Separators

With the exception of Oil and Water Separators, the structural treatment control BMPs noted above can be designed to meet the MEP standard and effectively reduce the rate, volume and pollutant loading of urban runoff (a requirement of the Salinas NPDES permit).

The details shown on the following fact sheets are intended to show design concepts. Preparation of final design plans, addressing structural details, excavation, foundation preparation, concrete work, steel reinforcing, backfill, metal work and other related appurtenances, including technical specifications, are the responsibility of the design engineer. Alternative designs to those presented in this section may be considered upon approval of the appropriate city or county department. However, at a minimum, alternative designs should incorporate the water quality design criteria presented in Section 4.4.

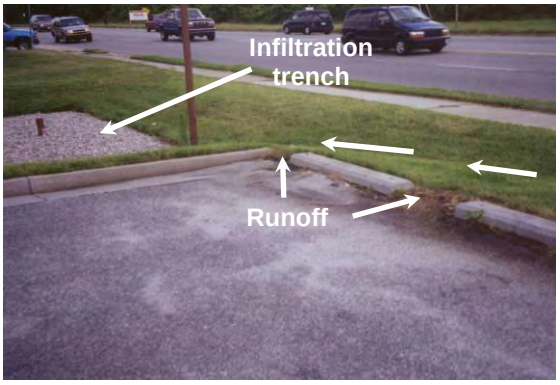
5.3.0 INFILTRATION TRENCHES

5.3.0 Infiltration Trenches

Description

An infiltration trench is a trench that has been lined with filter fabric and filled with a rock matrix to form a subsurface basin that captures, filters and infiltrates storm water runoff. Trenches allow for water retention such that the partial or total infiltration of storm water runoff into the underlying soil occurs. Infiltration trenches function to remove pollutants in storm water through the processes of adsorption, precipitation, filtering, and bacterial degradation. Efficiency of pollutant removal depends upon the types and concentration of pollutants in the storm water influent, the porosity of rock matrix, and the infiltration capacity of the underlying soils. They should be protected from sediment sources that can clog the filter media. Therefore upstream pretreatment with vegetated swales or other structural treatment controls is typically required.

Source: California Stormwater BMP Handbooks



Source: Center for Watershed Protection

Applications and Advantages

Infiltration trenches typically drain areas less than 5 acres in size. Their relatively small size allows them to fit easily along the margins, perimeter, and unused sections of developed sites and thus they are a good choice for retrofitting. They are commonly installed in median strips or in parking lot islands.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	75 - 90
Total Phosphorus	50 - 70
Total Nitrogen	45 - 60
Metals	75 - 90
BOD	70 - 80
Bacteria	75 - 90

Source: Schueler, 1987

5.3.0 INFILTRATION TRENCHES

Pollutant removal efficiency can be improved by adding organics and loam to the subsoil.

Limitations

- Do not install in areas with highly erodible soils.
- Do not apply on slopes greater than 15 percent.
- Infiltration rates of existing site soils should be a minimum of 0.5 in/hr (120 min/in) and a maximum of 2.4 in/hr (25 min/in).
- High failure rates are common in areas with inappropriate soils and subsurface conditions.
- Should not be applied in areas with clay or silty soils.
- Frozen conditions can severely impact the pollutant removal efficiency of infiltration trenches.
- Individual infiltration practice should not be larger than 5 acres.

Siting Criteria

- Infiltration trenches should not be used in areas where existing site soils have infiltration (percolation) rate of less than 0.5 in/hr (120 min/in).
- Apply the site screening, infiltration testing, separation, and setback standards for direct infiltration systems presented in Section 4.2. They include, but are not limited to the following:
    - Do not install in fill areas or on slopes greater than 15 percent.
    - Do not install within a wellhead protection zone.
    - Locate at least 100 ft from drinking water wells and surface waters.
    - Seasonally high groundwater should not be within 10 ft of the bottom of the infiltration trench.
    - Due to the potential of groundwater to contamination, infiltration trenches should not be installed in areas of high-risk land use such as near gas stations or heavy industrial sites where hazardous or toxic materials may be stored.
    - Infiltration trenches should be installed at least 100 ft upslope or 20 ft downslope from building foundations.

Design and Construction Criteria

- Registered professional civil engineers should design infiltration trenches.
- Sand and gravel should be rinsed with potable water prior to installation and construction of the sand filter. Sand and gravel should not be washed with recycled wash water, which typically includes sediment, dissolved pollutants and a high Ph.
- Size the infiltration trench to capture and treat the Water Quality Volume (WQ_V) using the method outlined in Section 4.5.1.
- Flows in excess of the WQ_V should be diverted around the infiltration trench with an upstream diversion structure.

- A 12 inch filter layer consisting of pea gravel should be installed at the top of the trench to maximize pollutant removal and improve sediment filtering in the top of the trench.
- A filter fabric should be installed below the filter layer above the trench rock matrix, to retain sediment and reduce potential for clogging.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- The rock matrix should consist of a nominal 1 ½ inch diameter clean stone.
- Void space of the rock aggregate should be between 0.30 and 0.40.
- A 6 to 12-inch sand filter layer or permeable filter fabric should be installed on the bottom of the trench between the subbase and the trench rock matrix.
- Determine the trench volume by assuming that the WQ_V will fill the void spaces of the rock matrix. Compute the porosity of the rock matrix based on the materials used.
- Check with the jurisdictional authority for applicable permitting requirements.
- The trench should be designed to drain the entire water quality volume within a maximum of 72 hours.
- Sufficient technical knowledge of the vertical and lateral movement of infiltrated runoff through soil and the interaction with groundwater should be established through a geotechnical investigation.
- Minimum acceptable hydraulic conductivity is 0.5 in/hr (120 min/in) as tested with a minimum of three in-hole conductivity tests.
- Determine the depth of the trench (D) based on the available surface area (SA) using the following equation:

$$D = V_T / SA$$

Where: V_T = total trench volume (ft^3)

$V_T = WQ_V$ / porosity (ft^3)

porosity = void space of the rock matrix (unitless)

- The walls and bottom of the trench should be lined with filter fabric to prevent migration of fine-grained sediments.
- To allow infiltration and prevent clogging, the filter fabric should be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- Berms should be created around the infiltration basin during construction to ensure that no sediment or runoff enters the filter media.
- During construction, an easily removable filter cloth can be installed over the rock matrix to prevent clogging of the trench from construction related sediments.
- Floor of the infiltration basin should not exceed a 1 percent slope.
- At least one observation well should be installed in the infiltration trench to monitor drainage and rates of sediment accumulation.
- Provide pretreatment such as grassed swales or vegetated filter strips designed to reduce the sediment load on the trench.

5.3.0 INFILTRATION TRENCHES

Inspection and Maintenance Requirements

- Life span of infiltration trenches ranges from 5 – 15 years, depending on maintenance.
- Inspect following major storm events during the first year after installation.
- Once the infiltration rate is stable, monitoring can be reduced to twice a year.
- Inspect for water levels in the trench, clogging of inlets and outlets, accumulation of sediments, and ponding of water on the surface.
- Non-routine maintenance involves rehabilitation of the trench if it becomes clogged. Clogging is most likely to occur in the top surface of the trench, between the filter fabric and the top gravel layer. Clogging can be alleviated by removing the top layer of gravel, removing the clogged filter fabric and replacing it, and either cleaning or replacing the top gravel layer.
- Check with the jurisdictional authority for applicable permitting requirements.
- If a spill occurs and hazardous materials contaminate sands or gravels in infiltration trenches, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

References

Barraud et al., 1999. The Impact of Intentional Stormwater Infiltration on Soil and Groundwater, Water Science and Technology. Vol. 39, No. 2, pp. 185-192.

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

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures.

Dierkes and Geiger, 1999. Pollution Retention Capabilities of Roadside Soils, Water Science and Technology. Vol. 39, No. 2, pp. 201-208.

Legret et al., 1999. Simulation of Heavy Metal Pollution from Stormwater Infiltration through a Porous Pavement with Reservoir Structure, Water Science and Technology. Vol. 39, No. 2, pp. 119-125.

Metropolitan Council. 2001. Minnesota Urban Small Sites BMP Manual.

Pitt et al., 1994. Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration, U.S. Environmental Protection Agency's Risk Reduction Engineering Laboratory, May 1994. EPA/600/SR-94/051.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments, Washington, DC.

5.3.0 INFILTRATION TRENCHES

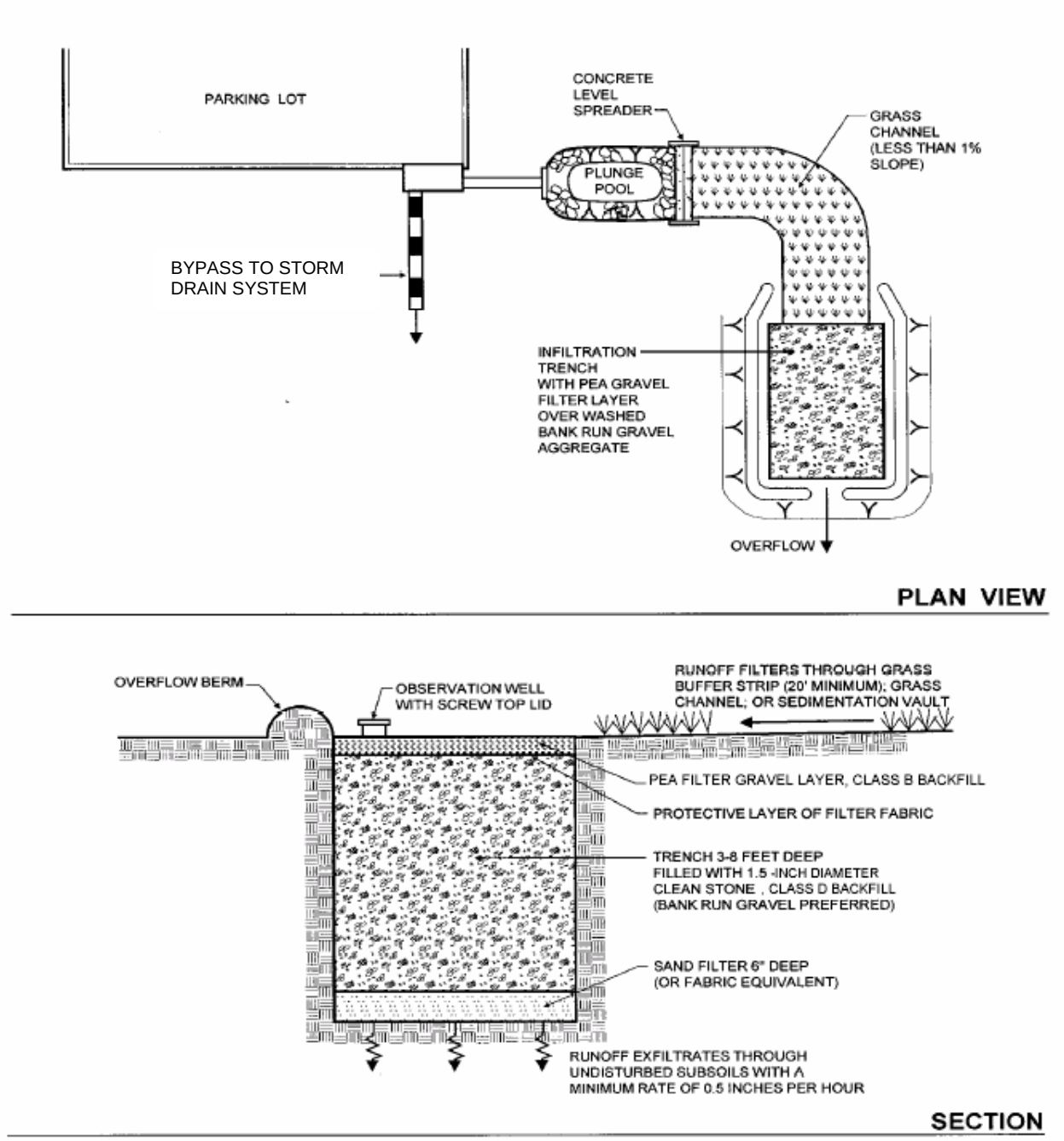


Figure 5-3: Example of an Infiltration Trench with an energy dissipation device and a bypass structure. (modified from CASQA, 2003)

5.3.0 INFILTRATION TRENCHES

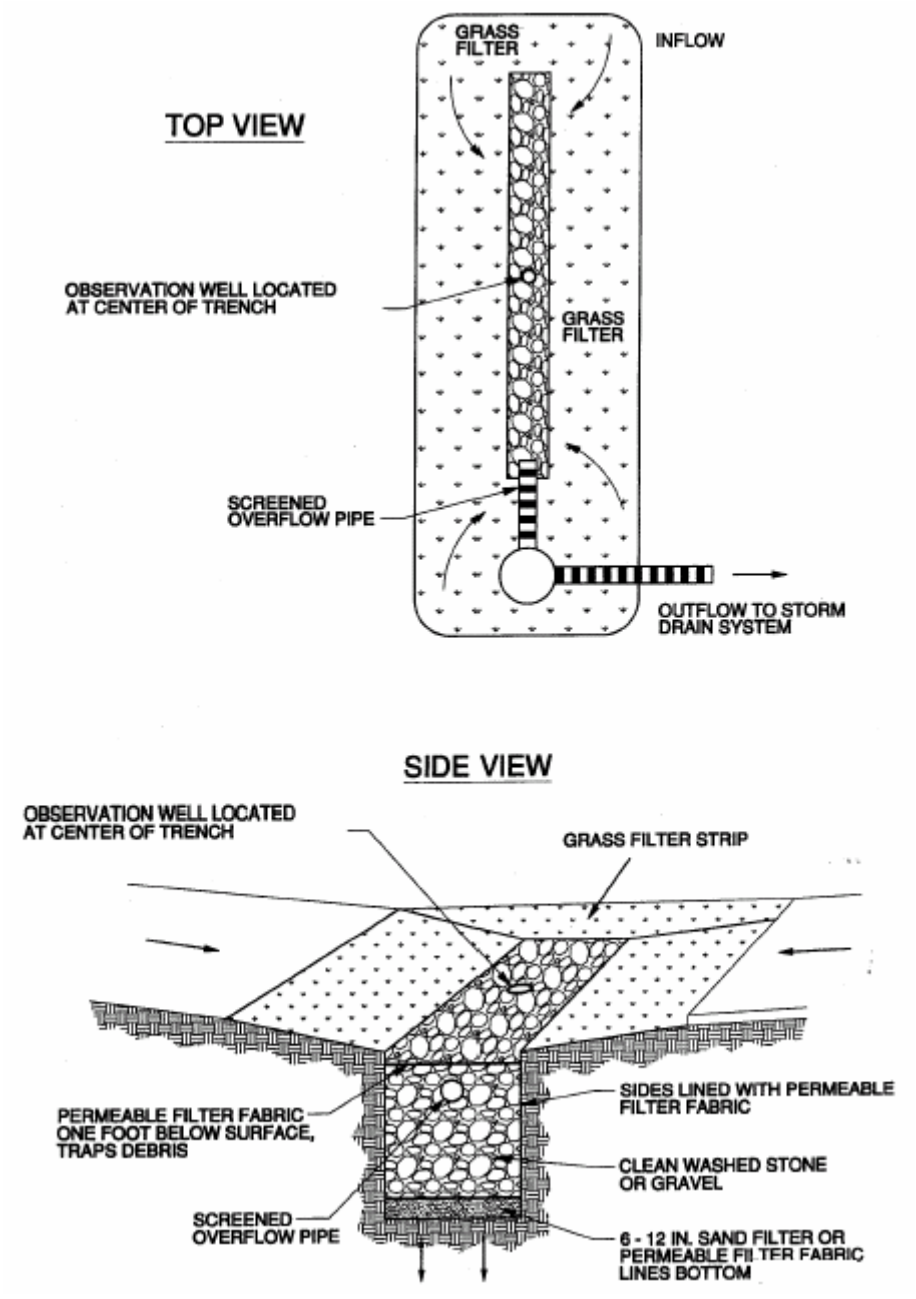


Figure 5-4: Example of a median strip Infiltration Trench with a grass buffer strip. (modified from City of Sacramento, 2000)

5.3.0 INFILTRATION TRENCHES

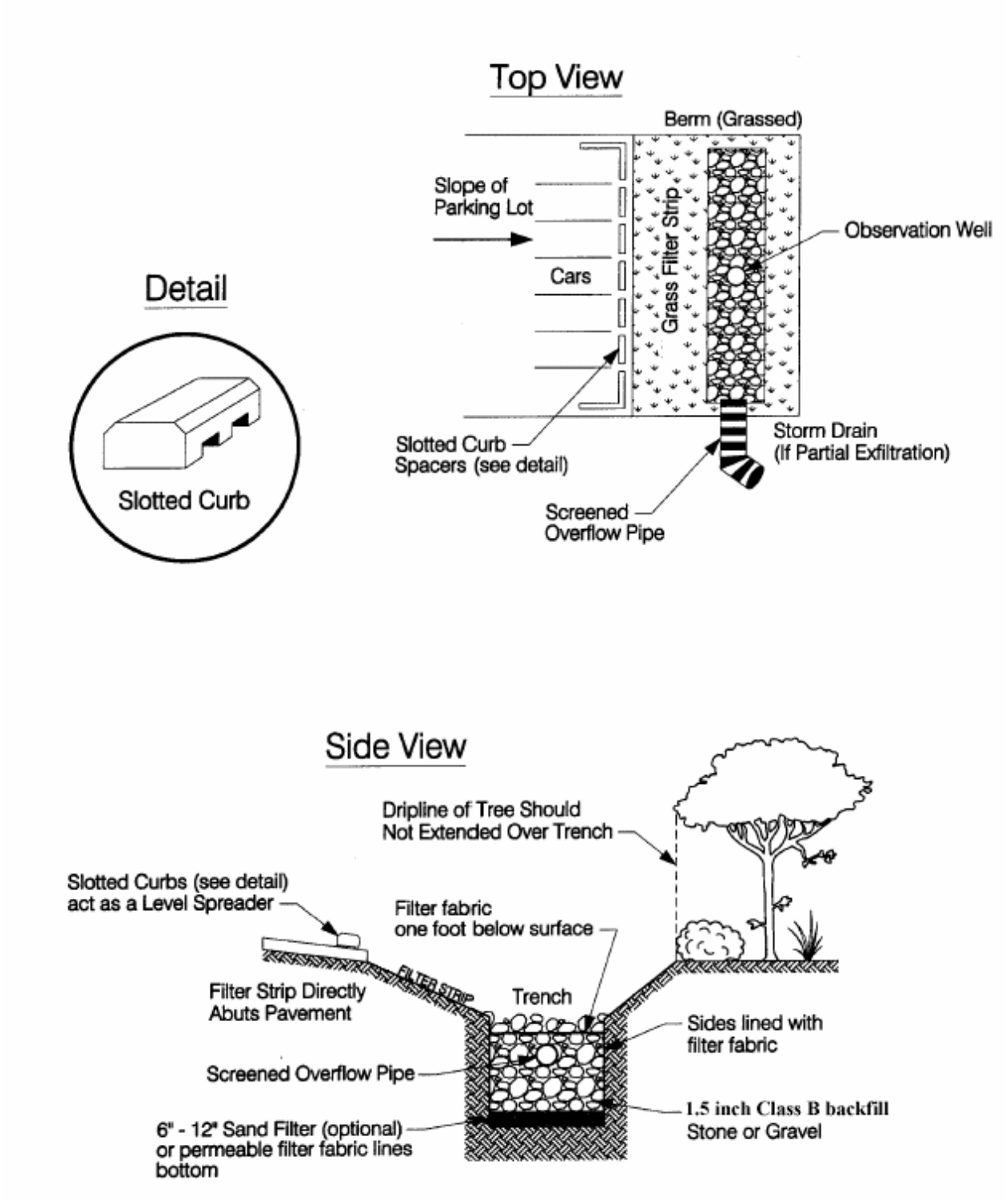


Figure 5-5: Example of a parking lot Infiltration Trench with a grass buffer strip. (modified from Sacramento, 2000)

5.3.1 INFILTRATION BASINS

5.3.1 Infiltration Basins

Description

Infiltration basins capture storm water runoff and allow it to infiltrate into the ground. They are similar to sedimentation basins or detention basins, however their purpose is to not only detain the water but also to promote infiltration. They are also similar to infiltration trenches, however they can use a wider variety of filter media, can be vegetated on the basin bottom and can serve larger drainage areas. Pollutants such as suspended solids, metals, nutrients, and bacteria are removed through sedimentation, adsorption, and physical filtration through permeable media and soil thereby improving water quality. As is the case with infiltration trenches, they should be protected from sediment sources that can clog the filter media. Therefore upstream pretreatment with vegetated swales or other structural treatment controls is typically required.

Applications and Advantages

Infiltration systems are applied in areas with well-drained and pervious soils. They are typically applied to drainage areas ranging between 5 and 50 acres. On select sites, it is relatively easy to incorporate an infiltration basin into a site's open space design and layout. Infiltration basins are ideal for areas adjacent to roadways and near interchanges. However, they should not be used in industrial or commercial areas where hazardous or toxic materials are stored outdoors and the potential for spills is relatively high.

Performance Data

Infiltration basins can provide 100 percent reduction in pollutant loading directly to surface waters. Infiltration basins can also provide high pollutant removal efficiency for particulates and moderate efficiency for soluble pollutants when functioning as designed. Actual loading to the subsurface may vary significantly depending on site-specific conditions. Studies in the Pacific Northwest have shown improved long-term performance for basins developed in highly permeable soils.

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total suspended solids	55 – 75
Total Phosphorus	45 – 55
Total Nitrogen	10 – 20
Total Recoverable Zinc	30 – 60
Total Recoverable Lead	55 – 80

Source: UDFCD, 1999.

Limitations

- There may be significant concerns regarding the potential to degrade groundwater.
- Should not be applied in locations where hazardous or toxic materials may be stored.

5.3.1 INFILTRATION BASINS

- Areas with highly erodible soils will require greater maintenance.
- Large drainage areas may require a large amount of space for an infiltration basin. Individual infiltration practice should not be larger than 5 acres.
- Not to be applied in areas with existing soil or water contamination.
- Not to be applied in areas with clay or silty soils or in areas of fill.
- Difficult to maintain and restore if clogging occurs.
- Infiltration may not occur under frozen conditions.
- Infiltration basins that incorporate piping that emplaces storm water underground may be subject to Underground Injection Control (UIC) regulations.
- If a spill occurs and hazardous materials contaminate soils, sands or gravels in infiltration basins, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

Siting Criteria

- Infiltration basins should not be used in areas where existing site soils have infiltration (percolation) rate of less than 0.5 in/hr (120 min/in).
- Apply the site screening, infiltration testing, separation, and setback standards for direct infiltration systems presented in Section 4.2. They include, but are not limited to the following:
    - Do not install in fill areas or on slopes greater than 15 percent.
    - Do not install within a wellhead protection zone.
    - Locate at least 100 ft from drinking water wells and surface waters.
    - Seasonally high groundwater should not be within 10 ft of the bottom of the infiltration trench.
    - Due to the potential of groundwater to contamination, infiltration basins should not be installed in areas of high-risk land use such as near gas stations or heavy industrial sites where hazardous or toxic materials may be stored.
    - Infiltration basins should be installed at least 100 ft upslope or 20 ft downslope from building foundations.

Design and Construction Criteria

- Registered professional civil engineers should design infiltration basins.
- Size the basin to capture and treat the water quality volume (WQ_V) using the method outlined in Section 4.5.1.
- Flows in excess of the WQ_V should be diverted around the infiltration basin with an upstream diversion structure.
- The basin should be designed to drain the entire water quality volume within 72 hours.
- Sufficient technical knowledge of the vertical and lateral movement of infiltrated runoff through soil and the interaction with groundwater should be established through a geotechnical investigation.

5.3.1 INFILTRATION BASINS

- Minimum acceptable hydraulic conductivity is 0.5 in/hr (120 min/in) as tested with a minimum of three in-hole conductivity tests.
- Installation of an inlet energy dissipation structure is recommended where inflow velocities may cause erosion of the filter media.

- The basin dimensions should be determined using the following equation:

$$A = WQ_V / (k \times t)$$

Where: A = Basin invert area (ft^2)

WQ_V = water quality volume (ft^3)

$k = 0.5 \times K_h$, where K_h is the lowest field measured hydraulic conductivity (in/hr)

t = minimum drain time (72 hours)

- Basin side slopes should be 3H:1V or flatter.
- The slope of the floor of the basin should not exceed 5 percent.
- Disturbed soils within the drainage area of the infiltration basin should be stabilized with vegetation within one week of construction.
- Berms should be created around the infiltration basin during construction to ensure that no sediment or runoff enters the filter media.
- During construction, an easily removable filter cloth can be installed over the permeable media to prevent clogging of the basin from construction related sediments.
- A large area, a flat bottom, and a dense-turf buffer zone will to improve the performance of an infiltration basin.

Inspection and Maintenance Requirements

- Inspect following major storm events during the first year after installation.
- Inspect annually for settling, cracking, erosion, leakage, condition of the riprap, state of the turf vegetation, and amount of sedimentation. If necessary, repair immediately.
- If the drawdown time is more than 72 hours, maintenance and replacement of the filter media is required.
- Debris and litter should be periodically removed from the infiltration basin and vegetation should be mowed when growth exceeds 6 inches in height.
- If barren and eroded areas are present in the drainage area directly adjacent to the infiltration basin, vegetation and/or additional stabilization methods may be required to prevent premature clogging.
- Every 5 – 10 years the area should be tilled, fine materials removed and the base of the basin regraded.
- Infiltration basins can be joined with detention basins to improve water quality.
- Vegetation installed within the infiltration basin tends to decrease the rate of clogging.

5.3.1 INFILTRATION BASINS

- A pretreatment device, such as an oil and water separator, may be required in areas where petroleum hydrocarbons in storm water are anticipated.

- If a spill occurs and hazardous materials contaminate soils, sands or gravels in an infiltration basin, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

References

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

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures.

Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, Fact Sheet – Infiltration Basin, http://www.fhwa.dot.gov/environment/ultraurb/3fs2.htm

5.3.1 INFILTRATION BASINS

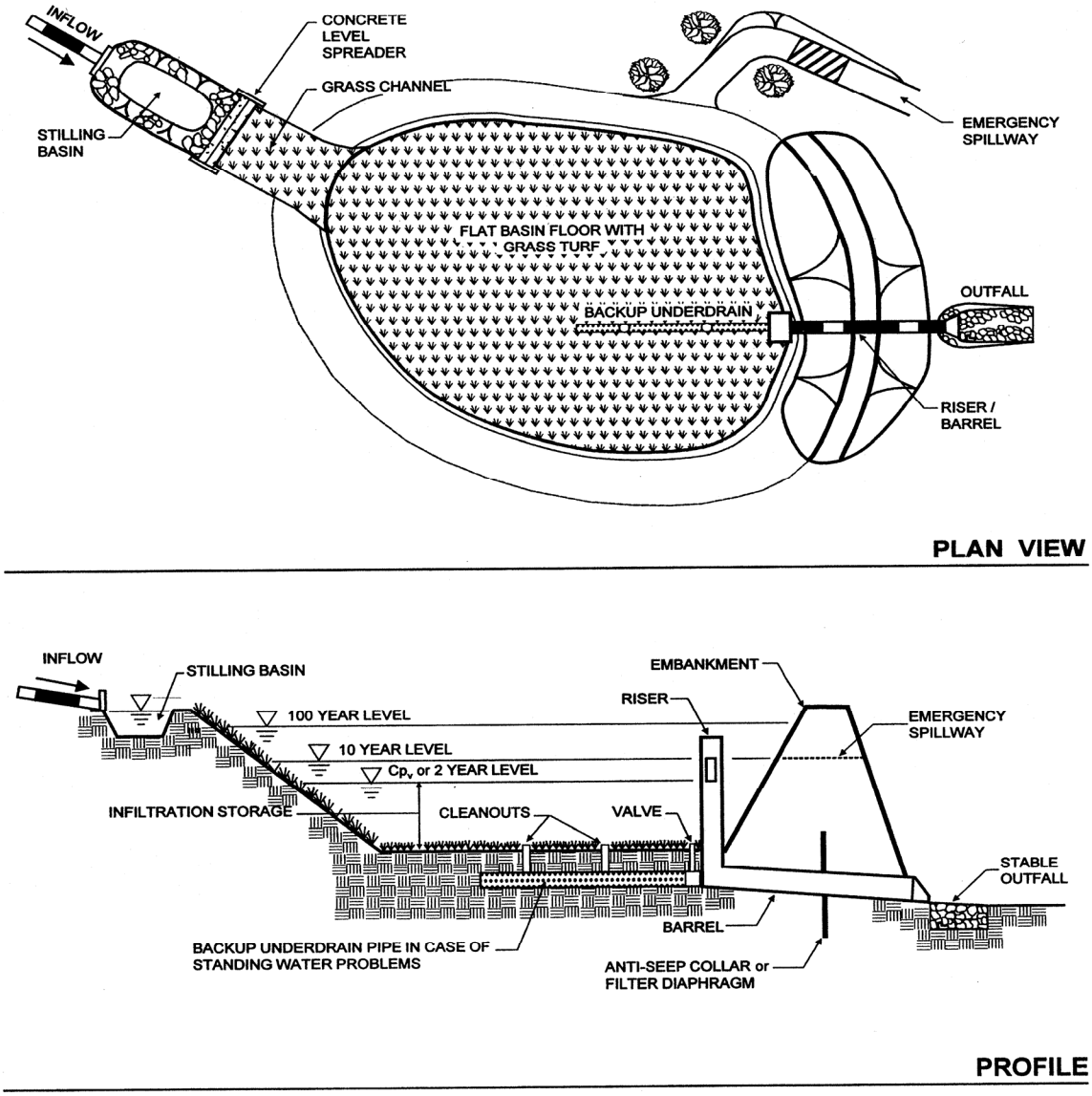


Figure 5-6: Example of a typical Infiltration Basin design.
(modified from CASQA, 2003)

5.3.2 SURFACE SAND FILTERS

5.3.2 Surface Sand Filters

Description

Surface sand filters, also known as Austin sand filters, are a type of media filter that applies a combination of sedimentation, filtration, and adsorption to remove sediment and associated pollutants. The surface sand filter is constructed of an upstream bypass structure (e.g. a weir), a sedimentation chamber, a flow distribution cell, and a sand filter bed. The purpose of the sedimentation chamber is to remove floatables and heavier suspended sediments. The sand filter bed removes lighter suspended sediments and additional contaminants. This BMP is widely used across the country. Site design configurations can vary significantly depending on local conditions and site constraints.

Photo: Kennedy/Jenks Consultants

Applications and Advantages

Applied to drainage areas ranging between 0.5 and 50 acres and containing both pervious and impervious surfaces. Surface sand filters are commonly applied at transportation facilities, large parking areas, and around commercial developments. They can also be applied in highly developed areas, on sites with steep slopes, and to retrofit existing sites. However, sand filters should not be applied where high sediment loads are expected unless a pretreatment device is to be applied.

Limitations

- Can frequently become clogged in areas with highly erodible or unstable soils.
- Clogging of the sand media in surface sand filters installed along roadways commonly occurs 2 – 10 years after installation if not maintained.
- Can only be used in areas where sufficient vertical relief in the land topography is available to allow the system to drain by gravity.

5.3.2 SURFACE SAND FILTERS

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	80 - 90
Total Phosphorus	45 - 55
Total Nitrogen	35 - 55
Total Zinc	50 - 80
Total Lead	60 - 80
BOD	60 - 80

Source: UDFCD, 1999.

Siting Criteria

- Sufficient vertical relief in land topography is required to allow the system to drain by gravity.
- Relatively large drainage areas require large surface sand filters. Therefore a significant amount of available open space may be required.
- A minimum distance of 3 feet should exist between the high seasonal water table and the bottom of the filter bed.
- Do not install in areas with highly erodible or unstable soils.

Design and Construction Criteria

- Registered professional civil engineers should design surface sand filters.
- Sand and gravel should be rinsed with potable water prior to installation and construction of the sand filter. Sand and gravel should not be washed with recycled wash water, which typically includes sediment, dissolved pollutants and a high Ph.
- In areas where large sediments loads in runoff are present, a pre-treatment BMP should be installed upstream of the surface sand filter.
- In areas of shallow groundwater, a liner may need to be installed below the sand filter to prevent potential groundwater contamination.
- Do not use as a sediment basin during construction.
- An upstream diversion structure should be used. The diversion structure should effectively isolate the water quality volume (WQ_V) and convey flows greater than the WQ_V past the basin.
- The sedimentation basin should be sized to capture and detain the WQ_V plus a minimum freeboard of 0.5 ft.
- The WQ_V sizing method is described in Section 4.5.1.

5.3.2 SURFACE SAND FILTERS

- Minimum depth of the sedimentation basin (d_f) is 3 feet.
- The sedimentation basin length to width ratio should be a minimum of 2:1.
- The sedimentation basin should not drain in less than 24 hours.
- The minimum surface area of the sedimentation basin (A_S) should be determined using the following equation:

$$A_S = WQ_V / d_f$$

Where: A_S = Surface area of the sedimentation basin in ft^2

WQ_V = Water Quality Volume in ft^3

d_f = Sediment basin depth in feet

- The sedimentation basin design criteria are summarized in Table 5-3.
- A trash rack should be provided around the outlet structure from the sedimentation basin. Openings in the trash rack should not exceed 1/3 the diameter of the vertical riser pipe. The trash rack should be made of a durable rust resistant material. A cone of 1 to 3-inch gravel should be placed around the base of the riser pipe to prevent clogging of the bottom perforations.

Table 5-3: Sedimentation Basin Design Criteria

Parameter	Design Criteria
Maximum drainage area	50 acres
Minimum sedimentation basin depth, d_f	3 ft
Minimum allowable surface area, A_S	WQ_V /10
Minimum length to width ratio	2:1
Maximum WQ_V drawdown time	24 hrs
Minimum freeboard	0.5 ft above WQ_V water level
Minimum basin volume	WQ_V + 1 ft freeboard
Maximum inlet entrance velocity	3 fps

- The primary design parameter of the sand filter basin is the surface area, which is a function of the sand permeability, the sand bed depth, the hydraulic head and the expected sediment loading.
- The required sand filter basin surface area (A_f) can be determined using the following equation, and the design criteria provided in Table 5-4.

$$A_f = (WQ_V)(d_f)/k(h + d_f)t_f$$

Where: A_f = surface area of the filter basin in ft^2

WQ_V = Water Quality Volume in ft^3

d_f = sand bed depth in feet

k = coefficient of permeability for the sand filter in ft/hr (typically 1.18 ft/hr for clean, well graded sand with d_{10}=0.1 mm)

h = one half of the maximum allowable water depth (2h) over the filter bed in ft

t_f = time required for the WQ_V to pass through the filter in hrs

- A gravel layer and under drain system should be placed below the sand filter layer.
- A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal should be installed between the sand filter and the gravel under drain.
- Additional design criteria for the sand filter basin are summarized in Table 5-4.

5.3.2 SURFACE SAND FILTERS

Table 5-4: Sand Filter Basin Design Criteria

Parameter	Design Criteria
Minimum sand depth, d_f	18 in
Filter sand size	ASTM 33 concrete sand
Minimum under drain gravel bed depth	16 in
Under drain gravel size	coarse aggregate[31]
Minimum water depth over sand filter, h	3 ft
Minimum gravel depth under sand filter	2 in
Minimum filtration rate of sand filter, k	3.5 ft/day
Slope of sand filter surface	0 (horizontal)
Minimum gravel cover over under drain pipes	2 in
Minimum under drain pipe size and type	6 in Schedule 40 PVC
Minimum under drain pipe slope	1 percent
Minimum under drain perforation size, diameter	3/8 in
Minimum number of perforation holes per row	6
Maximum spacing between rows of holes	6 in
Maximum WQ_V drawdown time, t_f	40 hrs

Inspection and Maintenance Requirements

- Inspect the system at least 3 times a year, once at the beginning of the rainy season and after major storm events to remove litter and debris and to keep the filter from clogging.
- Access should be provided for maintenance and repairs.
- Excess plant growth within the filter is not recommended.
- Rake the top 3 – 5 inches of sand once per year or when drainage begins to slow or pond. Remove sediments when accumulation exceeds 0.5 inches.
- If sand filter does not drain within 40 hours, maintenance is required.
- Every 2 – 5 years the vegetative cover should be removed for maintenance of the sand filter.
- Sand and gravel filter media may need to be replaced every 3 to 5 years.

[31] XX (aggregate specifications to be developed by the City of Salinas)

5.3.2 SURFACE SAND FILTERS

References

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

City of Austin, 2003. Environmental Criteria Manual.

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures, Sacramento Stormwater Management Program.

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #40 – Sand Filter. http://www.deq.state.id.us/water/permits_forms/permitting/catalog_bmps.cfm

Stormwater Technology Fact Sheet, Sand Filters, U.S. Environmental Protection Agency, http://www.epa.gov/owm/mtb/sandfltr.pdf

Stormwater Management Fact Sheet: Sand and Organic Filter, The Stormwater Manager's Resource Center, http://www.stormwatercenter.net/

Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

U.S. Department of Transportation, Federal Highway Administration, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, Fact Sheet – Surface Sand Filters, http://www.fhwa.dot.gov/environment/ultraurb/3fs8.htm

5.3.2 SURFACE SAND FILTERS

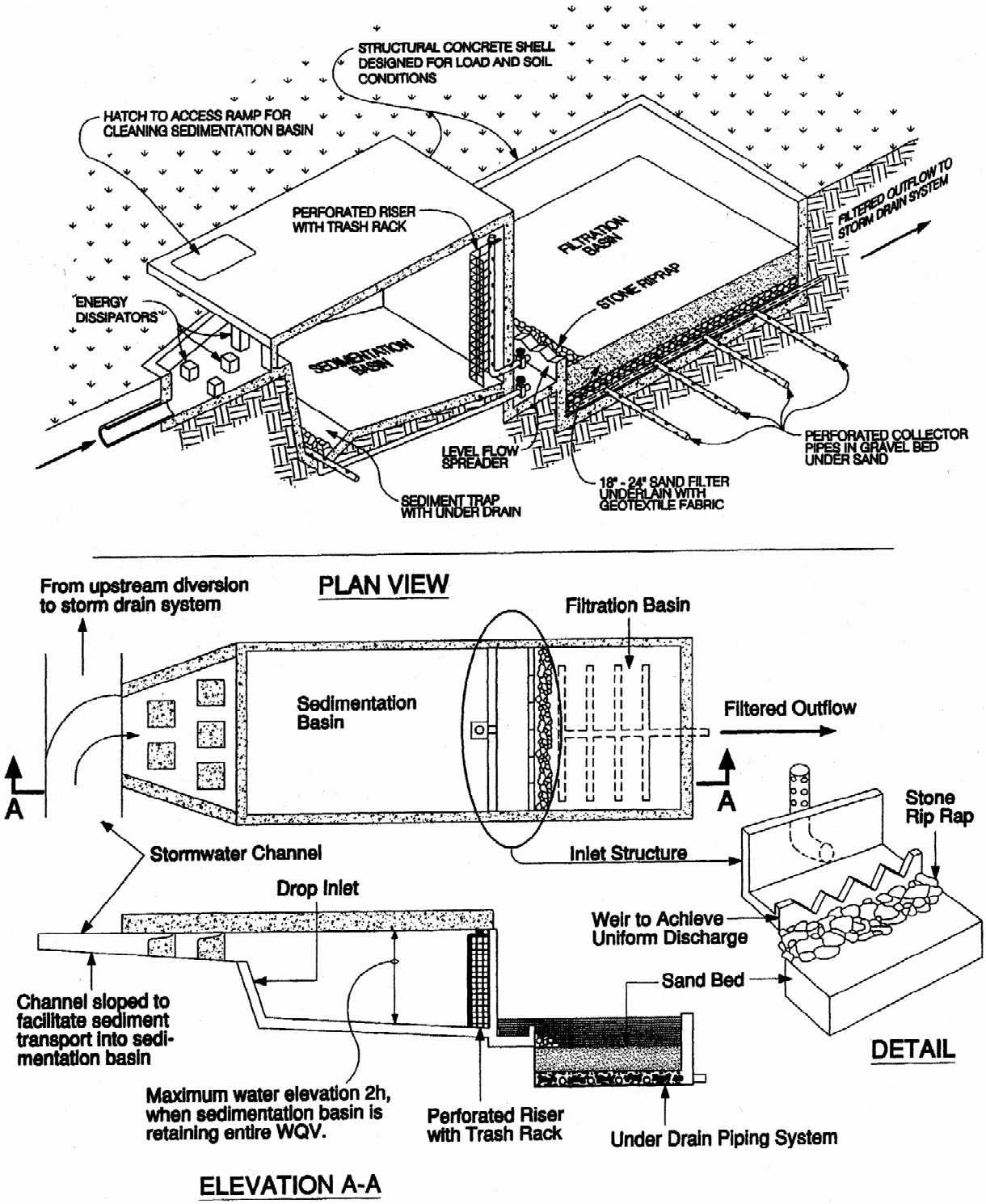


Figure 5-7: Conceptual Surface Sand Filter design.
(modified from City of Austin, 2003)

5.3.3 UNDERGROUND SAND FILTERS

5.3.3 Underground Sand Filters

Description

Also known as the D.C or a Delaware sand filter, the underground sand filter is composed of three main chambers and is located underground. The underground sand filter is constructed of a bypass chamber, a sedimentation chamber, a flow distribution cell, and a sand filter bed. The purpose of the sedimentation chamber is to remove floatables and heavy sediments. The sand filter bed removes suspended sediments and associated pollutants such as fecal coliform bacteria, trace metals, and oil and grease from the storm water runoff.

Source: Center for Watershed Protection

Applications and Advantages

Generally applicable for treating runoff from drainage areas containing a significant percentage of impervious area such as roadways, parking lots, commercial and industrial areas. Underground installation allows for placement under parking lots, sidewalks, and close to buildings. These filters are well adapted for locations with limited land area. Because the filter is located below grade, vandalism is not a concern and climate does not have a large impact on effectiveness.

Limitations

- Standing waters in the sediment chamber may provide mosquito habitat if access through manhole covers or other points of entry is available. Prevent vector entrance (mosquitoes, rodents, etc.) by covering the manhole covers and other points of entry.

Performance Data

The literature reported range of removal for various pollutants is as follows:

5.3.3 UNDERGROUND SAND FILTERS

Pollutant	Percent Removal Efficiency
Total Suspended Solids	80 - 90
Total Phosphorus	45 - 55
Total Nitrogen	35 – 55
Oil and Grease	70 - 80
Total Recoverable Zinc	50 – 80
Total Recoverable Lead	60 - 80
Biochemical Oxygen Demand	60 - 80
Fecal Coliform Bacteria	40 - 80

Sources: UDFCD, 1999; FHWA, 2003.

Siting Criteria

- The D.C. type underground sand filter can be placed under roadways, parking lots, sidewalks or landscaped areas and can treat drainage areas of up to 1.5 acres.
- The Delaware type underground sand filter is typically placed along the perimeter of parking lots and can treat drainage areas of up to 5 acres.
- Issues of buoyancy should be considered in areas with high groundwater tables.
- Do not install in drainage areas with highly erodible or unstable soils.

Design and Construction Criteria

The following design criteria apply to both D.C. and Delaware type underground sand filters.

- Registered professional civil engineers should design underground sand filters.
- Sand and gravel should be rinsed with potable water prior to installation and construction of the sand filter. Sand and gravel should not be washed with recycled wash water, which typically includes sediment, dissolved pollutants and a high Ph.
- Design the structure to detain the water quality volume (WQ_V) based on the method presented in Section 4.5.1.
- Flows in excess of the WQ_V should be diverted around the underground sand filter with an upstream diversion structure.
- Determine the maximum allowable depth of water in the underground sand filter (h_{max}) by considering the difference between the inlet and outlet invert elevations.
- The sand filter layer should consist of a minimum 16-inch gravel bed (d_g) covered with a minimum 18-inch sand filter layer (d_s) and a minimum 2-inch gravel layer above the sand filter layer. Geotextile fabric liners should be placed between the sand and gravel layers (e.g. above and below the sand layer).
- A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal should be installed between the sand filter and the gravel under drain.

5.3.3 UNDERGROUND SAND FILTERS

- The top of the sand and gravel filter should not have any slope or grade.

For D.C. type underground sand filter apply the following equations and the design criteria summarized in Table 5-5.

- The required sand filter basin surface area (Af) can be determined using the following equation:

$$A_f = (WQ_V)(d_f)/k(h + d_f)t_f$$

Where: A_f = surface area of the filter basin in ft^2

WQ_V = Water Quality Volume in ft^3

d_f = filter depth in ft ($d_f = d_g + d_s$)

k = coefficient of permeability for the sand filter (typically 1.18 ft/hr for clean, well graded sand with d_{10}=0.1 mm)

h = one half of the maximum allowable water depth (2h) over the filter bed in feet, $2h = (h_{max} – d_f)$

t_f = time required for the WQ_V to pass through the filter in hrs (max = 72 hrs)

- Considering site constraints, assume a filter width (W_f) and calculate the filter length (L_f) using: $L_f = A_f/W_f$
- Determine the volume of storage available above the filer bed using: $V_{tf} = A_f \times 2h$
- Compute the storage volume of the filter voids (V_v) by assuming a 40 percent void space and using: $V_v = 0.4 \times A_f \times d_f$
- Compute the flow through the filter during filling assuming 1 hour to fill the voids using: $V_q = kA_f(d_f + h)t_f / d_f$ (assume k = 0.0833 ft/hr and t_f = 1 hr)
- Compute net volume to be stored in the permanent pool awaiting filtration using: $V_{st} = WQ_V - V_{tf} - V_v - V_q$
- Compute the minimum length of the permanent pool using: $L_{pm} = V_{st}/(2h)(W_f)$

5.3.3 UNDERGROUND SAND FILTERS

Table 5-5: D.C. Type Underground Sand Filter Design Criteria

Parameter	Design Criteria
Maximum drainage area	1.5 acres
Filter sand size	ASTM 33 concrete sand
Typical sand coefficient of permeability (k) for sand with Dmax=10 mm and Effective Size D10=0.1 mm	1.18 ft/hr*
Maximum diameter of gravel in upper gravel layer	1 in
Diameter of gravel in under drain gravel layer	½ to 1 in
Minimum size of under drain pipes	6-in Schedule 40 PVC
Minimum size of perforations in under drain pipes	3/8-in diameter
Minimum number of perforations per under drain pipe	6
Minimum spacing of perforations	6 in
Maximum spacing of under drain pipes	27 in center to center
Minimum volume of sediment chamber	20 percent of the WQ_V
Minimum length of the clearwell chamber	3 ft

*USCOE, 2001 EM 1110-2-1100 Part VI

For Delaware type underground sand apply the following equations and the design criteria summarized in Table 5-6.

- When the maximum ponding depth above the filter (2h) is less than 2.67 feet, the area of the sediment chamber (A_s) and the area of the filter chamber (A_f) can be found using the following equation: $A_s = A_f = WQ_V / (4.1h + 0.9)$
- When the maximum ponding depth above the filter (2h) is 2.67 feet or greater, use the following equation: $A_s = A_f = (WQ_V)(d_f) / k(h + d_f)t_f$

Establish the dimensions of the facility assuming sediment chambers (A_s) and filter chambers (A_f) are typically 18 to 30 inches wide. Use of standard grates requires a chamber width of 26 inches.

5.3.3 UNDERGROUND SAND FILTERS

Table 5-6: Delaware Type Underground Sand Filter Design Criteria

Parameter	Design Criteria
Maximum drainage area	5 acres
Filter sand size	ASTM 33 concrete sand
Typical sand coefficient of permeability (k) for sand with D_{max}=10 mm and Effective Size D_{10}=0.1 mm	1.18 ft/hr*
Maximum diameter of gravel in upper gravel layer	1 in
Diameter of gravel in under drain gravel layer	½ to 1 in
Weir height between sediment chamber and sand filter	2 in above filter bed
Minimum size of under drain pipes	6-in Schedule 40 PVC
Minimum size of perforations in under drain pipes	3/8-in diameter
Minimum number of perforations per under drain pipe	6
Minimum spacing of perforations	6 in
Minimum weephole diameter	3 in
Minimum spacing between weepholes	9 in – center to center
Sedimentation chamber and sand filter trench width	18 to 30 in

*USCOE, 2001 EM 1110-2-1100 Part VI

Inspection and Maintenance Requirements

- The life of a well-maintained underground sand filter is between 5 and 20 years.
- Upon installation, water levels should be monitored every 3 months and after each big storm for the first year. Once the system is functioning properly, monitor 3 times a year.
- Monitor and record the depth of oil and grease ponding in the first chamber, depth of water over the sand medium, and the amount of material accumulated over the sand medium.
- Pump out the sediment chamber at least twice every year. After cleaning, refill the first chamber to a depth of 3 feet with clean water to reestablish the seals.
- The filter cloth and ballast gravel should be removed and replaced when drawdown takes longer than 72 hours.
- The three chambers need built-in ladders and manholes to allow access for cleaning and maintenance.
- Filter media may need to be replaced every 3 to 5 years.

5.3.3 UNDERGROUND SAND FILTERS

References

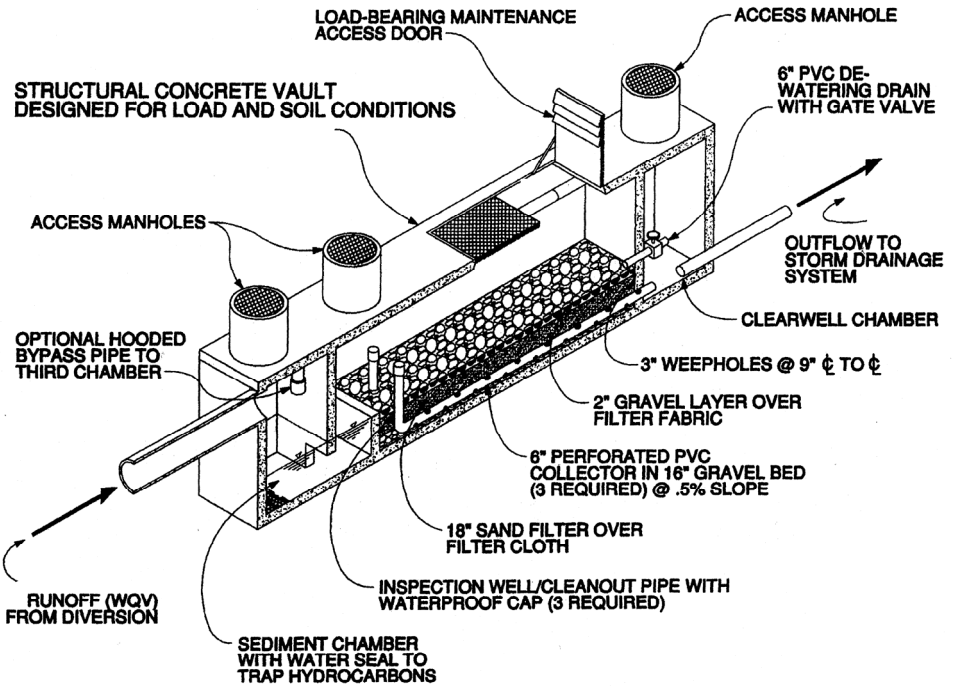
California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practice Handbook, New Development and Redevelopment.

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures, Sacramento Stormwater Management Program.

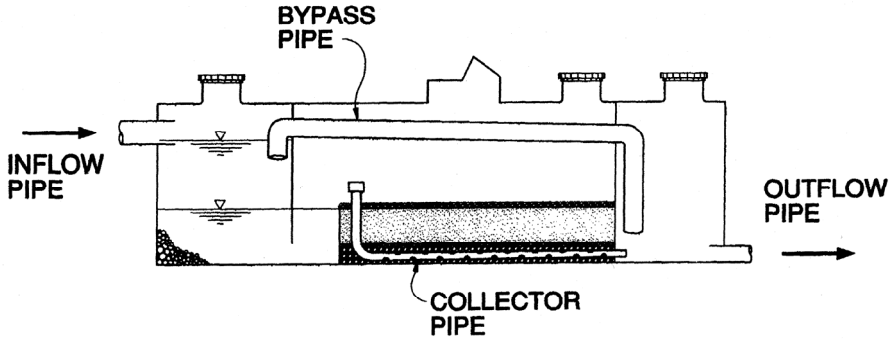
Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

U.S. Department of Transportation, Federal Highway Administration, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, Fact Sheet – Underground Sand Filters, http://www.fhwa.dot.gov/environment/ultraurb/3fs7.htm

5.3.3 UNDERGROUND SAND FILTERS



D.C. UNDERGROUND SAND FILTER SYSTEM



D.C. UNDERGROUND SAND FILTER HOODED BYPASS ILLUSTRATION

Figure 5-8: Example of a D.C. type Underground Sand Filter. (modified from City of Sacramento, 2000)

5.3.3 UNDERGROUND SAND FILTERS

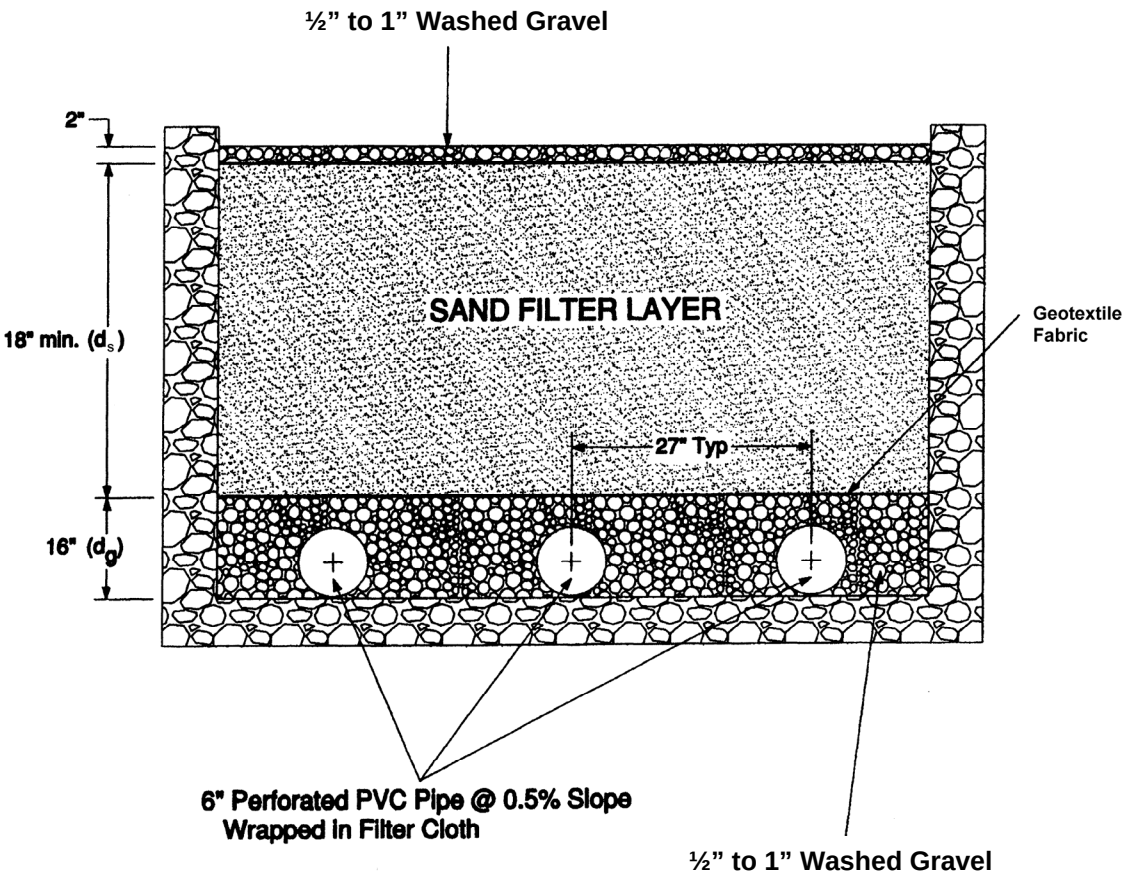


Figure 5-9: Cross-section of a D.C. type Underground Sand Filter.
(modified from City of Sacramento, 2000)

5.3.3 UNDERGROUND SAND FILTERS

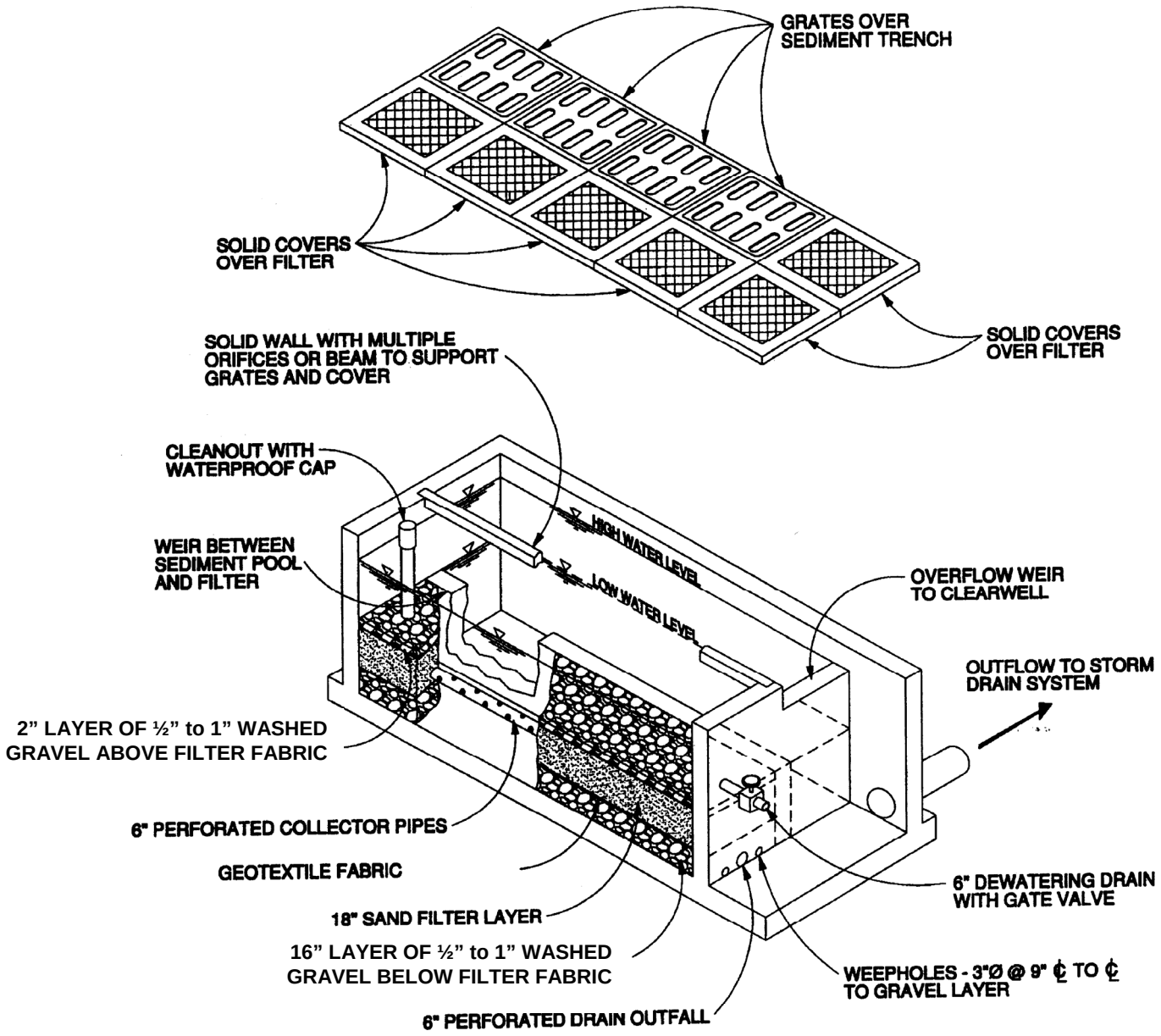
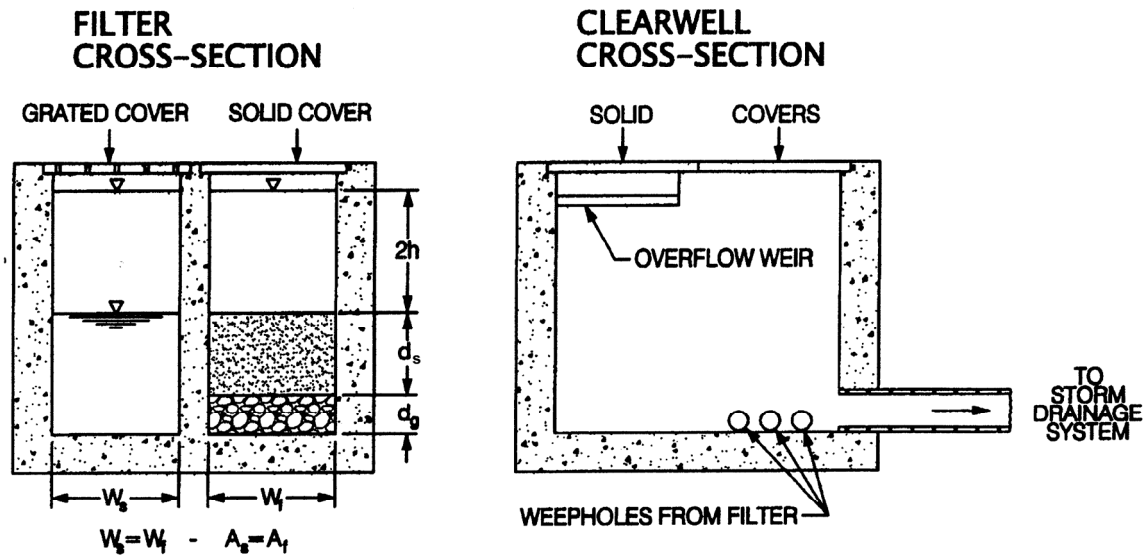


Figure 5-10: Example of a Delaware type Underground Sand Filter.
(modified from City of Sacramento, 2000)

5.3.3 UNDERGROUND SAND FILTERS



Where:
W_s = Width of sediment chamber
W_f = Width of filter
A_s = Area of sediment chamber
A_f = Area of filter
2h = Maximum achievable ponding depth over filter
d_s = Depth of sand
d_g = Depth of gravel underdrain

Figure 5-11: Cross-sections of a Delaware type Underground Sand Filter showing dimensional relationships.
(modified from City of Sacramento, 2000)

5.3.4 SEDIMENTATION BASINS

5.3.4 Sedimentation Basins

Description

Also known as extended detention basins or dry ponds, sedimentation basins allow for the collection and slow draining of frequently occurring runoff producing storm events. The outlet structure is specifically designed to detain the water quality volume for a minimum of 72 hours to allow fine-grained sediments and associated pollutants to settle. Between storm events, the basin is typically dry. Sedimentation basins are typically unlined and depending on the characteristics of the local underlying soils, some infiltration also typically occurs, providing additional pollutant load reduction and groundwater recharge. Sedimentation basins not only improve water quality, but can also provide flood control by including additional flood detention storage. The outlet structure of sedimentation basins can be used to retrofit existing flood control detention facilities, providing a significant storm water quality treatment enhancement. This type of structural treatment control measure requires a minimal amount of hydraulic head and has few siting constraints, making it one of the most flexible and applicable technologies for storm water treatment.

Source: Caltrans

Applications and Advantages

Typically used as a regional method of improving urban runoff storm water quality from residential, commercial, and industrial areas. However, this treatment technology can also be used on a small scale as a pretreatment device for additional treatment controls.

Limitations

- Unless landscaped and properly maintained, sedimentation basins can detract from the value of surrounding homes.
- If the outlet is located next to a stream or a wetland, discharges from sedimentation basins can increase water temperatures downstream.
- Not effective in areas with clay soils.

5.3.4 SEDIMENTATION BASINS

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Influent	Effluent
Total Suspended Solids (mg/l)	87.7 (48.4-159)	41.4 (30.8-55.5)
Total Copper (µg/l)	32.3 (22.7-46)	18.9 (16.6-23.4)
Dissolved Copper (µg/l)	12.1 (8-18.3)	14.7 (11.4-20.9)
Total Lead (µg/l)	69.2 (33.6-143)	15.0 (9.2-23.8)
Dissolved Lead (µg/l)	3.4 (2-5.8)	2.33 (1.7-3.3)
Total Zinc (µg/l)	274 (178-422)	85.3 (50.6-143.7)
Dissolved Zinc (µg/l)	n/a	n/a
Total Phosphorus (mg/l)	0.4 (0.3-0.5)	0.3 (0.2-0.44)
Total Nitrogen (mg/l)	n/a	n/a
TKN (mg/l)	1.99 (1.6-2.5)	1.87 (1.46-2.39)

Source: International BMP database, 2005

Pollutant removal efficiencies may be improved by adding a small, shallow permanent pool or wetland to the floor of the sedimentation basin.

Siting Criteria

- Do not place sediment basins adjacent to sensitive wetlands or perennial streams.
- Existing flood control detention basins can be retrofitted with sedimentation basin outlet structures.
- To be applied on sites with a minimum drainage area of 5 acres.
- Can be applied in areas underlain by all soil and rock types (except clayey soils).
- Sedimentation basins should not intersect the groundwater table.
- If part of a regional flood control facility, the area within a sedimentation basin that detains the water quality volume is not recommended for ballparks, picnic areas, or playing fields.

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design of sedimentation basins.
- Calculate the water quality volume (WQ_V) for the drainage area based on the method presented in Section 4.5.1.

5.3.4 SEDIMENTATION BASINS

- The basin should be designed to hold a volume equal to 120 percent of the WQ_V.
- The outflow structure should be designed to drain the water quality volume to be released within a minimum of 48 hours with no more than 50 percent draining within a 24-hour period.
- The maximum basin drain time is 72 hours to prevent mosquito breeding.
- A trash rack should be provided and sized such that the hydraulic capacity of the outlet is not affected.
- The basin should have a minimum length to width ratio of 2:1 (3:1 is preferable).
- Optimal depth of sediment basins ranges from 2 – 5 feet.
- Side slopes within the sedimentation basin should be 4H:1V or flatter. Exterior side slopes should not be steeper than 3H:1V.
- Embankment soils should be compacted to 95 percent of their maximum density.
- If the structure is an in-line treatment control (e.g. no upstream diversion structure), an emergency spillway should be provided capable of safely passing up to and including the 100-year storm event.
- Vegetation can be installed on the bottom of the ponds, along banks and on the side slopes to provide stability.
- Stones or gabions may be used on the banks.
- An access and maintenance ramp should be provided.
- A forebay will aid in the settling out of particles by dissipating energy and collecting coarser grained sediments and debris.
- If outdoor storage of chemicals occurs within the drainage basin, an impermeable liner may be needed to prevent infiltration and groundwater contamination.
- Vegetation should be established immediately on the banks of the basin following installation.
- For perforated pipe outlet structures and structures with vertical plates and multiple orifices use the following equations to determine the required area per row of perforations:

$$A_O = WQ_V / K_{40}$$

Where: $K_{40} = 0.013D_{BS}^2 + 0.22D_{BS} - 0.10$

A_O= Total area of perforations per row (in^2)

WQ_V = Water Quality Volume (acre-ft)

D_{BS} = the depth of water above the centerline of the bottom row of perforations when the basin is retaining the WQ_V (ft)

- Select the appropriate perforation diameter and number of perforations per row (e.g. columns) with the objective of minimizing the number of columns and using a maximum perforation diameter of 2 inches.
- Rows should be spaced at 4 inches on center from the bottom perforation.

- Calculate the number of rows (nr) using the following equation:

$$nr = 1 + (12D_{BS}/3)$$

- Calculate the total orifice area by multiplying the area per row (A_O) by the number of rows (nr).
- A minimum ¼-inch steel screen should be placed over the outlet perforations to prevent debris from clogging the perforations. Stainless steel screen is recommended for long-term durability and performance.

Inspection and Maintenance Requirements

- Inspect after the first large storm event to ensure that the basin is draining as designed.
- Inspect before and after the rainy season for standing water, accumulation of sediments, debris and trash, presence of animal burrows, and the stability of surrounding slopes.
- Remove debris from screen covering perforations and overflow grate as needed.
- Vector control (mosquitoes, rodents, etc.), vegetation maintenance, and debris removal comprise the majority of maintenance activities.
- When the volume of accumulated sediments exceeds 10 percent of the basin volume, the sediments should be removed and the area should be regraded.
- If a spill occurs and hazardous materials contaminate soils in a sedimentation basin, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

References

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures, Sacramento Stormwater Management Program.

Maryland Department of the Environment (MDE), 2000. Maryland Stormwater Design Manual.

Sedimentation Basin, http://www.deq.state.mi.us/documents/deq-swq-nps-sb.pdf , Dec.1, 1992.

Urban Drainage and Flood Control District (UDFCD), 2005. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

Ventura County, 2002. Technical Guidance Manual for Stormwater Quality Control Measures. Ventura Countywide Stormwater Quality Management Program.

5.3.4 SEDIMENTATION BASINS

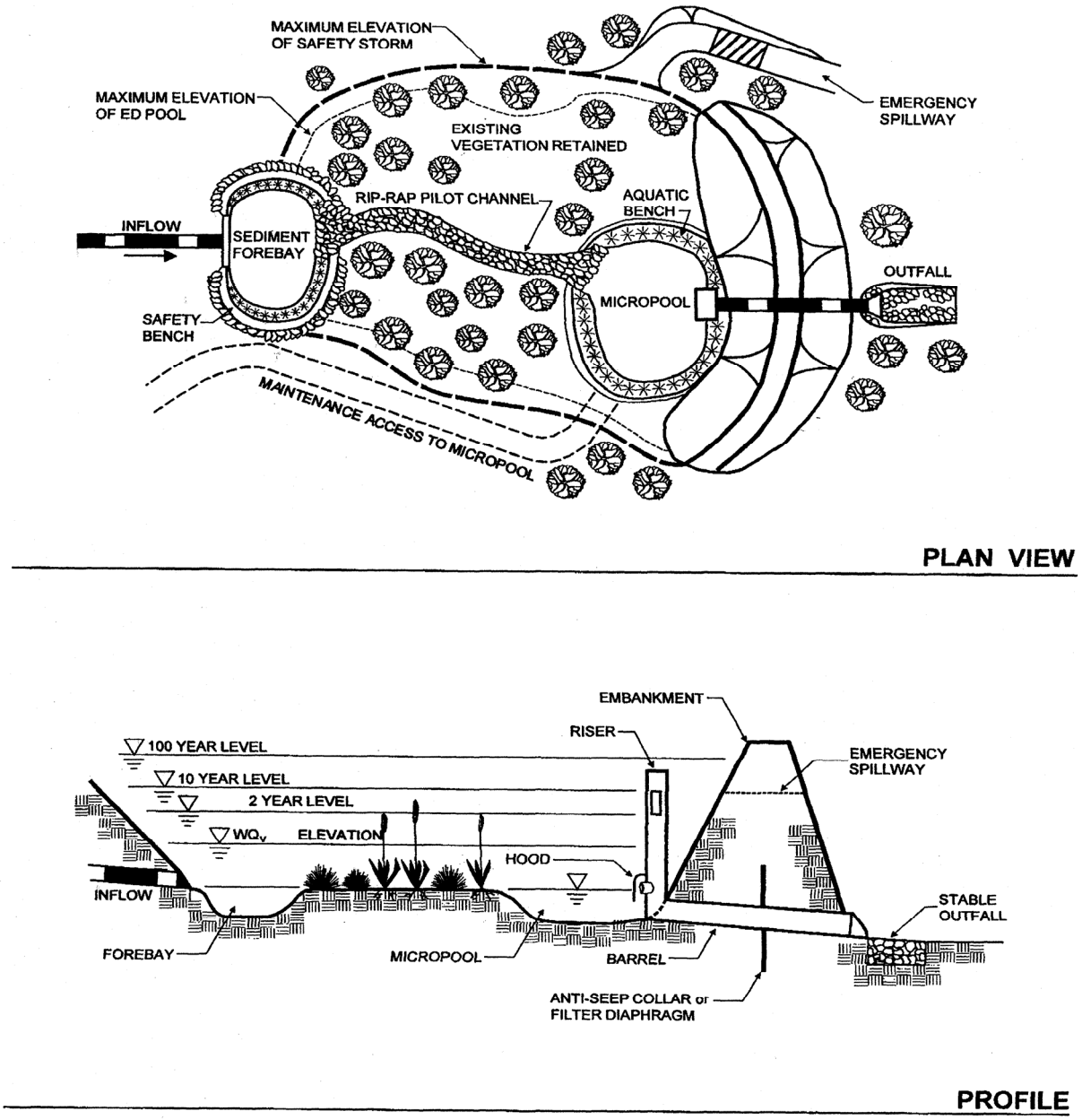
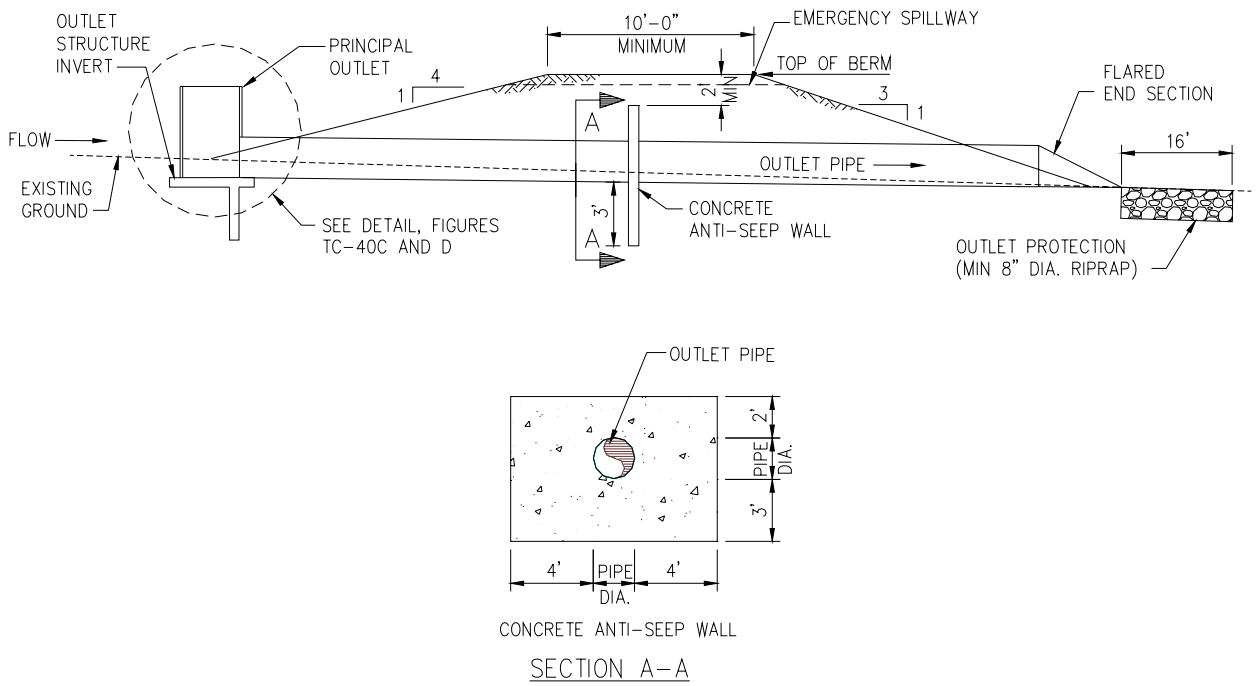


Figure 5-12: Typical components of a Sedimentation Basin.
(modified from MDE, 2000)

5.3.4 SEDIMENTATION BASINS

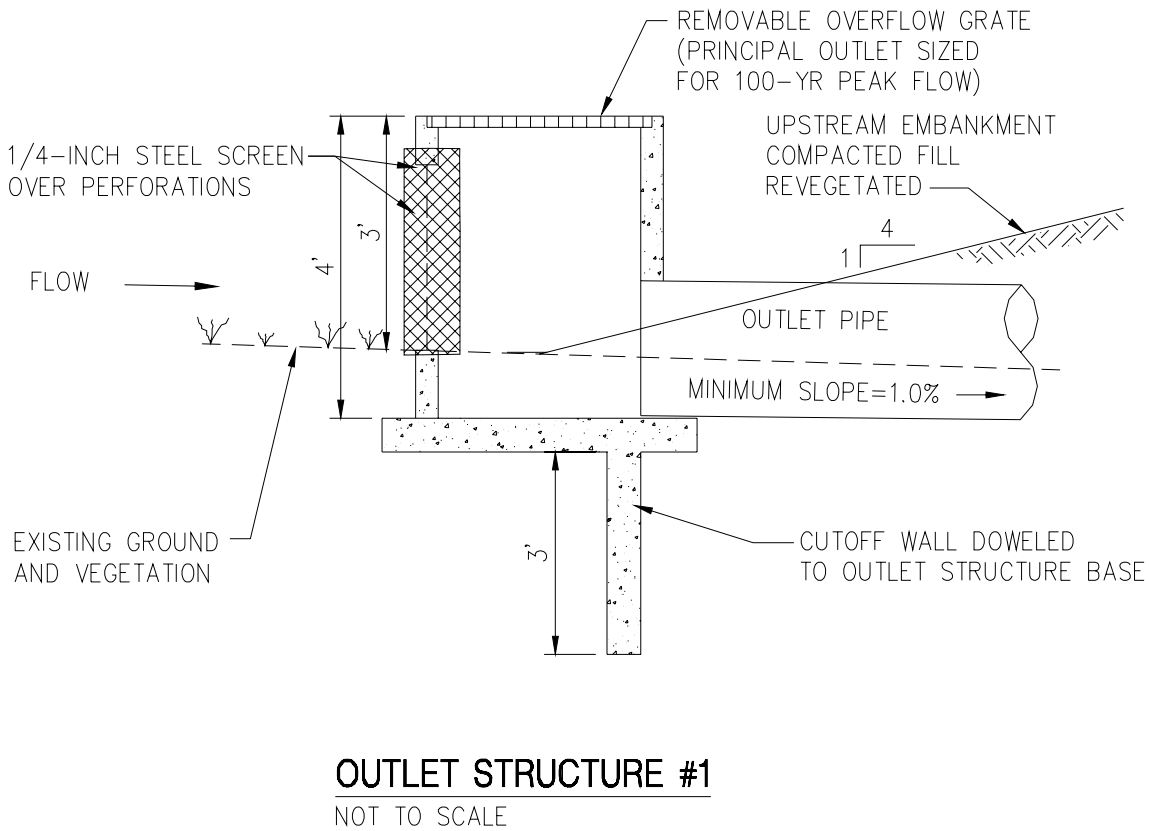


NOT TO SCALE

(Source: Kennedy/Jenks Consultants)

Figure 5-13: Example design of a sedimentation basin embankment and outlet structure.

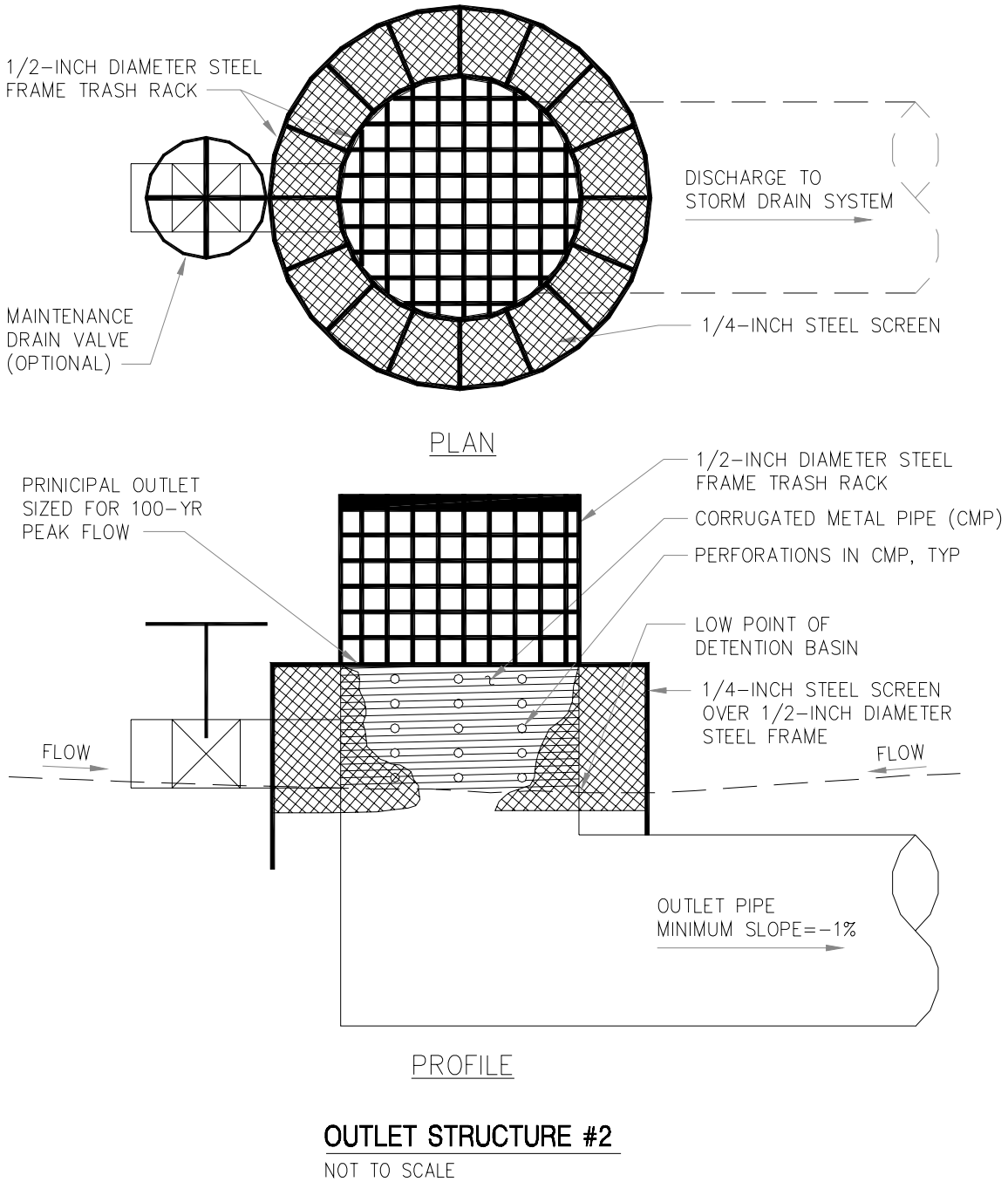
5.3.4 SEDIMENTATION BASINS



(Source: Kennedy/Jenks Consultants)

Figure 5-14: Example sedimentation basin outlet structure #1 – vertical plate with multiple orifices.

5.3.4 SEDIMENTATION BASINS



(Source: Kennedy/Jenks Consultants)

Figure 5-15: Example sedimentation basin outlet structure #2 – perforated pipe.

5.3.5 SAND FILTER BASINS

5.3.5 Sand Filter Basins

Description

A sand filter basin is a combination of a sedimentation basin and a sand filter. The water quality volume (WQ_V) collects in the basin and gradually infiltrates into an underlying sand bed with an under drain system. Fine grained sediments and associated pollutants are filtered out of the storm water and collected in the void spaces of the sand. The under drain system gradually dewaters the sand bed and filtered storm water then discharges into a vegetated swale, a channel or the storm drain system.

Source: UDFCD, Denver, CO.

Applications and Advantages

Sand filter basins can be applied in urban areas with thin soils or soils with low infiltration rates. They are generally used as offline treatment devices with an upstream diversion that diverts the water quality volume into the basin and allows larger flows to bypass. They should be sited in drainage areas with relatively low sediment loads and no baseflow.

Limitations

- Potential of clogging exists if runoff contains high amounts of clays and silts.
- Sand filter basins should not be installed in new development until construction is complete and disturbed soils are stabilized.

Performance Data

The literature reported range of removal for various pollutants is as follows:

5.3.5 Sand Filter Basins

Pollutant	Percent Removal Efficiency
Total suspended solids	80 - 90
Total Phosphorus	45 - 55
Total Nitrogen	35 – 55
Total Recoverable Zinc	50 – 80
Total Recoverable Lead	60 - 80
Biochemical Oxygen Demand	60 - 80

Source: UDFCD, 1999.

Siting Criteria

- Sand filter basins should not be installed near building foundations or in areas containing expansive soils.
- Due to the horizontal design of this BMP, it may be difficult to install a sand filter basin on a steep slope.
- Not to be used in areas where there is a high water table.
- Should not be used in drainage areas that have a perennial base flow because a preferential flow path through the sand filter may occur as well as clogging of the filter media.

Design and Construction Criteria

- Registered professional civil engineers should design sand filter basins.
- Sand and gravel should be rinsed with potable water prior to installation and construction of the sand filter. Sand and gravel should not be washed with recycled wash water, which typically includes sediment, dissolved pollutants and a high Ph.
- Size the basin to capture and treat the water quality volume (WQ_V) using the method outlined in Section 4.5.1.
- Flows in excess of the WQ_V should be diverted around or through the basin without resuspending collected sediments.
- The basin should be designed with a drain time of 72 hours.
- The maximum depth of the basin should be 3 feet.
- The minimum sand filter surface area (A_s in ft^2) at the base of the basin should be determined using the following equation:

$$A_s = WQ_V / 3 \text{ ft}$$

- The bottom of the sand filter basin should be lined with 18 inches of fine aggregate overlying a 9-inch gravel layer. XX (aggregate specifications to be developed by the City of Salinas)
- If chemicals are stored or handled within the catchment area, install an impermeable layer beneath the gravel layer.

5.3.5 SAND FILTER BASINS

- The following types of under drains can be applied: center collector pipe or a longitudinal pipe in a 9-inch gravel backfill containing a collector pipe at the outlet.
- Collector under drainpipes should have a minimum slope of 0.5 percent.
- The under drainpipes should have a minimum diameter of 6 inches and should be composed of perforated schedule 40 PVC.
- Basin side slopes should be 4H:1V or flatter.

Inspection and Maintenance Requirements

- Routinely remove debris and litter from the sand filter basin to minimize clogging and to maintain aesthetics.
- Replace vegetation and perform maintenance on the sand filter basin every 2 – 5 years by removing vegetation and the top 3 inches of the sand layer.
- Rake the top 3 – 5 inches of the filter surface a minimum of once a year.
- Inspect at least twice a year (with one inspection following a significant storm event) to ensure proper drainage and no ponding of water.
- If a spill occurs and hazardous materials contaminate the sand layer in a sand filter basin, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

References

Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

Urban Drainage and Flood Control District (UDFCD), 2005. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

Surface Sand Filters, Metropolitan Council/Barr Engineering Co., http://www.metrocouncil.org/environment/Watershed/bmp/CH3_STFiltSurfSand.pdf

5.3.5 Sand Filter Basins

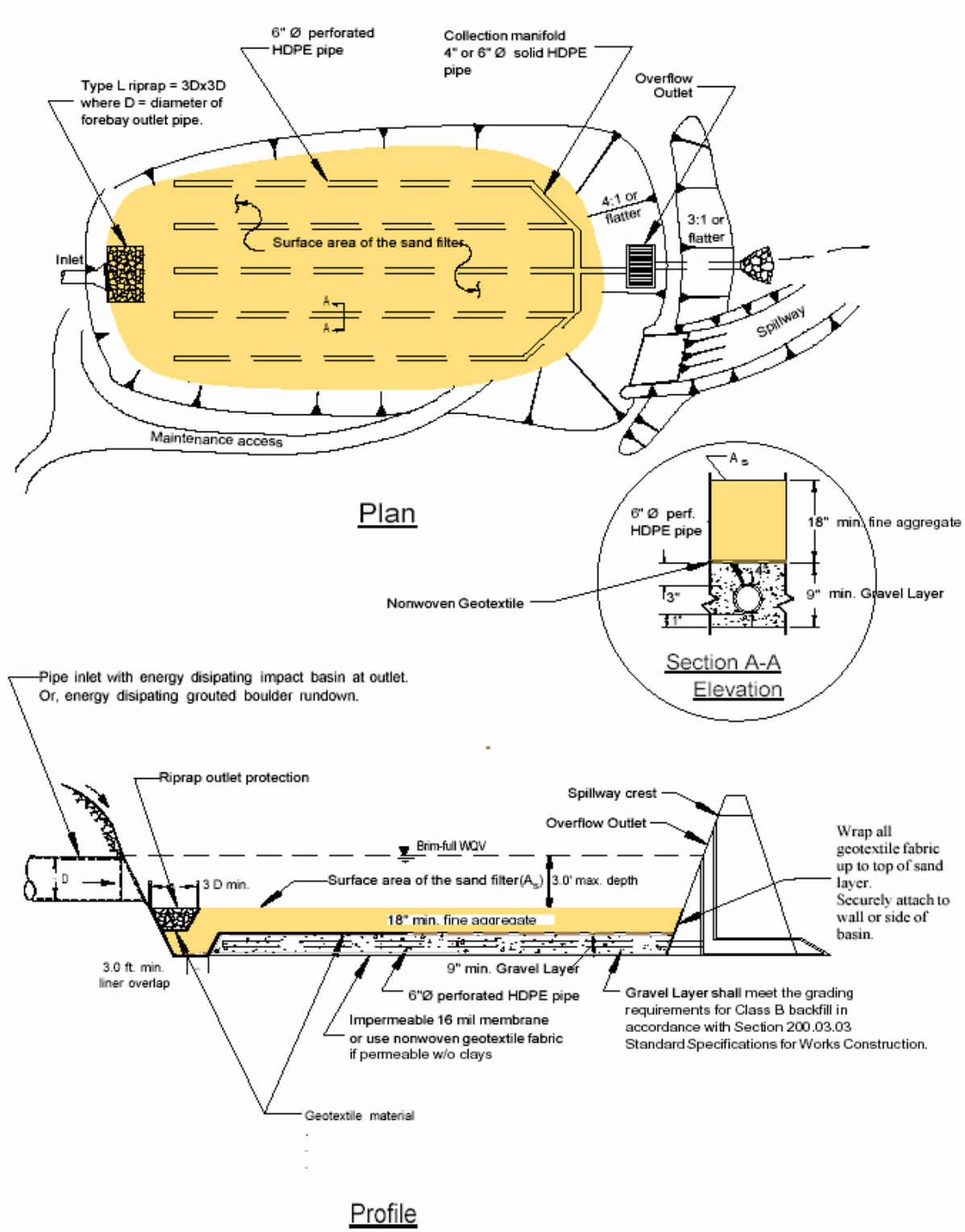


Figure 5-16: Example of a Sand Filter Basin design. (modified from UDFCD, 2005)

5.3.6 OIL AND WATER SEPARATORS

5.3.6 Oil and Water Separators

Description

Oil and water separators are also known as oil/grit separators and water quality inlets. They are typically designed to remove oil and grease and some sediment from storm water. They typically consist of three chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from storm water. Some oil and water separators contain screens to help retain floating debris. Many newer designs include coalescing plate interceptors that help promote oil/water separation. They are effective at capturing hydrocarbon spills. However, they are less effective at removing metals and nutrients and due to their limited storage capacity and flow through design; they have a limited ability to treat storm water runoff.

Applications and Advantages

Oil and water separators are typically applied at industrial areas where there is a risk of leaks and spills, such as airport aprons, equipment washdown areas, gas stations and loading docks. With regular maintenance, oil and water separators can also be used as pre-treatment systems before discharging to additional structural treatment controls.

Performance Data

Oil and water separators are effective at oil/water separation and recovery and some models can handle flow rates up to 5000 GPM.

Limitations

- Frequent maintenance is required to prevent resuspension and washout of the captured sediments.
- Other than oil/water separation and recovery, oil and water separators provide limited pollutant removal from storm water.
- Oil and water separators cannot be used for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.
- Standing waters in oil and water separators can provide a mosquito breeding habitat. Prevention is achieved through screening the ventilation pipes and other access points.

Siting Criteria

- Industrial areas where there is a risk of leaks and spills or as a pre-treatment device prior to discharge to another BMP.
- Contributing drainage areas one acre or less is recommended.

Design and Construction Criteria

- Registered professional civil engineers should design oil and water separators.
- Generally the permanent pool in an oil and water separator should be sized based on a minimum volume of 400 ft^3 per acre of impervious drainage area.

5.3.6 Oil and Water Separators

- Sizing of oil and water separators should conform to the manufacturer's recommendations.
- The depth of the sump should be at least four times the diameter of the inflow pipe.
- The outlet should be a minimum of 4 feet below the inlet.
- Vault baffles should be made of concrete, stainless steel, fiberglass reinforced plastic, or another noncorrosive material and should be securely fastened to the vault.
- Maximum allowable velocity through the inlet of the separator should be 0.5 ft/sec.
- Construction activities within the drainage area should be completed prior to installation of oil and water separators.
- Design life is either 50 years or manufacturer's specifications, whichever is less.

Inspection and Maintenance Requirements

- Maintenance is typically required every one to six months.
- Proper disposal of trapped sediment and oil and grease is required.
- In areas where high sediment loading is common, inlets should be inspected and cleaned after every major storm event and should be inspected monthly.
- Proprietary systems may have their own, specific maintenance requirements.
- Where appropriate, confined space entry procedures should be followed.

References

City of Boise, Storm Water Management: A Design Manual pg. 4-7

Minnesota Urban Small Sites BMP Manual, Detention Systems: Oil/Grit Separators
www.metrocouncil.org/environment/Watershed/bmp/CH3_STDetOilGrit.pdf

5.3.6 OIL AND WATER SEPARATORS

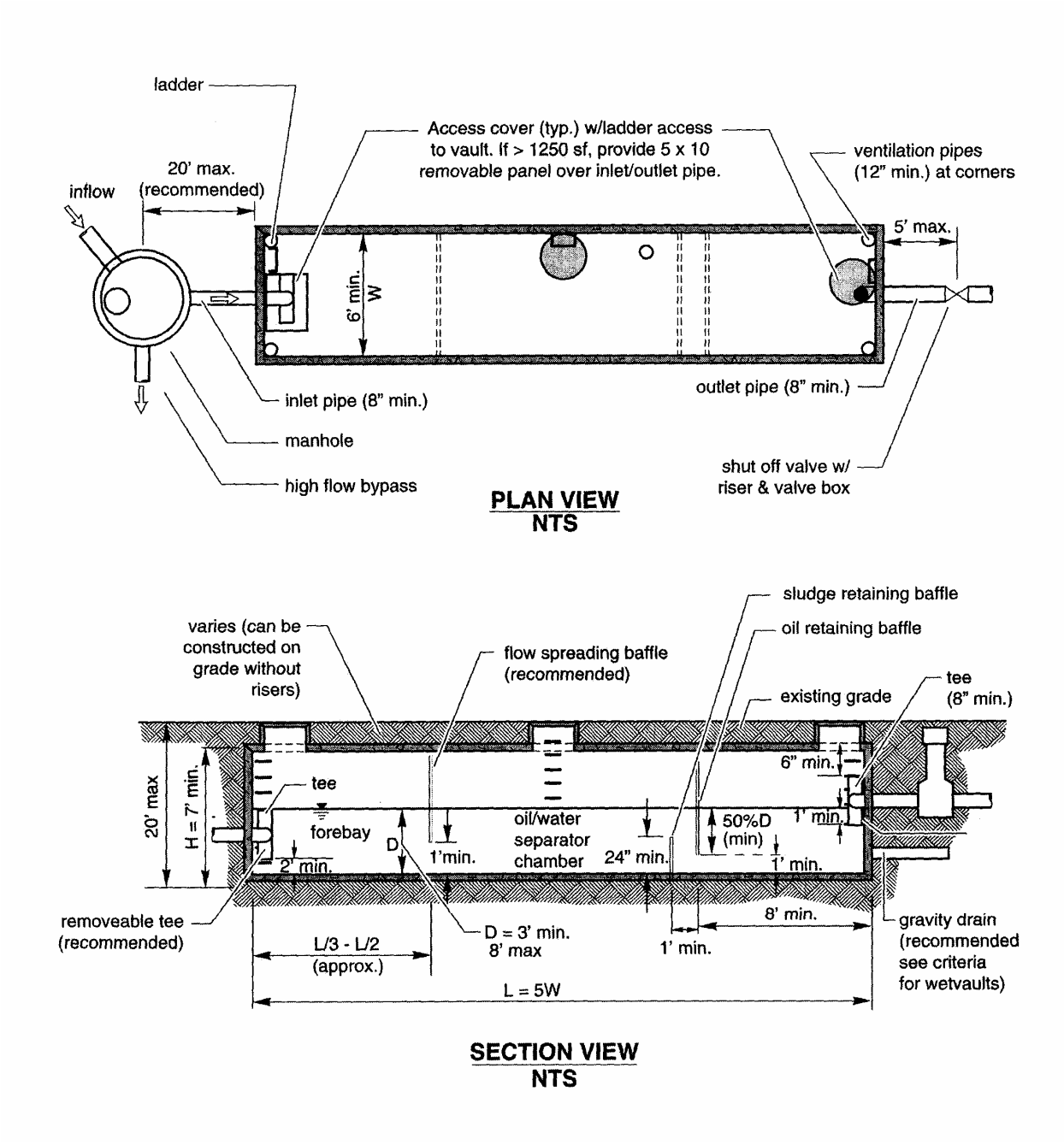


Figure 5-17: Example design and structural information for a typical oil and water separator. (Source: Washington Department of Ecology, 1999)

5.4 Manufactured Structural Treatment Control BMPs

Manufactured or proprietary treatment controls are commercially available storm water treatment devices that are designed and distributed by private companies. They are often prefabricated and available in a number of sizes depending on the flow rate or volume to be treated. They are also typically designed and sized based on criteria determined by the manufacturer, which often differs from the sizing criteria required by NPDES permits and municipalities such as the City of Salinas. Whenever possible, manufactured treatment control BMPs applied in the City of Salinas should be sized based on the criteria for public domain treatment controls presented in Sections 4.4.1 and 4.4.2 of this manual. However, alternative sizing criteria may be acceptable if it is commonly used in other communities and the manufacturer provides performance data that demonstrates acceptable pollutant removal rates.

Manufactured treatment controls can be applied in a wide variety of urban settings, but are often most useful where space is limited. Therefore, they can be particularly applicable to retrofit situations. The science and technology of storm water treatment is evolving and new and innovative structural treatment control BMPs continue to be developed. This is particularly true with manufactured treatment control BMPs. The manufactured treatment control BMPs that are currently available can be broadly grouped into the following categories:

- Hydrodynamic Separators
- Wet Vaults
- Modular Wetlands
- Catch Basin Inserts
- Media Filtration Systems
- Gross Solids Removal Devices

When used alone, the manufactured treatment control BMPs noted above and in the following fact sheets typically do <u>not</u> meet the MEP standard of the Salinas NPDES permit because they do not effectively reduce the rate and volume of urban runoff. Some manufactured treatment control BMPs, such as hydrodynamic separators, are also typically only effective at removing relatively coarse sediment, trash, debris and some oil and grease from urban runoff. Fine sediment, suspended sediment and dissolved pollutants, which are the primary pollutants of concern in the City of Salinas and in many other areas, are typically not effectively reduced. Therefore, additional downstream treatment may be required to meet the MEP standard. Manufactured treatment control BMPs can be effectively used for pretreatment or urban runoff, such as upstream of an infiltration system or a bioretention system for removal of coarse sediment, trash, debris prior to infiltration. Manufactured treatment control BMPs sometimes require relatively frequent maintenance and/or specialized equipment. Because they are typically underground, they can become “out of sight and out of mind” easily forgotten and not maintained. When this occurs, they can become a source of storm water pollution and/or a public health concern because they can hold standing water and breed mosquitoes. Therefore, the use of manufactured treatment control BMPs should consider the limitations and maintenance requirements of these devices prior to approval.

Note: The manufactured or proprietary treatment control BMPs discussed in this manual are provided only as examples of the types of devices that are currently commercially available. The companies and devices noted do not indicate an endorsement by the City of Salinas.

5.4.0 HYDRODYNAMIC SEPARATORS

5.4.0 Hydrodynamic Separators

Description

Hydrodynamic separators (a.k.a. vortex separators or swirl concentrators) are round gravity separators that are increasingly used for storm water treatment. They are designed to remove trash, debris, and some amount of sediment, oil, and grease from urban runoff. They consist of flow-through structures that have a settling or separation unit to remove sediment and other pollutants. The energy of storm water flowing into a hydrodynamic separator is utilized to create centrifugal forces that allow suspended sediment and attached pollutants to move to the center of the device and settle to the bottom. Hydrodynamic separators are best suited for heavy particulates (which settle) or floatables (which can be captured), rather than dissolved solids and pollutants that do not settle. Several examples of commercially available hydrodynamic separators have been provided in Figures 5-18 through 5-20.

Applications

Hydrodynamic separators are available in many sizes and are easily added to a new or existing storm drain system. They may achieve a pollution reduction performance similar to wet vaults, but in a smaller space. Their versatility makes them a good option for storm water “hotspots” such as near industrial sites where higher concentrations of pollutants are more likely.

Performance Data

Performance claims differ depending on the manufacturer and the type of separator. However, in general, hydrodynamic separators are capable of removing 90% of all particles with a specific gravity of 2.65 (glacial sand) down to 150 microns (CASQA, 2003). They can also effectively capture floatable trash and debris and oil and grease. Proper design and maintenance is necessary for maximum performance.

Limitations

- Will not significantly remove pollutants such as nutrients, which adhere to fine particulates or are dissolved.
- Typically not designed with significant detention storage, therefore is limited in the ability to reduce the rate or volume of runoff.
- Units with standing water potentially face problems with mosquito breeding.
- Non-steady flows of storm water decrease the efficiency that is estimated from testing under constant flow.

Siting Criteria

- Hydrodynamic separators can be installed anywhere a standard manhole can be installed. They can be retrofit into many locations including existing manholes.
- The size of the drainage area that can be served is directly related to the capacities of the largest models.
- Individual units can be placed in series to provide treatment for larger flows.

5.4.0 HYDRODYNAMIC SEPARATORS

Design and Construction Criteria

- Hydrodynamic separators are often sized based upon the manufacturers design criteria, which can vary significantly. The sizing requirements of hydrodynamic separators should be based on the water quality flow criteria outlined in Section 4.4.2. However, alternative sizing criteria may be acceptable if it is commonly used in other communities and performance data demonstrates acceptable pollutant removal rates.
- Hydrodynamic separators have two capacities, a treatment capacity and a hydraulic capacity. The designer should be certain that the peak flow of the design event matches the stated treatment capacity, not the hydraulic capacity.
- If an in-line facility, the design peak flow (hydraulic capacity) should be four times the treatment capacity.
- If an off-line facility, the design peak flow should be equal to the treatment capacity.
- Head loss differs by product and by model but is generally on the order of one foot or less.
- Soils should provide adequate bearing strength.
- Cost dependent on the flow rate to be treated, site constraints, source control implementation, and any other treatment technologies that are presently being used.
- Installation costs are generally 30 to 50% of the manufacturer's delivered cost.
- Eliminate access openings for adult mosquitoes.

Inspection and Maintenance Requirements

- For most sites, hydrodynamic separators are cleaned annually.
- Hydrodynamic separators should be inspected twice a year.
- A dipstick can be used to measure sediment level.
- Hydrodynamic separators should be cleaned when collected sediments reach 25% of the storage capacity.
- Cleaning can be accomplished with a sump vac or a vacuum truck.
- Proper disposal of trash, debris, sediment, oil and grease is required.

References and Sources of Additional Information

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment. http://www.cabmphandbooks.com/Development.asp

Minton, G.R., 2002. Stormwater Treatment, Biological, Chemical & Engineering Principles, Resource Planning Associates, Seattle, Washington.

USEPA, Stormwater Technology Fact Sheet: Hydrodynamic Separators. www.epa.gov/owm/mtb/hydro.pdf

5.4.0 HYDRODYNAMIC SEPARATORS

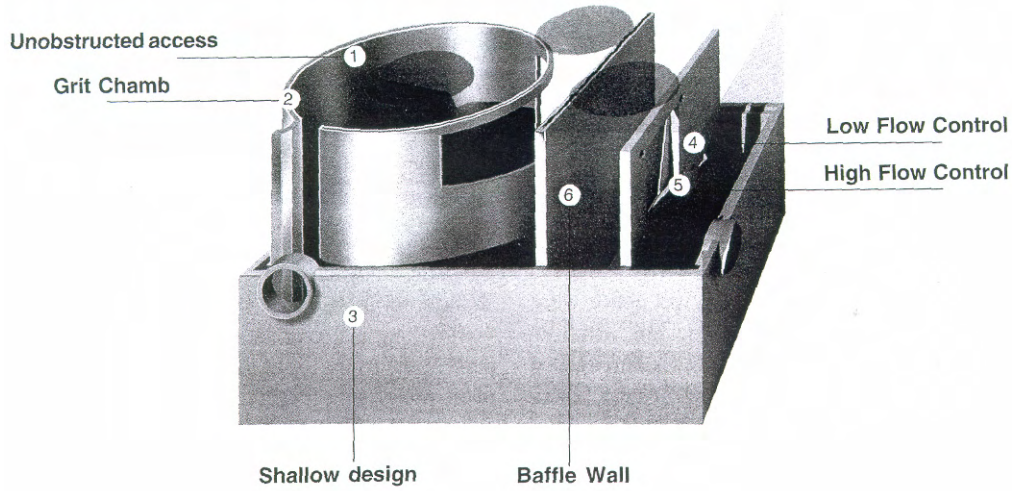


Figure 5-18: Vortechs System.

Graphic provided by Stormwater 360

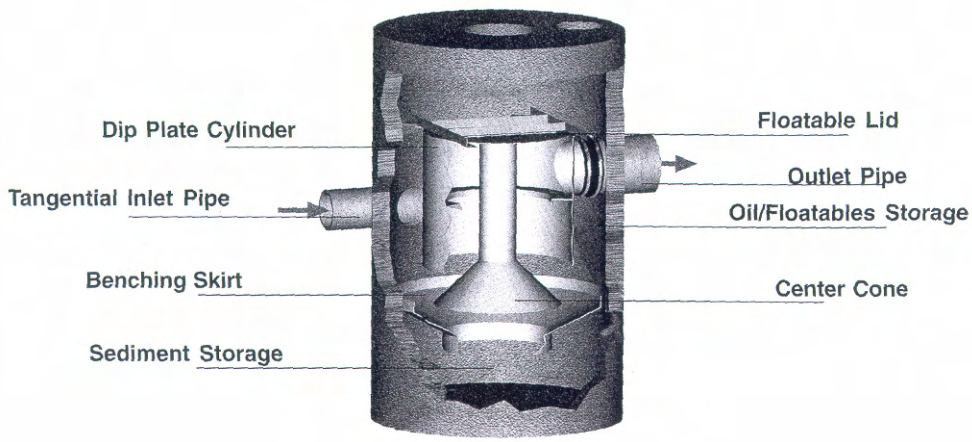


Figure 5-19: Downstream Defender™

Graphic provided by Hydro International, Inc.

5.4.0 HYDRODYNAMIC SEPARATORS

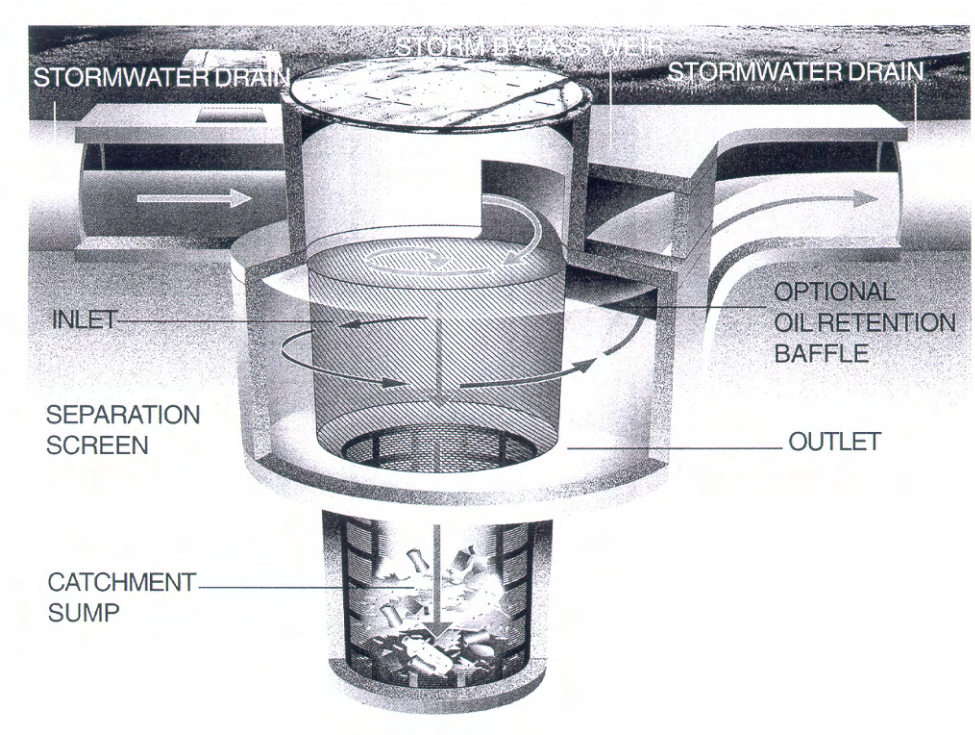


Figure 5-20: CDS Separator

Graphic provided by CDS Technologies Inc.

5.4.1 WET VAULTS

5.4.1 Wet Vaults

Description

Wet vaults are subterranean structures designed to dissipate the energy of storm water runoff with baffles and chambers and promote the settling of particulate storm water pollutants. They have a permanent pool of water, generally 3 to 5 feet deep. They may also have a constricted outlet that causes a temporary rise in the water level of the pool during storm events. The temporary additional volume of storm water generally drains within 12 to 72 hours after the end of each storm event. Wet vaults are typically used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs. Manufactured wet vaults generally fall into three classifications.

Type A (Figure 5-21) – This system consists of two standard precast manholes that create an upstream (primary) chamber and a downstream (storage) chamber. The manholes are sized to capture a desired treatment volume. Storm water runoff enters the primary chamber where coarse-grained solids settle and collect. Storm water then flows to the storage chamber carrying floatable debris and trash where they are captured and retained. Further sedimentation occurs in the storage chamber and flows in excess of the design treatment flow rate are bypassed around the storage chamber to the storm drain system. The storage chamber serves as an off-line reservoir for floatables and finer-grained sediments and storm water flows through it at flow rates less that the design treatment flow rate of the device. The bypass prevents the resuspension of sediments that have accumulated in the storage chamber. The manufacturer currently provides 5 models with treatment flow rates ranging from 1.1 to 21.8 cfs. The hydraulic capacities of the 5 models range from 8.5 to 100 cfs, respectively. Customized sizes are also available from the manufacturer that can handle higher flow rates than the design capacity of the standard models.

Type B (Figure 5-22) – This system is similar to a standard rectangular wet vault; however there are significant internal design differences. A series of baffles attached to the top and bottom function to reduce energy, aid in sedimentation and reduce the resuspension of collected sediments. The vault includes a permanent pool and a constricted outlet that causes a temporary rise in the water level of the pool during storm events. The system consists of standard modular units that can be configured to provide the desired treatment volume. Floating absorbent pads can also be added for oil and grease.

Type C (Figure 5-23) – This style of wet vault consists of one circular structure that can be constructed of a standard precast manhole. Larger drainage areas require the use of larger non-standard size manholes. A proprietary internal bypass weir structure routes all storm water flows up to the bypass rate into a center well where sedimentation occurs. Flows in excess of the treatment flow rate are diverted directly across the top of the center well and over the bypass weir to the storm drain system. These systems are best suited for drainages under 10 acres. The manufacturer provides the capacity and efficiency of these systems. Dimensions vary to accommodate a 24” storm drain pipe with a holding capacity of 470 gallons to a 60” storm drain pipe with a holding capacity of 15,918 gallons.

5.4.1 WET VAULTS

Applications

Wet vaults are typically used for commercial, industrial, or roadway projects where space constraints limit the use of other treatment controls.

Performance Data

The targeted constituents of wet vaults are sediment, nutrients, trash, metals, oil and grease, and organics. Manufactured wet vaults can be expected to perform similarly to Storm Water Ponds (TC-50) as long as the design features are effective at preventing the resuspension of collected sediments. However, there are not sufficient data indicating the incremental benefit of the particular design elements of each manufactured product.

Limitations

- Can be considerably more expensive than many other BMPs. However, the added cost may be offset by the value of continued use of the land surface.
- Wet vaults are believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper.
- As sediment fills the storage chamber of wet vaults, treatment efficiencies decline.
- There is some concern that oxygen levels in wet vaults may decline in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.
- Maintenance of wet vaults can require special equipment.
- No biological activity occurs to increase storm water treatment.
- Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault if regular maintenance is neglected.
- Standing water may create a mosquito-breeding habitat.
- The area served is limited by the capacity of the specific models.
- A loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units.

Siting Criteria

- There are no unique siting criteria. The size of the drainage area that can be served by a manufactured wet vault is directly related to the capacities of the specific models and individual site constraints.

Design and Construction Criteria

- Depending on the particular unit, it should be sized to convey the WQ_F or detain the WQ_V as outlined in Sections 4.5.1 and 4.5.2, respectively. However, alternative sizing criteria may be acceptable if it is commonly used in other communities and performance data is available that demonstrates acceptable pollutant removal rates.
- Wet vaults designed to treat the WQ_V should have a permanent pool with a capacity equivalent to the WQ_V and additional capacity equivalent to $2WQ_V$.

5.4.1 WET VAULTS

- Minimum of 3000 psi structural reinforced concrete. All construction joints should be provided with water stops. Pre-cast vaults should be designed by a structural engineer.
- All vault access openings should have round, solid, locking lids using 1/2-inch diameter allen head screw locks.
- Cost dependent on the volume to be treated, site constraints, and any source or treatment controls used within the drainage area.
- Installation costs are generally 50 to 100% of the manufacturers delivered cost.
- Soils should provide adequate bearing strength.
- Eliminate access openings for adult mosquitoes.

Inspection and Maintenance Requirements

- Recommended cleaning rates differ depending on the manufacturer and the land uses of the drainage area being treated. However, for most sites, wet vaults should be cleaned annually.
- Wet vaults should be inspected twice a year.
- A dipstick can be used to measure sediment level.
- Units should be cleaned when sediment reaches 25% of the vault storage capacity.
- Cleaning can be accomplished with a sump vac or a vacuum truck.
- Proper disposal of trapped sediment and oil and grease is required.
- Internal wet vault maintenance or repairs should meet OSHA confined space entry requirements.

References and Sources of Additional Information

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment. http://www.cabmphandbooks.com/Development.asp

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #51 – Wet Vault/Tank. http://www.deq.state.id.us/Water/stormwater_catalog/doc_bmp51.asp

Minton, G.R., 2002. Stormwater Treatment, Biological, Chemical & Engineering Principles, Resource Planning Associates, Seattle, Washington.

5.4.1 WET VAULTS

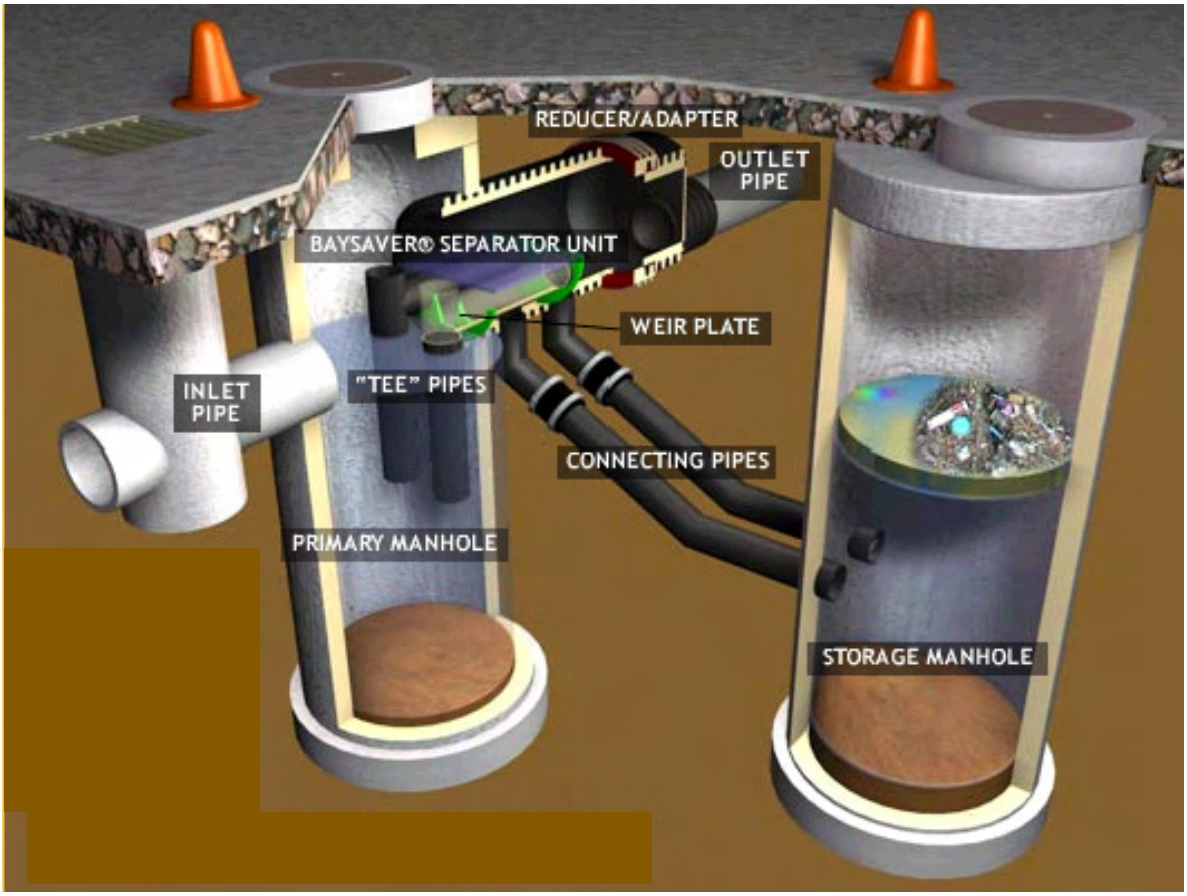


Figure 5-21: Type A System - BaySaver™

Graphic provided by BaySaver, Inc.

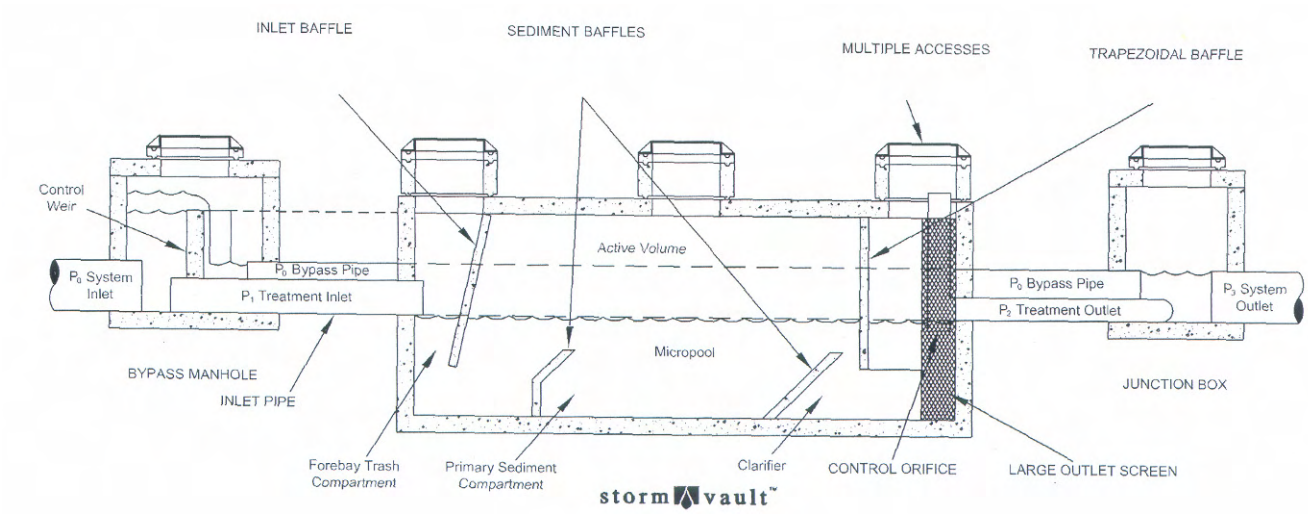


Figure 5-22: Type B System - Jensen StormVault™

Graphic provided by Jensen Precast, Inc.

5.4.1 WET VAULTS

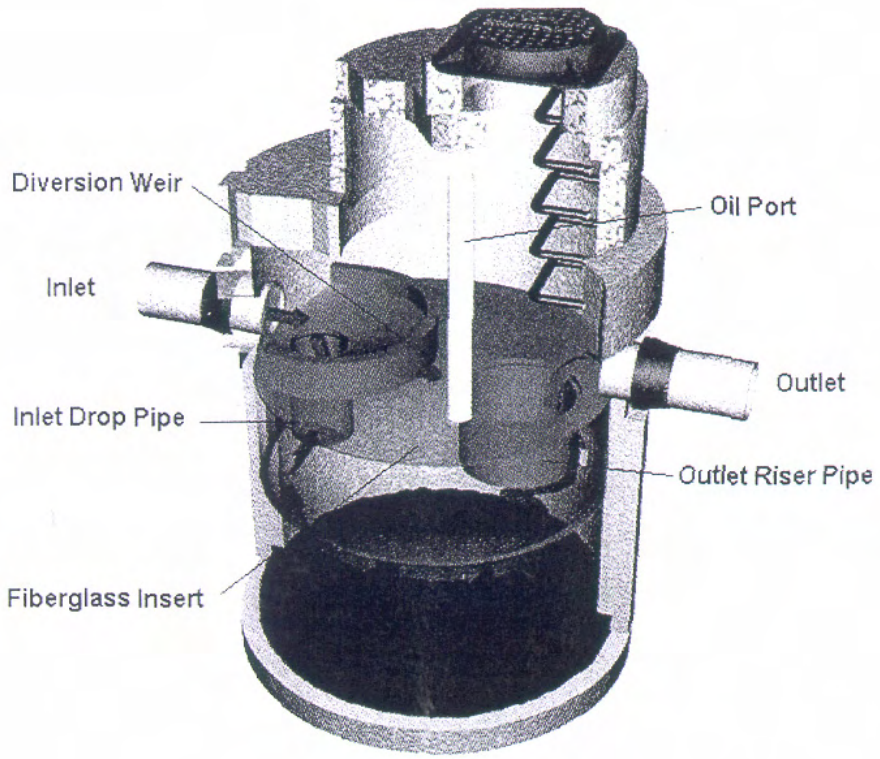


Figure 5-23: Type C System - Stormceptor®

Graphic provided by Rinker Materials, Inc.

5.4.2 MODULAR WETLANDS

5.4.2 Modular Wetlands

Description

Modular wetlands, or manufactured wetlands, consist of a two concentric chambers that circulate storm water for an extended period of time to allow for contact and interaction with wetland vegetation. The inner chamber is a closed storage tank and the outer chamber is filled with fine gravel and wetland vegetation such as cattails, reeds, and rushes. Storm water enters the center tank, moving in a circular motion around the tank, and then flows into the outer chamber via floating skimmers. A subsurface flow of storm water is routed through the gravel and wetland vegetation root system allowing for microbial utilization and plant uptake of pollutants. Pretreatment with an upstream treatment control can be added to remove litter, debris and coarse sediment loads. Supplemental media including activated carbon, iron wool and zeolite can also be added to increase pollutant removal efficiency. Modular wetlands are reportedly effective at removing dissolved and suspended solids, nutrients, pesticides, heavy metals and bacteria from urban runoff.

Applications

Can be used to treat runoff from parking lots, buildings, roadways, and residential properties where discharge into a sensitive water body is a concern. Pollutant removal and treatment efficiency improves as contact time increases. Some models are equipped with a spill contamination feature that can capture an upstream release and lessen the spill impact on the environment.

Performance Data

High removal efficiency of TSS, nutrients, pesticides, total metals, petroleum hydrocarbons, and microbiological materials can be expected. Removal of BOD and TDS is considered moderate, while low removal of dissolved metals is associated with modular wetlands.

Limitations

- Typically limited to drainage areas less than one acre.
- Larger drainage areas require numerous units to treat runoff and may take up valuable land surface space.
- Requires a perennial water source to maintain wetland vegetation.
- May create a mosquito breeding habitat if water ponds above the surface of the gravel for more than seven days.
- If litter, debris and coarse sediment loads are not removed with an upstream pretreatment device, clogging of the debris bag may occur.
- Wetland vegetation requires annual maintenance.

Siting Criteria

- Modular wetlands require sufficient land surface space.
- Can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas. Requires relatively small drainage areas.

5.4.2 MODULAR WETLANDS

Design and Construction Criteria

- Modular wetlands should be sized to capture and treat the WQ_V as outlined in Section 4.5.1. However, alternative sizing criteria may be acceptable if it is commonly used in other communities and performance data is available that demonstrates acceptable pollutant removal rates.
- Excavation depth of over 5 ft is typical.
- Refer to the manufacturer's specifications for additional design and construction criteria.
- Installation costs are generally 50 to 100% of the manufacturer's delivered cost.

Inspection and Maintenance Requirements

- Inspect periodically and remove any invasive wetland plant species.
- Inspect periodically to prevent water ponding standing longer than 7 days.
- Annual inspection and replacement of grit filter bag is required.
- Wetland vegetation should be harvested once a year during mid-summer before plants transfer phosphorus and metals from aboveground foliage to subsurface roots.
- The entire plant mass (foliage and roots) should be harvested and replaced every three to five years.
- Sediment should be removed from the center tank every three to five years.
- A vacuum truck or a septic tank service truck can conduct sediment removal.

References and Sources of Additional Information

California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practice Handbook, New Development and Redevelopment. http://www.cabmphandbooks.com/Development.asp

James Payton's Construction Wetlands Page, 1996. Constructed Wetlands. www.eng.auburn.edu/users/paytojd/wetland.html

Minton, G.R., 2002. Stormwater Treatment, Biological, Chemical & Engineering Principles, Resource Planning Associates, Seattle, Washington.

State of California - Department of Transportation, 2003. Caltrans New Technology Report. p. B-62.

5.4.2 MODULAR WETLANDS

MODULAR WETLANDS MTC-40

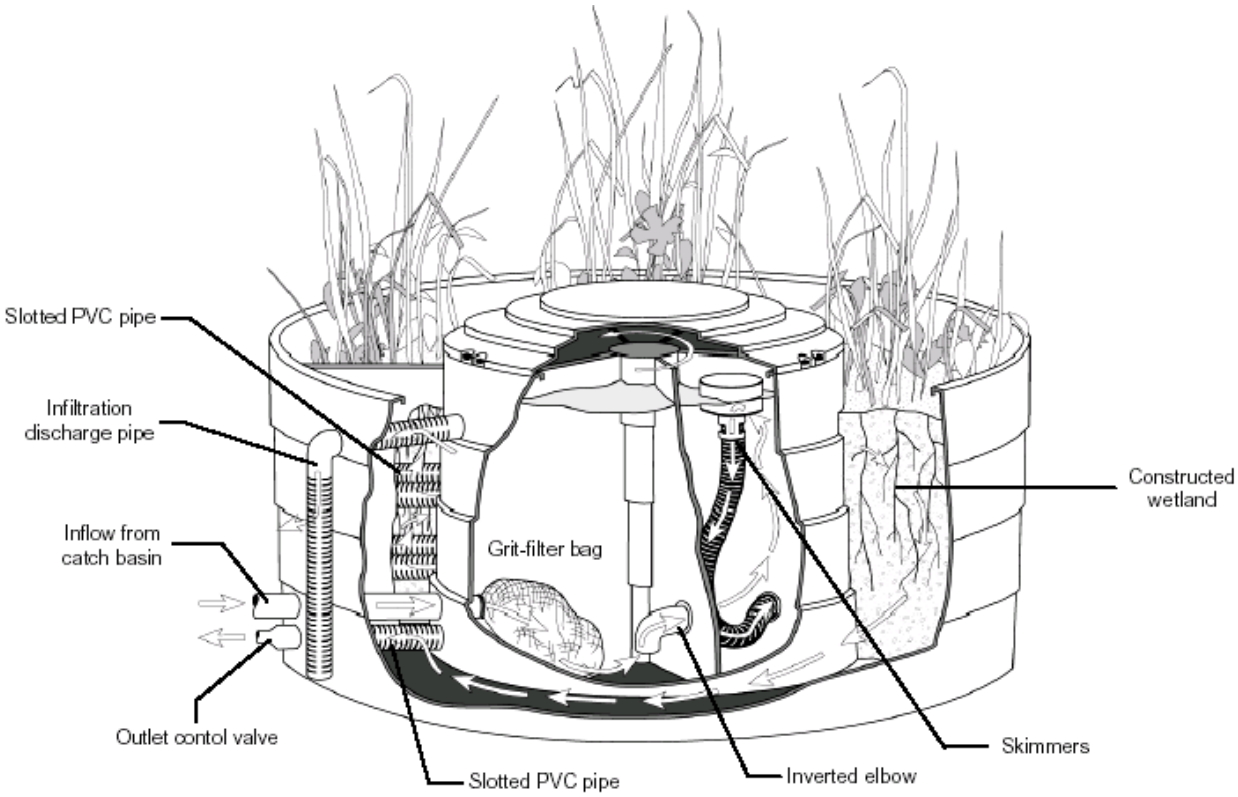


Figure 5.24: Example of a modular wetland

Graphic provided by StormTreat™ Systems).

5.4.3 CATCH BASIN INSERTS

5.4.3 Catch basin inserts

Description

Catch basin inserts (a.k.a. drain inserts) are manufactured filters placed in drop inlets to help remove sediment and debris from storm water runoff. They are used to increase a catch basin's efficiency at removing trash, debris and sediment and some oil and grease, organics, and metals. There are many varieties of catch basin inserts, however, they typically fall into one of three main types: trays, boxes or socks. The tray insert option consists of a series of trays, with the top tray serving as an initial sediment trap. Underlying trays often contain filters composed of a variety of different types of media including polypropylene, porous polymers, treated cellulose, and activated carbon. The box option is typically constructed of plastic or wire mesh with filtering medium that fits directly into the box within the catch basin. Hydrocarbons are removed as the storm water passes through the adsorbent filters while trash, debris and sediment remains in the box as the storm water exits. Both tray and box type catch basin inserts typically provide overflow features and reportedly do not reduce the original hydraulic capacity of the catch basin. The sock option uses filter fabric (usually polypropylene) to remove pollutants from vertical drop inlets. The fabric is either attached to a frame or directly to the catch basin grate. Each of these options provides very little volume; therefore frequent sediment removal and maintenance is required. Some models allow for sediment removal with a vacuum truck while others require physically removing the insert for cleaning.

Applications

Catch basin inserts are typically used for retrofit applications. They can also be used as a pretreatment device for other manufactured treatment controls. They do not require additional space, can be easily accessed for inspection and maintenance, and do not provide standing water for the breeding of mosquitoes.

Performance Data

Few manufacturers have collected performance data under field conditions. The University of California, Los Angeles has tested "Ultra-Urban" brand filters in low flow situations. The results of these tests indicate up to 80 percent removal rate of the petroleum hydrocarbons. The captured oil is then permanently bonded within the "Smart Sponge", which eliminates leaching.

Limitations

- Typically require maintenance several times per year.
- May reduce the hydraulic capacity of a catch basin, particularly when full of debris.
- Performance is likely significantly less than other available treatment systems such as ponds and vaults.
- Usually not suitable for large areas or areas with trash or leaves that can plug the insert.
- Studies have found that a variety of inserts showed little removal of total suspended solids (TSS), partially due to scouring and resuspension from relatively small (6-month) storm events.
- Some options require extensive maintenance to prevent build up of sediment while others allow sediment removal with a vacuum system.

5.4.3 CATCH BASIN INSERTS

- The relative low cost of inserts ($100 to $2,000) may tend to favor the use of these systems over other, more effective treatment controls. However, the initial cost savings may be offset by the number of units required, the costs associated with frequent maintenance, and replacement requirements due to shorter structural life spans.

Siting Criteria

- Can be installed in new or existing catch basins.
- Drainage area for each catch basin insert should be less than 10 acres.

Design and Construction Criteria

- The diameter of the catch basin should be equal to 4 times the diameter of the outlet pipe.
- Refer to manufacturer's guidelines; there are many options to choose from depending on individual site needs.
- Installation should be done in a manner that ensures that runoff enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the grate of the catch basin can easily occur with vertical drop inlets.

Inspection and Maintenance Requirements

- Inspect several times during the first year to establish cleaning frequencies.
- At a minimum, inserts should be cleaned or replaced once or twice per year.
- Removal of sediment in catch basins may require a vactor truck.
- Many brands of inserts can be serviced in ten minutes or less.
- "Ultra Urban" brand filters recommend replacement of filter box every 1-3 years.

References and Sources of Additional Information

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment. http://www.cabmphandbooks.com/Development.asp

USEPA, National Pollutant Discharge Elimination System (NPDES). Post-Construction Stormwater Management in New Development & Redevelopment. Catch Basin/Catch Basin Insert. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post_7.cfm

USEPA, Region 1: New England. AbTech Ultra-Urban™ Filter With OARS® Onboard, http://www.epa.gov/region01/assistance/ceitts/stormwater/techs/abtechfilter.html

USEPA, Region 1: New England. Aqua-Guard™ Catch Basin Insert, http://www.epa.gov/NE/steward/ceitts/stormwater/techs/aquaguard.html

5.4.3 CATCH BASIN INSERTS

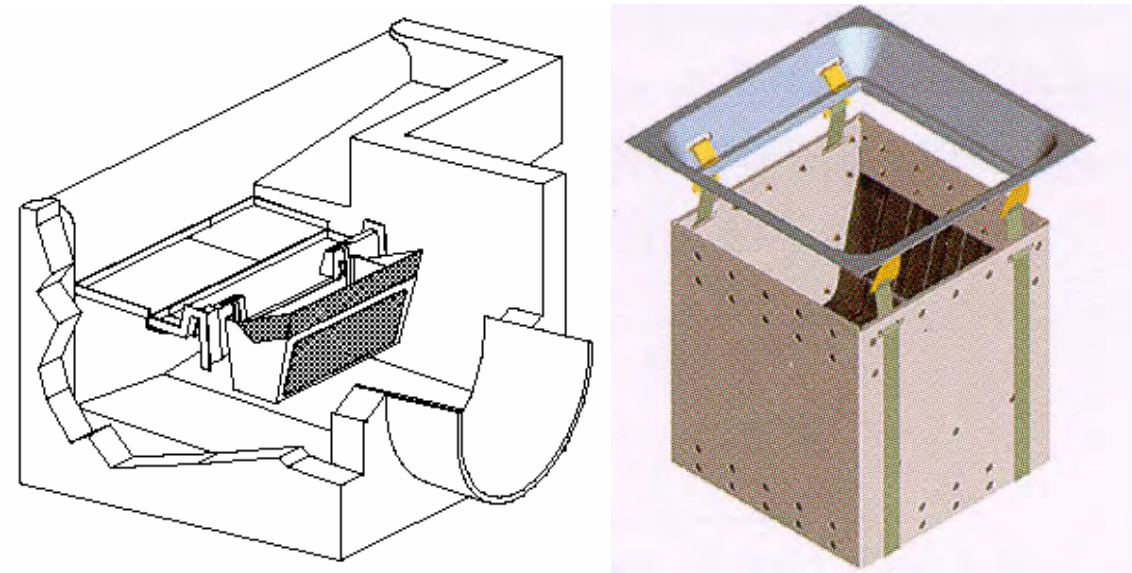


Figure 5-25: Examples of a basket type insert for a curb inlet catch basin and a box type insert for a vertical drop inlet. (Graphics provided by Bio Clean Environmental Services, Inc. and Abtech Industries™).

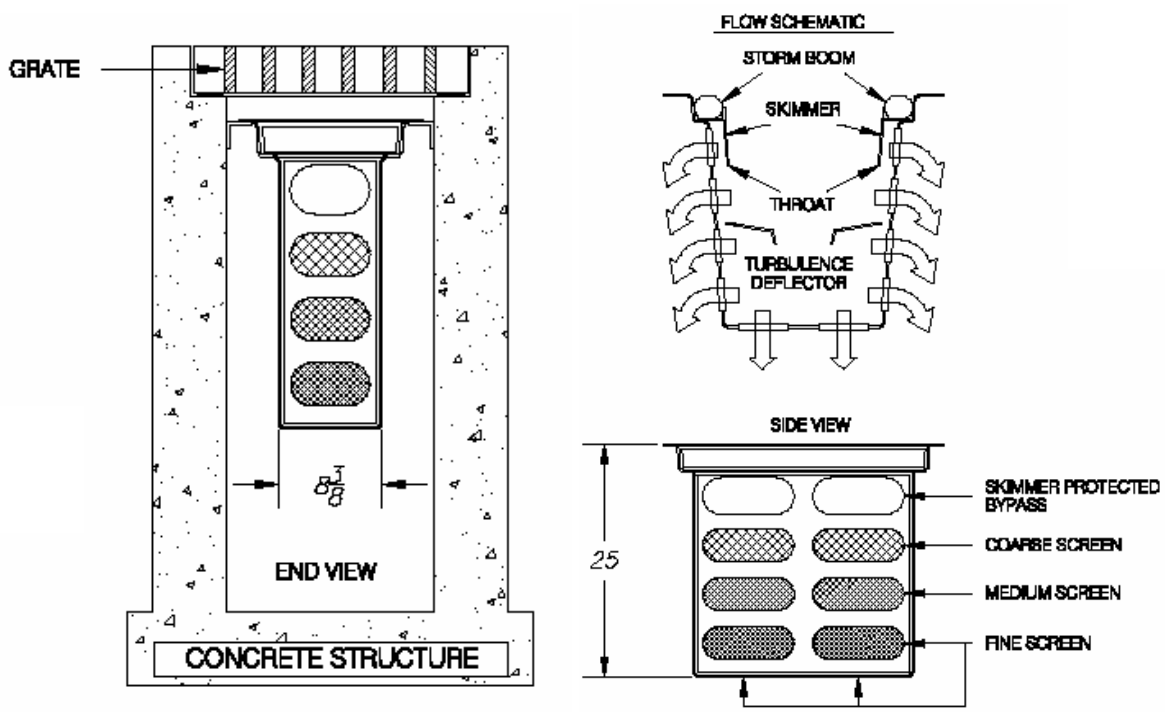


Figure 5-26: Example of a box type catch basin insert (Graphic provided by Bio Clean Environmental Services, Inc.).

5.4.3 CATCH BASIN INSERTS

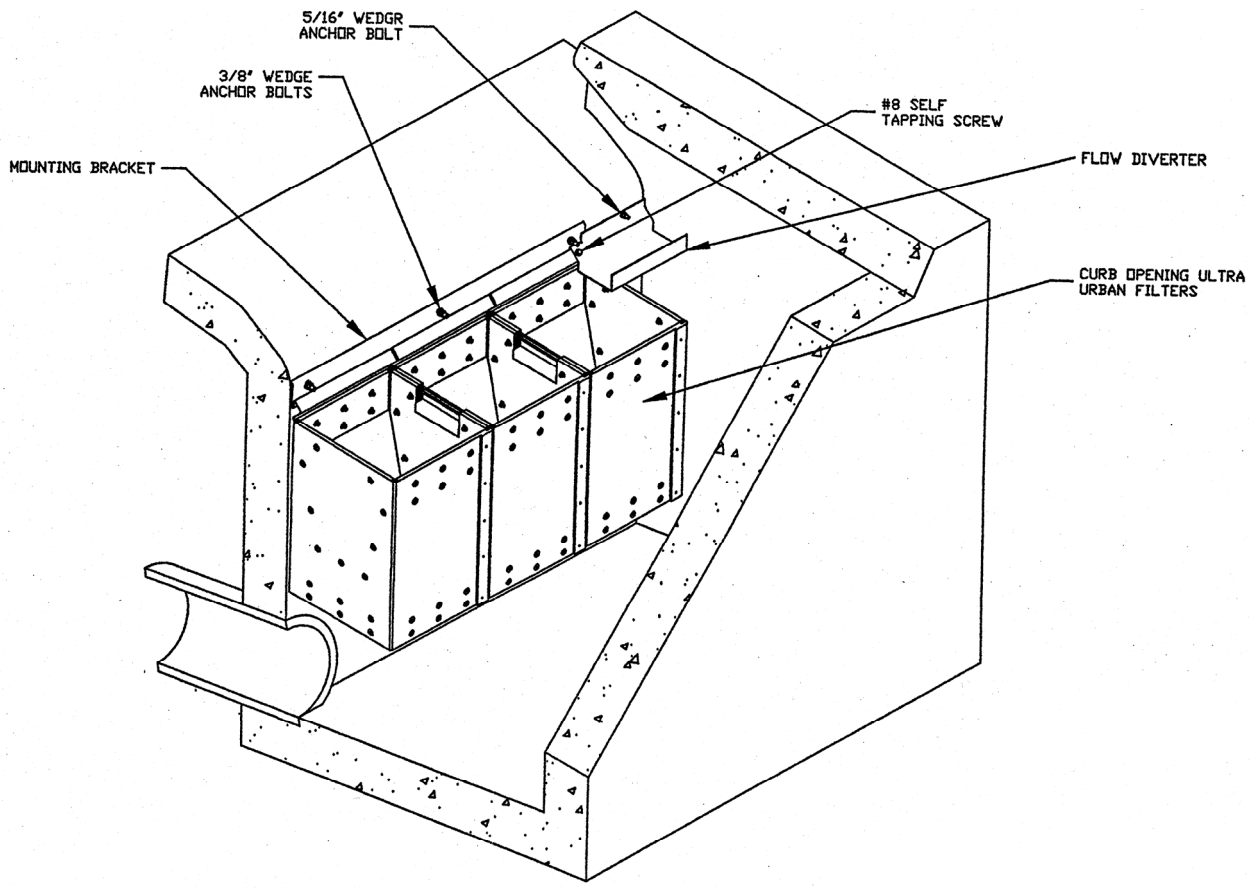


Figure 5-27: Example of a box type insert for a curb inlet catch basin (Graphic provided by Abtech Industries™).

5.4.4 MEDIA FILTRATION SYSTEMS

5.4.4 Media Filtration Systems

Description

Manufactured media filters are typically subsurface BMPs consisting of two chambers that include a pretreatment settling basin and a basin with a sand filter or an absorptive filter media. Large particles and floatables are typically removed in the first chamber while finer grained particles and other pollutants are removed by the filtering media in the second chamber. Overflow weirs are typically incorporated to allow higher flows from larger storm events to bypass the device and flow directly into the storm drain system.

Applications

Manufactured media filters are typically used for commercial, industrial or roadway projects where space constraints limit the use of other treatment controls.

Performance Data

Manufactured media filters can be expected to have similar pollutant removal efficiencies to public domain media filters (TC-60 and 61). Removal of dissolved constituents depends on the type of media used in the device. Filters with perlite and filter fabric are not effective at removal of dissolved constituents, whereas filters with zeolites, activated carbon, compost and peat are more effective at removal of dissolved constituents.

Limitations

- Some manufactured media filters have reduced pollutant removal efficiencies at higher flow rates.
- Use in drainage areas with high sediment loads can lead to premature clogging.
- Filter replacement may require confined space entry.
- Standing waters in the device may provide mosquito habitat.

Siting Criteria

- Can be placed under roadways, parking lots, sidewalks or landscaped areas and can treat drainage areas of up to 5 acres (depending on the manufacturer and model).
- Issues of buoyancy should be considered in areas with high groundwater tables.
- Do not install in drainage areas with highly erodible or unstable soils.

Design and Construction Criteria

- Media filtration systems should be sized to capture and treat the WQ_V as outlined in Section 4.5.1. However, alternative sizing criteria may be acceptable if it is commonly used in other communities and performance data is available that demonstrates acceptable pollutant removal rates.
- The porosity of the filler media should be considered when sizing.
- Detention times of 4 to 6 hours are common. Increased detention time will increase pollutant removal effectiveness.

5.4.4 MEDIA FILTRATION SYSTEMS

- May be used on sites with impermeable soils since the runoff filters through filter media, not existing site soils.
- The main factors that influence removal rates are the storage volume, filter media, and detention time.
- Refer to the manufacturer's specifications for additional design and construction criteria.
- Installation costs are generally 30 to 50% of the manufacturer's delivered cost.

Inspection and Maintenance Requirements

- Inspect several times during the first year to establish loading and cleaning frequencies.
- Media filtration systems are typically cleaned once a year.

References and Sources of Additional Information

California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practice Handbook, New Development and Redevelopment. http://www.cabmphandbooks.com/Development.asp

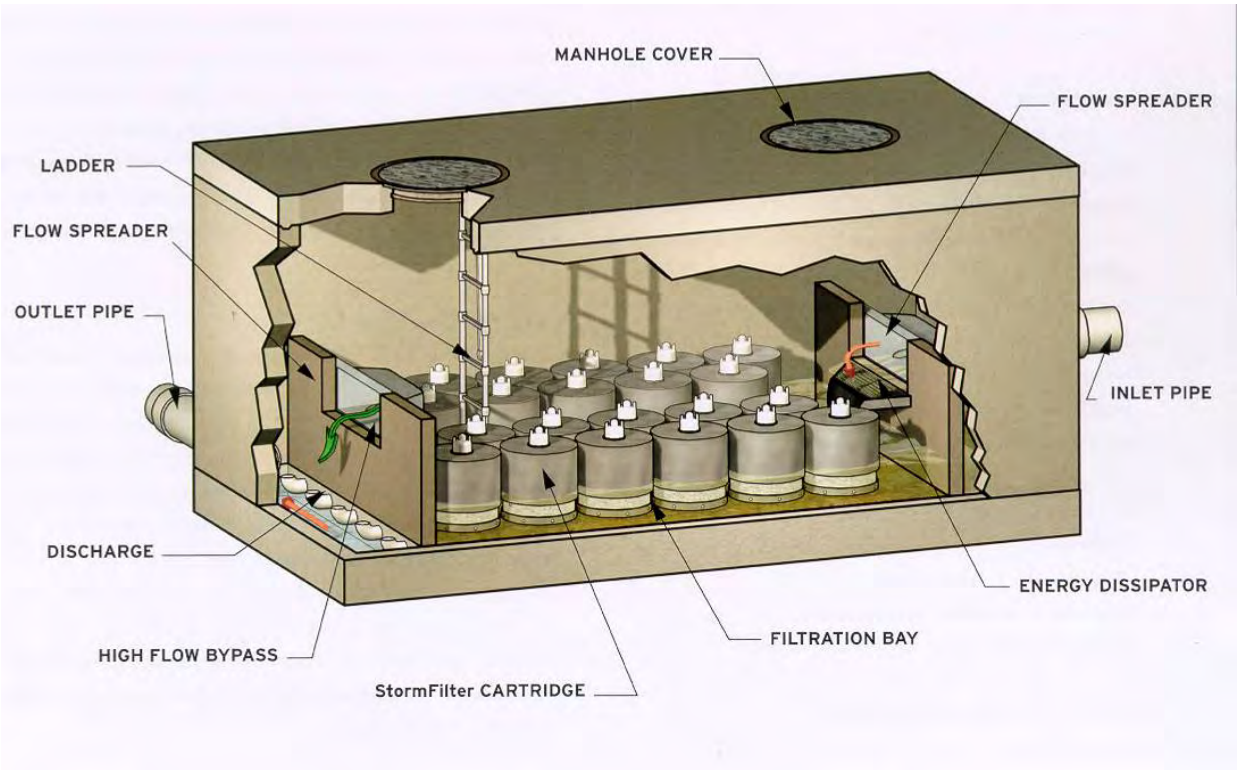


Figure 5-28: Example of a vault type media filtration system (Graphic provided by Stormwater 360).

5.4.4 MEDIA FILTRATION SYSTEMS

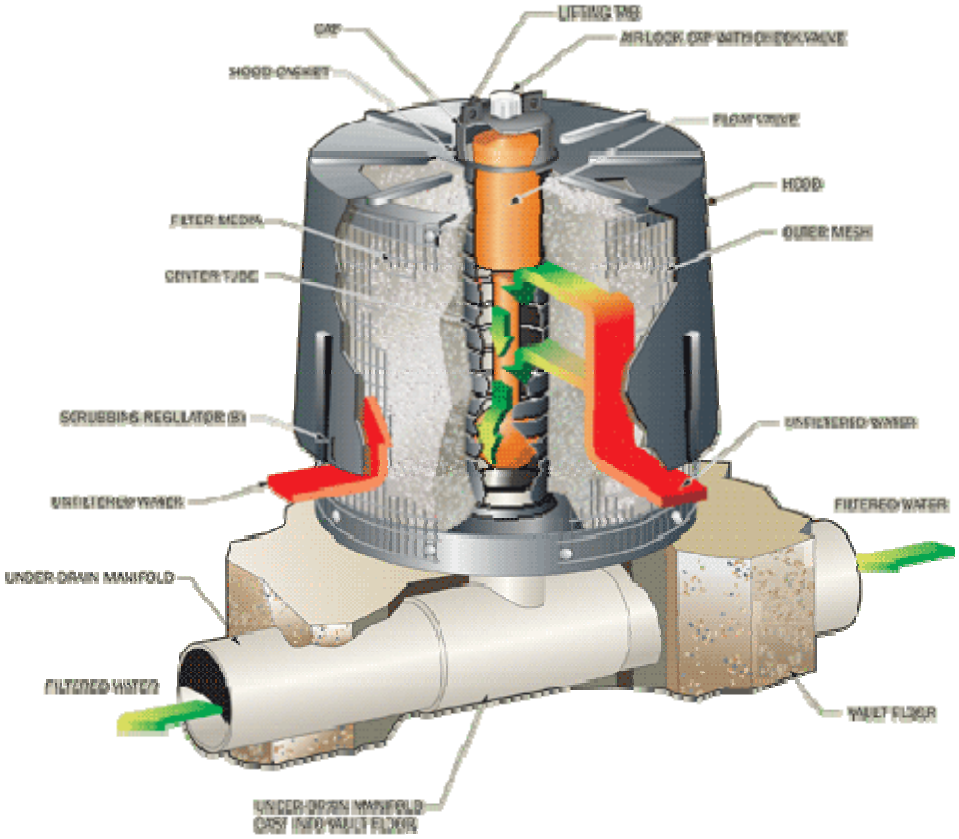


Figure 5-29: Example of a media filter cartridge
(Graphic provided by Stormwater 360)

5.4.4 MEDIA FILTRATION SYSTEMS

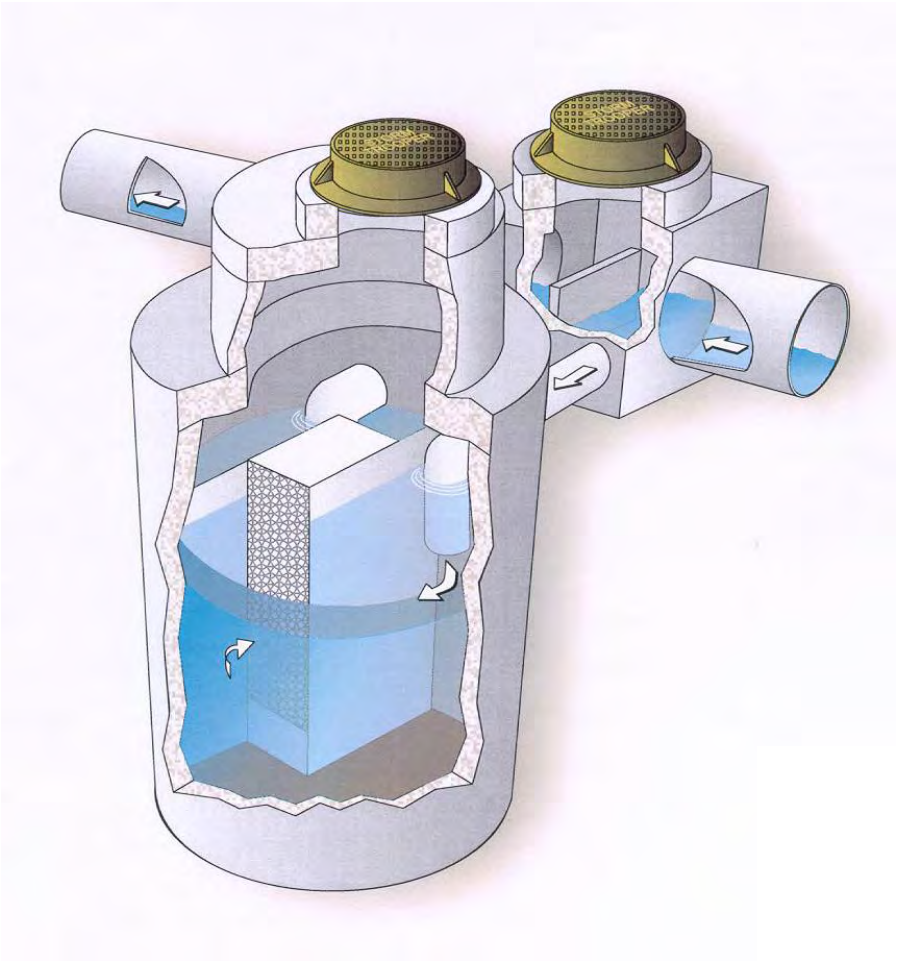


Figure 5-30: Example of a manhole media filtration system
(Graphic provided by Park Environmental Equipment)

5.4.4 MEDIA FILTRATION SYSTEMS

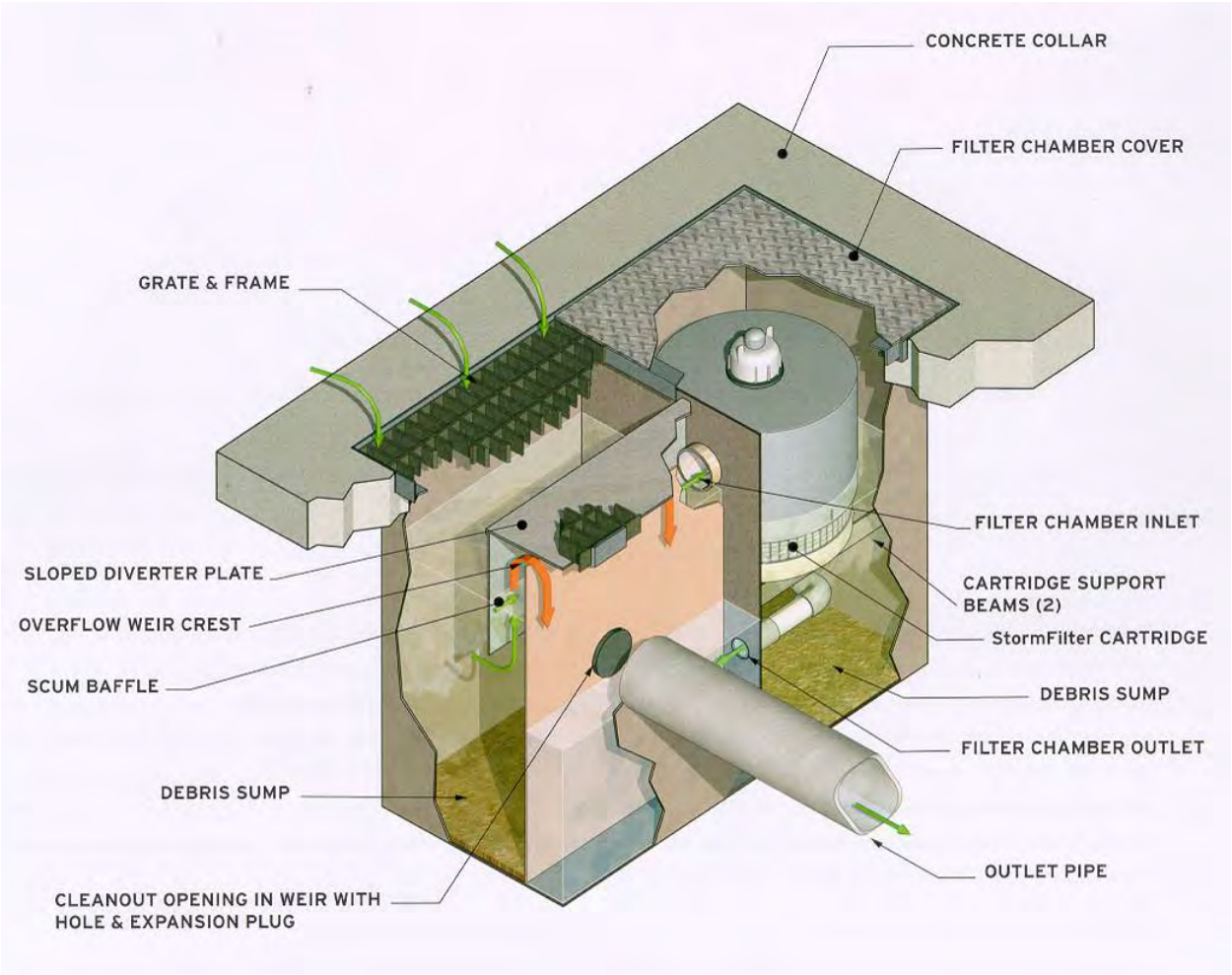


Figure 5-31: Example of a catch basin media filtration system
(Graphic provided by Stormwater 360)

5.4.5 GROSS SOLIDS REMOVAL DEVICES

5.4.5 Gross Solids Removal Devices

Description

Gross Solids Removal Devices (GSRDs) are designed for the removal of litter and solids transported by storm water. Linear radial devices use louvered well casings with slotted openings. Litter and solids are trapped in the casings while flow passes radially through the louvers. These systems capture litter and solids 0.25 inch and larger. These devices are designed to work in-line with the existing storm drain system and can be retrofit into existing pipelines. They can also be placed in end-pf pipe configuration. An overflow/bypass device can be incorporated if the device becomes clogged.

Applications

Should be considered for areas where receiving water bodies are trash, litter, or other debris is considered a major concern.

Performance Data

Gross Solids Removal Devices can be expected to have high removal efficiency for litter and debris. The device requires very little head to operate and has been pilot tested for a 1 percent slope, but may work on flatter slopes.

Limitations

- Removal efficiency can be decreased with accumulation of debris and sediment.
- Designed only to remove litter and solids, does not provide nutrient removal.
- Requires sufficient space for maintenance and inspection including use of vacuum trucks or other large equipment for trash removal.

Siting Criteria

- Suited for narrow and flat right-of-way with limited space.
- Requires low hydraulic head to operate.
- Maximum installation depth of 8 feet suggested.
- Device length is sized according to drainage area.
- Contained in a concrete block or on an open pad.

Design and Construction Criteria

- Sized to accommodate gross pollutants storage for a given maintenance period, typically annually.
- Screen section diameter and length are designed for site specific needs. Diameters range in size from 6 to 60 inches. Sections available in 5 foot lengths.
- Litter and debris accumulation data for a given drainage area should be available to properly size the device; if not available than 24.5 ft^3/ha/yr may be used.

5.4.5 Gross Solids Removal Devices

- Size for peak design flow while carrying design gross loads.
- Can be placed in an open channel, in a vault, or as an end-of-pipe feature.
- Vaults can be constructed with grates or covers. Recommended to keep out wind-blown material which may enter concrete vault and be discharged into the storm drain system.
- Vaults can be constructed as traffic or non-traffic rated.
- Can be designed both in-line and off-line. In-line configuration incorporates a bypass to eliminate back-up in the storm water conveyance system.
- Energy dissipation devices may be incorporated.
- The device should drain within 72 hours to avoid mosquito breeding.
- Available from the manufacturer in a variety of steel types and sizes. For corrosion resistance the screens are available in stainless, galvanized, and high strength-low alloy steel.
- Refer to the manufacturer's specifications for additional design and construction criteria.

Inspection and Maintenance Requirements

- Annual maintenance is required at the end of the rainy season to remove accumulated trash, debris, and sediment. More frequent inspection, and maintenance as required, during the rainy season is recommended.
- Designed to contain a full storm season amount of debris without impeding passage of storm water.
- Inspect at the beginning of the rainy season as well as a few times during the rainy season following significant storm events.
- Should be cleaned when accumulation is at 50 percent of capacity.
- Screens may need to be power washed to remove fine sediment.
- Litter can be removed at the job-site with a vacuum truck or screens can be taken off-site for cleaning.
- Access to the interior through hatchways installed at the top of the screen. Additional access can also be provided via a perforated door at the downstream end of the device.
- Special fittings and access features can be installed to facilitate cleaning and maintenance.

References and Sources of Additional Information

California Department of Transportation (Caltrans). 2003. Final Report Phase 1 Gross Solids Removal Devices Pilot Study: 2001-2002. http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/litter/CTSW-RT-03-072.pdf

Nevada Department of Transportation (NDOT). 2004. Stormwater Quality Design Manuals: Planning and Design Guide. http://www.nevadadot.com/reports_pubs/Water_Quality/pdfs/PDG_PlanningAndDesignGuide.pdf

5.4.5 Gross Solids Removal Devices

Roscoe Moss Company http://www.roscoemoss.com/gsrd.html

Sobleman, T.B. et al. 2005. Caltrans Takes Out the Trash. *Civil Engineering Magazine, vol. 75:10.* http://www.pubs.asce.org/ceonline/ceonline05/1005feat.html

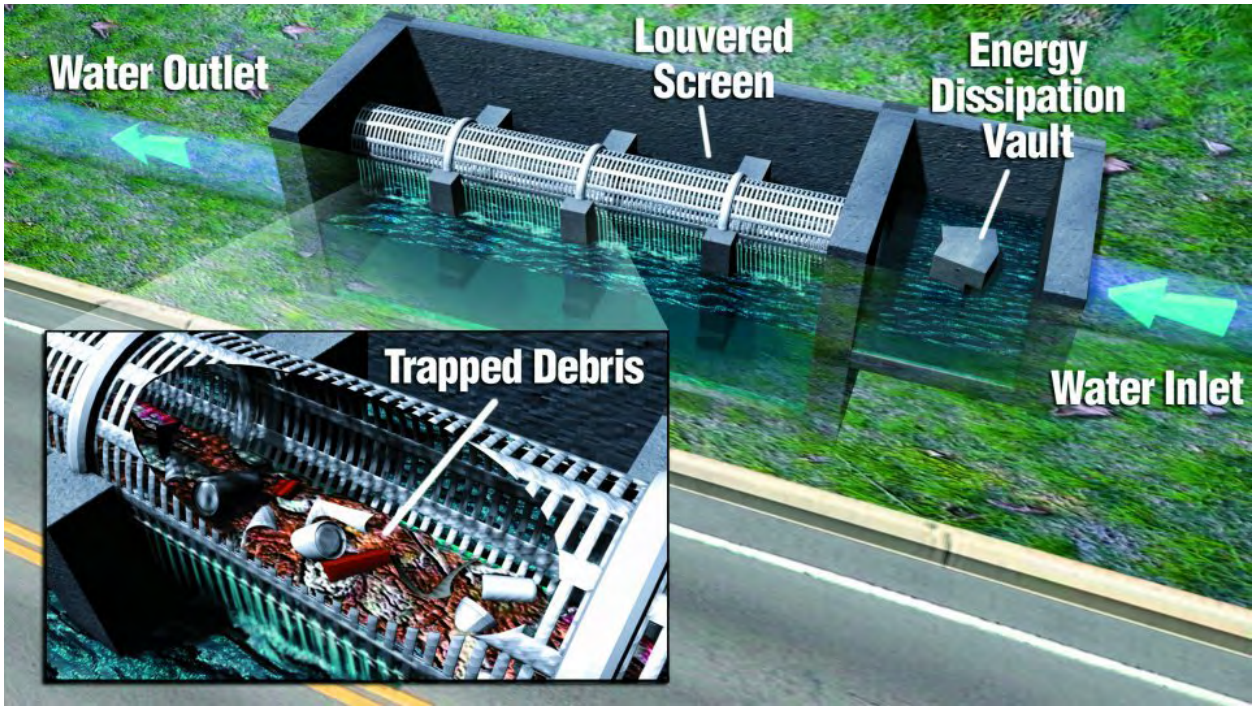


Figure 5-32: Linear Radial Gross Solids Removal Device with an energy dissipating feature. (Graphic courtesy of Civil Engineering Magazine)

5.4.5 Gross Solids Removal Devices

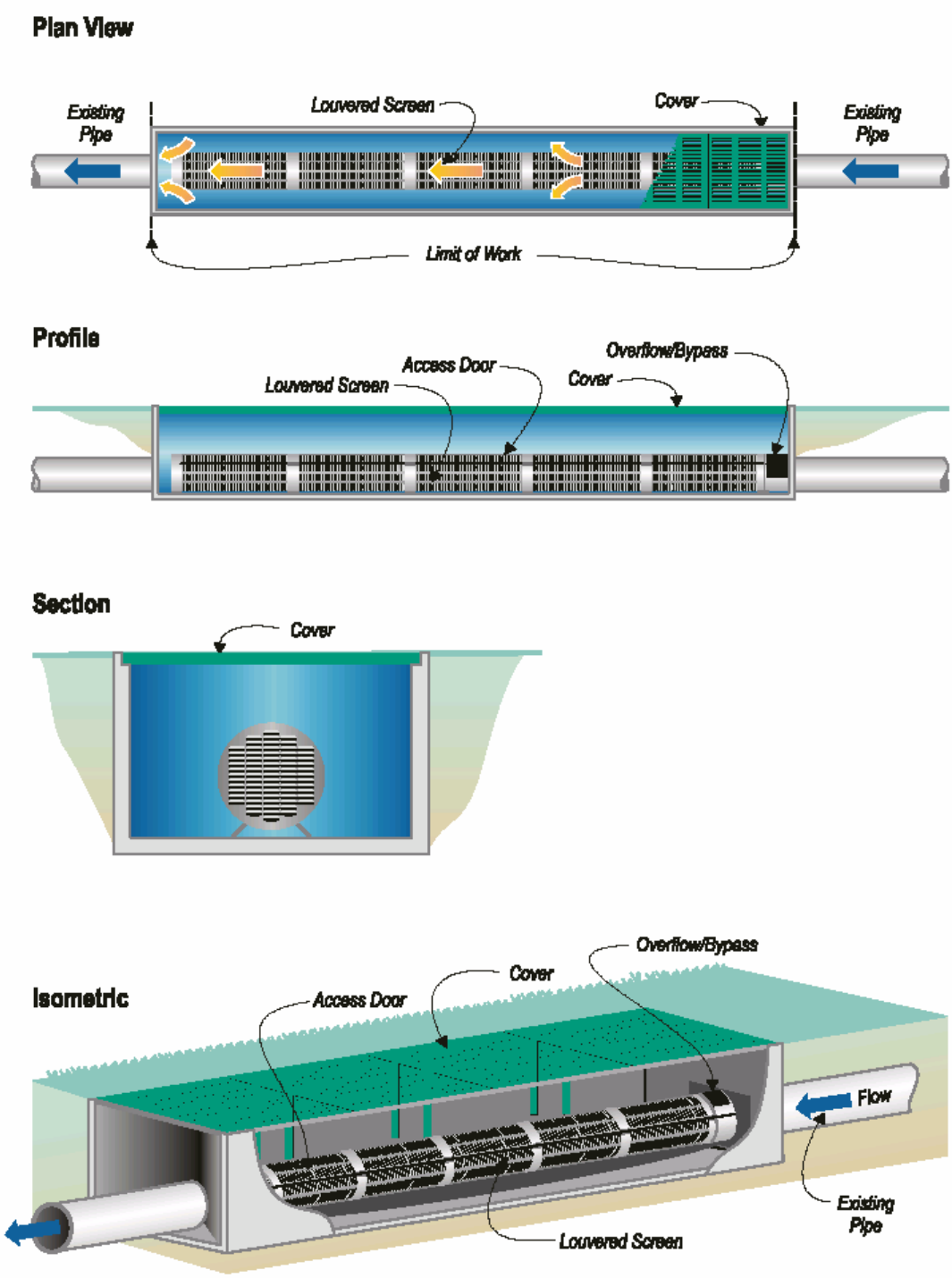


Figure 5-33: Example of a Linear Radial Device
(graphic courtesy of Caltrans)

Appendix A: Attachment 4 to Regional Board Order R3-2004-0135

STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401-7906

ATTACHMENT 4
STORM WATER MANAGEMENT PROGRAM REVISION REQUIREMENTS

ORDER R3-2004-0135
NPDES NO. CA0049981

Proposed for Consideration at the February 11, 2005 Regional Board Hearing

FOR

THE CITY OF SALINAS
MUNICIPAL STORM WATER DISCHARGES
Monterey County

I. GENERAL

a. This attachment to Order R3-2004-0135 describes the revision requirements for the City of Salinas (the Permittee) Storm Water Management Program (SWMP)). The Permittee shall review and modify its SWMP to address the requirements herein, and submit the revised SWMP within 180 days of permit adoption for approval by the RWQCB or its Executive Officer. Interested persons shall have 30 days to comment on the revised SWMP prior to RWQCB or Executive Officer approval.

b. This attachment requires the Permittee to revise the current SWMP to update and/or include the following major program elements:

   i. Construction Site Management Component
   ii. Development Standards Component
   iii. Commercial/Industrial Facilities Component
   iv. Municipal Maintenance Component
   v. Illicit Discharge Detection and Elimination Component
   vi. Public Education and Participation Component
   vii. Program Effectiveness
   viii. Legal Authority

c. The Permittee is required to continue implementing the current SWMP during this revision process.

d. The Permittee's Storm Water Pollution Prevention Program may need to be modified, revised, or amended from time to time to respond to a change in conditions and to incorporate more effective approaches to pollutant control. Proposed SWMP revisions will be part of the annual review process and

incorporated in the Annual Reports. In addition, the Permittee shall revise the SWMP to comply with regional or watershed-specific requirements, and/or waste load allocations developed and approved pursuant to the process for the designation and implementation of TMDLs for impaired water bodies. Significant SWMP revisions shall be brought before the Regional Board for approval. Minor SWMP revisions may be approved by the Executive Officer following a 30-day public comment period.

II. Construction Site Management Component

The Permittee shall develop and implement a construction site management program to reduce to the MEP the discharge of pollutants from both private and public construction sites that fall within the City's jurisdiction. Should a site outside of Permitee's regulatory jurisdiction be discovered to be illicitly discharging into the MS4, the Permitee shall notify the RWQCB. The construction site management program shall include the following elements:

a. **Minimum Requirements.** For construction sites one acre or greater, the Permittee shall require construction permittees to submit a State Water Resources Control Board (SWRCB) "WDID number" (Waste Discharge Identification number) as proof of application for coverage pursuant to the SWRCB General Construction Storm Water Permit. Construction permittees must also submit a SWPPP to the City for approval prior to commencing construction. The City shall implement a program to control runoff from applicable construction sites within its jurisdiction. The program shall ensure that the following minimum requirements are effectively implemented at applicable construction sites:

   i) Sediments generated at the project site shall be controlled using adequate source control and/or structural BMPs;

   ii Construction-related materials and wastes shall be retained at the project site to avoid discharge to the MS4 and waters of the state;

   iii) Unauthorized non-storm water runoff shall be contained at the project site; and

   iv) Erosion from slopes and channels shall be controlled by implementing an effective combination of erosion control (source control) and other BMPs as described in the San Francisco Regional Water Quality Control Board's Erosion and Sediment Control Field Manual, the California Stormwater Quality Association's Construction Stormwater BMP Handbook, or equivalent manual.

b. **Inventory of active construction projects.** The Permittee shall develop and implement an effective system to track grading permits and active construction projects. The system shall identify basic site information (e.g. owner, location,

contractor, etc.), status (active, complete), size in acres, proximity to natural and man-made hydrologic features, required inspection frequency, project start and anticipated completion dates. The Permittee shall develop the inventory within one year of permit adoption and update this inventory as new projects within its jurisdiction are initiated or on a monthly basis. Outputs from the system shall be available to Regional Board upon request.

c. **Minimum construction BMPs.** All construction projects shall implement the following BMPs unless the BMP is not practicable. If a BMP is not practicable, a detailed justification shall be included with the approved SWPPP.
   - Stabilized construction entrance
   - Scheduling of grading activities to minimize bare graded areas during the rainy season
   - Downslope sediment controls (e.g., sediment logs)
   - Concrete truck washouts
   - Storm drain inlet protection
   - Protection of slopes and channels
   - Good housekeeping practices (e.g., trash management, proper material storage, etc.).

   The Permittee may designate additional BMPs as minimum BMPs at construction sites. The Permittee shall revise and distribute within 1 year of permit adoption a brochure describing the minimum construction BMPs to be implemented at construction sites. This brochure shall be distributed during the SWPPP review stage and during inspections, if necessary.

d. **Verification of permits and plans.** Prior to issuing a grading or building permit for a construction site one acre or more, the Permittee shall
   i. Require proof that a Notice of Intent (NOI) for coverage under the General Construction Permit has been submitted, if applicable.

   ii. Require submittal of a storm water pollution prevention program (SWPPP) to the Permittee that contains, at a minimum, the following:

      1) A vicinity map showing nearby roadways, the construction site perimeter, and the geographic features and general topography surrounding the site;

      2) A site map showing the construction project in detail, including the existing and planned paved areas and buildings; general topography both before and after construction; drainage patterns across the project area; and anticipated storm water discharge locations (i.e., the receiving water, a conduit to receiving water, and/or drain inlets);

3) A detailed, site-specific listing of the potential sources of storm water pollution;

4) A description of the type and location of erosion and sediment control BMPs to be employed at the site;

5) The name and telephone number of the qualified person responsible for implementing the SWPPP; and

6) Certification/signature by the landowner or an authorized representative.

iii. Review the SWPPP for compliance with the Permittee's ordinances and this Order.

e. **Inspections.** The Permittee shall inspect all active construction sites within City jurisdiction, a minimum of once a month during the wet season (1 October to 30 April) to ensure compliance with local ordinances and this Order. During the remainder of the year, the Permittee shall inspect all active construction sites a minimum of once every other month. The Permittee shall inspect high priority construction sites a minimum of once a week during the wet season. These inspections shall commence within the first permit year. The Permittee shall establish criteria for high priority sites in the SWMP, which at a minimum shall consider the following factors:

- Project size
- Soil erosion potential
- Proximity to waters of the State and 303(d) listed water bodies
- Previous violations of City of Salinas storm water ordinances.

At a minimum, all projects greater than five acres shall be considered high priority.

The inspections shall include a review of site erosion and sediment controls, BMP implementation plans, and/or SWPPPs. Records of the inspection shall be maintained. The inspectors shall use an inspection checklist, or equivalent, to document site conditions and deficiencies.

f. **Enforcement of construction site management program.** The Permittee shall enforce appropriate ordinances and permits at all construction sites as necessary to maintain compliance with this Order. The Permittee shall develop and implement a written escalating enforcement policy to ensure construction sites are brought into compliance. The Permittee's ordinances or other regulatory mechanisms shall contain sanctions to ensure compliance. Sanctions may include the following or their equivalent: Non-monetary penalties, stop work orders, fines, bonding requirements, and/or permit denials or suspension for non-compliance.

g. **Process to Refer Noncompliance and Non-filers to the Regional Board.** In the advent the Permittee has exhausted their use of sanctions and cannot bring a construction site or construction operator into compliance with their ordinances or this Order, or otherwise deems the site to pose an immediate and significant threat to water quality, the Permittee shall provide oral notification to the Regional Board within five (5) business days of such determination. Such oral notification shall be followed by written notification within ten (10) business days of the incident.

For construction sites requiring coverage under the General Construction Permit, the Permittee shall refer non-filers (i.e., those projects that cannot demonstrate that they have submitted an NOI or received a WDID number) to the Regional Board within ten (10) business days of discovery. In making such referrals, the Permittee shall include, at a minimum, the following information:

- Project location;
- Developer;
- Estimated project size; and
- Records of communication with the developer regarding filing requirements.

h. **Training.** The Permittee shall provide annual training for employees in targeted positions (whose jobs or activities are engaged in construction activities including construction inspection and plan review staff) regarding the requirements of this Order. This training shall include erosion and sediment control installation and maintenance techniques, inspection procedures, enforcement procedures, and information on the requirements in the General Construction Permit including elements in an effective SWPPP.

III. Development Standards Component

a. The Permittee shall minimize the short and long-term impacts on receiving water quality from new development and significant redevelopment. In order to reduce pollutants in runoff flows from these sources to the MEP, the Permittee shall review and update its existing program, which shall, at a minimum, address the following:

i. The Permittee shall incorporate water quality and watershed protection principles into planning procedures and policies such as: the General Plan or equivalent plans (e.g., Comprehensive, Master, Community, and/or Specific Plans) to direct land use decisions and require implementation of consistent water quality protection measures for all development projects. Such water quality and watershed protection principles and policies shall consider the following:

1. Minimize the amount of impervious surfaces and directly connected impervious surfaces in areas of new development and redevelopment and use on-site infiltration of runoff in areas with appropriate soils where the

infiltration of storm water would not pose a potential threat to groundwater quality.

2. Implement pollution prevention methods supplemented by pollutant source controls, and if source controls are not practicable, by treatment controls. Where practical, use strategies that control the sources of pollutants or constituents to minimize the transport of storm water and pollutants offsite and into MS4s.

3. Preserve and, where possible, create or restore areas that provide important water quality benefits, such as riparian corridors, wetlands and buffer zones.

4. Limit disturbances of natural water bodies and natural drainage systems caused by development within Permittee's jurisdictional authority, including roads, highways, and bridges.

5. Require developers to prepare and submit studies analyzing pre- and post-project pollutant loads (including sediment) and flows resulting from projected future development. Require incorporation of structural and non-structural BMPs to mitigate the projected increases in pollutant loads in runoff.

6. Identify, minimize, and regulate development in areas that are particularly susceptible to erosion and sediment loss, or establish development guidance that protects areas from erosion and sediment loss.

7. Implement source and/or treatment controls as necessary to protect downstream receiving water quality from increased pollutant loads in runoff flows from new development and significant redevelopment.

8. Control the post-development peak storm water run-off discharge rates and velocities to prevent or reduce downstream erosion, and to protect stream habitat.

ii. Prior to project approval and issuance of local permits for new development and significant redevelopment, the Permittee shall review the proposed project plan and require measures to ensure that all development is in compliance with the Permittee's storm water ordinances, local permits, and other applicable requirements.

b. **Development Standards Plan**. Within 1 year of permit adoption, the Permittee shall develop and submit for public review and comment and Executive Officer approval, a Development Standards Plan (DSP) that describes measures to reduce pollutant discharges to the MEP from all new development and significant redevelopment

projects. Public review and comment will include a 30-day posting to the Regional Board website, with notification to interested parties of the draft's availability. Public comments must be addressed to the satisfaction of all prior to Executive Officer approval. If comments cannot be satisfactorily addressed informally, then the public may request a hearing before the Regional Board on this issue.

The DSP must be consistent with the applicable portions of State Board Order WQ 2000-11. To ensure consistency with Order WQ 2000-11, the DSP shall provide the following information:

i. A description of existing Development Standards, if any, including project categories, BMP requirements and numeric sizing criteria;

ii. A comparison of existing development standards to the requirements established under State Board Order WQ 2000-11 and/or other applicable directives; and

iii. A description of the proposed modifications to the Development Standards to ensure that, at a minimum, they are consistent with the requirements of State Board Order WQ 2000-11 and this Order.

Within one year of approval of the DSP, the Permittee shall amend, or adopt if needed, its own local Development Standards, including amendment of ordinances as needed.

c. **Review of Plans**. Upon amendment or adoption of local Development Standards, the Permittee shall ensure that all new development and significant redevelopment projects falling under the priority project categories listed below are reviewed and conditioned for compliance with the Development Standards. The local Development Standards shall apply to all priority projects or phases of priority projects that do not have approval by the City Engineer, permit for development or construction, an approved special permit, or an approved tentative map by the adoption date for the local Development Standards. Development Standards shall apply as follows:

i. *Priority Development Project Categories*: Development Standards requirements shall apply to all new development and significant redevelopment projects within the Permittee's jurisdictional authority and falling under the priority project categories listed below. The term "significant redevelopment" is defined as the creation or addition of at least 5,000 square feet of impervious surfaces on an already developed site. Significant redevelopment includes, but is not limited to expansion of a building footprint, or replacement of a structure; replacement of impervious surface that is not part of a routine maintenance activity; and land-disturbing activities related to structural or impervious surfaces. Where significant redevelopment results in an increase of less than 50 percent of the impervious surfaces of a previously existing development, and the existing

development was not subject to Development Standards, the BMP design standards discussed below apply only to the addition, and not to the entire development. Priority Development Project Categories are listed below.

1. Home subdivisions with ten housing units or more. This category includes single-family homes, multi-family homes, condominiums, and apartments.

2. Commercial developments. This category is defined as any development on private land that is not for heavy industrial or residential uses where the impervious land area for development is 100,000 square-feet or more. The category includes, but is not limited to hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, commercial nurseries, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses, and other light industrial facilities.

3. Automotive repair shops. This category is defined as a facility that is categorized by one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539, where the total impervious area for development is 5,000 square feet or more.

4. 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) and has 5,000 or more feet of impervious area.

5. Hillside developments 5,000 square feet or more of impervious area. This category is defined as any development that creates 5,000 square feet of impervious surface in an area with known erosive soil located in an area with natural slopes having a twenty-five percent or greater grade.

6. Parking lots exposed to rainfall that are 5,000 square feet or more, or with 25 or more parking spaces. This category is defined as an uncovered impervious area for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.

7. Street, roads, highways, and freeways. This category includes any paved surface five acres or greater used by automobiles, trucks, motorcycles, and other vehicles.

8. Retail Gasoline Outlets. “Retail Gasoline Outlet” is defined as any facility engaged in selling gasoline with 5,000 square feet or more of impervious surface area.

ii. *BMP Requirements*: The Development Standards Plan shall include a list of recommended source and/or structural treatment control BMPs for all new development and significant redevelopment projects falling under the above priority project categories or locations. At a minimum, Retail Gasoline Outlets shall be required to use the BMPs listed in the California Storm Water Quality Task Force, March 1997 BMP Guide for Retail Gasoline Outlets.

iii. *Numeric Sizing Criteria*: As a part of the DSP, the Permittee shall review their existing numeric sizing criteria for structural treatment BMPs and ensure that it is comparable to the following numeric sizing criteria:

1. Volume-based BMPs shall be designed to mitigate (infiltrate or treat) either:

   a) The volume of runoff produced from a 24-hour 85th percentile storm event, as determined from the local historical rainfall record; or

   b) The volume of runoff produced by the 85th percentile 24-hour rainfall event, determined as the maximized capture storm water volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, (1998); or

   c) The volume of annual runoff based on unit basin storage volume, to achieve 80 percent or more volume treatment by the method recommended in the California Stormwater Best Management Practices Handbook – New Development and Redevelopment, (2003).

2. Flow-based BMPs shall be designed to mitigate (infiltrate or treat) either:

   a) The maximum flow rate of runoff produced by the 85th percentile hourly rainfall intensity, as determined from the local historical rainfall record, multiplied by a factor of two; or

   b) The maximum flow rate of runoff, as determined from local historical rainfall records, that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile hourly rainfall intensity multiplied by a factor of two.

iv. *Equivalent Numeric Sizing Criteria*: The Permittee may develop or use any equivalent numeric sizing criteria or performance-based standard for post-construction structural treatment BMPs as part of these requirements. Such equivalent sizing criteria may be authorized for use in place of the above criteria. In the absence of an equivalent numeric sizing criteria, the criteria contained above shall be implemented.

v. *Pollutants and Activities of Concern*: The DSP shall consider pollutants of concern or activities of concern in identifying appropriate BMPs for new development or significant redevelopment projects. In selecting BMPs, the following shall be considered: (1) the target pollutants; (2) land use and pollutants associated with that land use type; (3) pollutants expected to be present on site at concentrations that would pose potential water quality concerns; and (4) changes in flow rates and volumes resulting from the development project and sensitivity of receiving waters to changes in flow rates and volumes.

vi. *Implementation Process*: The DSP shall describe the process used to implement the Development Standards and all proposed modifications to the process. The process shall also include identification of the roles and responsibilities of various municipal departments in implementing these standards, as well as any other measures necessary for the implementation of these standards.

vii. *Infiltration and Groundwater Protection*: To protect groundwater quality, the Permittee shall apply restrictions to the use of structural BMPs designed to primarily function as infiltration devices (such as infiltration trenches and infiltration basins). Such restrictions shall ensure that the use of such infiltration structural treatment BMPs shall not cause a violation of applicable groundwater quality standards.

viii. *Downstream Erosion*: The DSP shall include any existing criteria or proposed modifications to ensure that discharges from new development and significant redevelopment address the potential for downstream erosion and protect stream habitat. At a minimum, the Permittees' Development Standards process shall consider the need for measures to control peak storm water discharge rates and velocities in order to protect downstream erosion and stream habitat. Storm water discharge volumes and durations should also be considered in the Development Standards.

ix. *Waiver Provision*: The Permittee may provide for a project to be waived from the requirement of implementing structural treatment BMPs if infeasibility can be established as described below.

x. *Conflicts with Local Practices*: The DSP shall include a description of necessary modifications to existing codes and ordinances and an implementation schedule for these modifications.

d. **Regional Storm Water Mitigation Program**: The Permittee may apply to the Regional Board for approval of a regional or sub-regional storm water mitigation program to substitute in part or wholly for Development Standard requirements. Upon review and a determination by the Executive Officer that the proposal is

technically valid and appropriate, the Regional Board may consider for approval such a program if its implementation will:

i. Result in equivalent or improved storm water quality;
ii. Protect stream habitat;
iii. Promote cooperative problem solving by diverse interests;
iv. Be fiscally sustainable via secured funding; and
v. Be completed in five years, including the construction and start-up of treatment facilities.

Nothing in this provision shall be construed as to delay the implementation of Development Standard requirements as required by this Order.

e. **Waiver Program**: Anytime during the term of the Order, the Permittee may propose a waiver program that would require any developers receiving waivers to transfer the savings in cost, as determined by the Permittee, to a storm water mitigation fund. Any proposed waiver program shall be subject to the approval of the Executive Officer. The Permittee may consider a waiver for projects where structural treatment BMPs are infeasible. The Permittee shall only grant a waiver when all appropriate structural treatment BMPs have been considered and rejected as infeasible. The Permittee shall notify the Regional Board within one month of each waiver issued and shall include the name of the person granting each waiver. Funds may be used for projects to improve urban runoff quality within the watershed of the waived project. At a minimum, a proposed waiver program shall identify the following:

i. The entity or entities that will manage (i.e., assume full responsibility for) the storm water mitigation fund;

ii. The range and types of acceptable projects for which mitigation funds may be expended;

iii. The entity or entities that will assume full responsibility for each mitigation project, including its successful completion; and

iv. How the dollar amount of fund contributions will be determined and managed.

f. **Maintenance Agreement and Transfer**: The Permittee shall require that all developments subject to Development Standards and site specific plan requirements provide verification of maintenance provisions for post-construction structural and treatment control BMPs. Verification shall include one or more of the following as applicable:

i. The developer's signed statement accepting responsibility for maintenance until the maintenance responsibility is legally transferred to another party; or

ii. Written conditions in the sales or lease agreement that require the recipient to assume responsibility for maintenance; or

iii. Written text in project conditions, covenants and restrictions for residential properties assigning maintenance responsibilities to a home owner's association, or other appropriate group, for maintenance of structural and treatment control BMPs; or

iv. Any other legally enforceable agreement that assigns responsibility for maintenance of structural or treatment control BMPs.

g. **California Environmental Quality Act Document Update**: The Permittee shall incorporate into its CEQA process, <u>within one year of the effective date of this Order</u>, procedures for considering potential storm water quality impacts and providing for appropriate mitigation when preparing and reviewing CEQA documents. The procedures shall require consideration of the following:

i. Potential impact of project construction on storm water runoff;
ii. Potential impact of project post-construction activity on storm water runoff;
iii. Potential for discharge of storm water from material storage areas, vehicle or equipment fueling, vehicle or equipment maintenance (including washing), waste handling, hazardous materials handling or storage, delivery areas or loading docks, or other outdoor work areas;
iv. Potential for discharge of storm water to impair the beneficial uses of the receiving waters or areas that provide water quality benefit;
v. Potential for the discharge of storm water to cause significant harm on the biological integrity of the waterways and water bodies;
vi. Potential for significant changes in the flow velocity or volume of storm water runoff that can cause environmental harm; and
vii. Potential for significant increases in erosion of the project site or surrounding areas.

h. **General Plan Update**: The Permittee shall do the following:

i. Evaluate and amend, revise, or update as necessary, its General Plan to include watershed and storm water quality and quantity management considerations and policies when any of the following General Plan elements are updated or amended: land use, housing, conservation, and open space.

ii. Provide the Regional Board with the draft amendment or revision when a listed General Plan element or the General Plan is noticed for comment in accordance with California Government Code § 65350 et seq.

i. **Targeted Employee Training**: The Permittee shall provide annual training for its employees in targeted positions (whose jobs or activities are engaged in development planning), regarding the requirements of this Order that affect development planning.

j. **Technical Guidance and Information for Developers**

i. The Permittee shall make Development Standards available to developers as they are adopted/approved.

ii. Within one year of adopting Development Standards, the Permittee shall make available in hardcopy and in addition may post on its website, new or amended technical guidance materials to the development community in the Permittee's jurisdiction for the siting and design of storm water quality BMPs. The technical material(s) shall at a minimum include:

1. Source and treatment control BMP design criteria for BMPs acceptable for use in the local area;

2. Peak flow control criteria to control peak discharge rates, velocities and duration in conformance with the numeric sizing criteria selected under C.5.c.iii above;

3. Expected pollutant removal performance ranges for the BMPs (or references to national databases, technical reports and/or scientific literature); and

4. Maintenance considerations.

IV. Commercial/Industrial Facilities Component

The Permittee shall develop and implement a commercial/industrial discharge management program to reduce to the MEP the discharge of pollutants from certain commercial and industrial operations within its jurisdiction. At a minimum, the program shall include:

a. **Identify and inventory all *industrial* facilities and activities**. By the end of the first year of the permit, the Permittee shall develop an inventory of all industrial facilities and activities that discharge to its MS4. The inventory shall include the facility name, address, nature of business or activity, SIC code(s) that best reflect the principal facility product or service, principle storm water contact, and whether statewide General Industrial Permit coverage has been obtained. At a minimum, the inventory shall include:
- Municipal landfills (open and closed)
- Hazardous waste recovery, treatment, storage and disposal facilities

- Facilities subject to Section 313 of the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. 11023
- Facilities subject to the statewide General Industrial Permit
- Industrial facilities tributary to a Clean Water Act Section 303(d) impaired water body, where a facility generates pollutants for which the water body is impaired;
- And any other industrial facility that either the Permittee or the Regional Board determines is contributing a substantial pollutant loading to the MS4.

The inventory shall be updated annually. The update may be accomplished through collection of new information obtained during field activities or though other readily available intra-agency informational databases (e.g., business licenses, pretreatment permits, sanitary sewer hook-up permits).

b. **Identify and inventory all *commercial* facilities and activities**. By the end of the first year of the permit, the Permittee shall develop an inventory of high risk commercial facilities and activities that discharge to its MS4. The inventory shall include the facility name, address, nature of business or activity, SIC code(s) that best reflect the principal facility product or service, and principle contact. At a minimum, the inventory shall include:
   - Restaurants
   - Retail Gasoline Outlets
   - Automotive Repair Facilities
   - Carpet Cleaners
   - Commercial Car Washes
   - Agricultural chemical dealers
   - And any other industrial facility that either the Permittee or the Regional Board determines is contributing a substantial pollutant loading to the MS4.

   The inventory shall be updated by the end of the third year of the new permit term, and annually thereafter. The update may be accomplished through collection of new information obtained during field activities or though other readily available intra-agency informational databases (e.g., business licenses, pretreatment permits, sanitary sewer hook-up permits).

c. **Establishment of minimum BMPs**. The Permittee shall designate a set of minimum BMPs designed to reduce the discharge of pollutants to the MEP. The minimum BMPs shall be industry or activity specific as appropriate. At a minimum, BMPs shall be developed for fuel storage and delivery, vehicle fueling and maintenance, equipment maintenance and washing. The minimum BMPs shall be produced within the second year of the permit.

d. **Requiring BMPs for all commercial/industrial facilities and activities**. The Permittee shall require the implementation of the designated minimum BMPs on all sites within the inventory identified in 3.a above. If particular minimum BMPs are

infeasible at a specific site, the Permittee shall require the implementation of other equivalent BMPs. All minimum BMPs shall be required to be implemented at each site within four years of permit adoption. The Permittee shall also implement or require any additional site specific BMPs as necessary to comply with this permit including BMPs that are more stringent than those required under the General Industrial Permit. The minimum BMPs shall be disseminated to the storm water contact for each industrial or commercial facility by the end of the third permit year and every other year thereafter. The Permittee shall take steps necessary to ensure that minimum BMPs are fully implemented within five years of permit adoption.

e. **Inspecting *industrial* facilities and activities**. The Permittee shall inspect all industrial facilities and activities identified in IV.b to ensure compliance with ordinances and this Order, including a review of BMP implementation plans and/or SWPPPs. All industrial facilities, shall be inspected once each year, commencing in the first permit year. Inspectors shall be trained to readily identify deficiencies, assess potential impacts to receiving waters, and evaluate the appropriateness and effectiveness of deployed BMPs and SWPPPs, if applicable. At a minimum, the inspectors shall ensure compliance with all local ordinances. Inspectors shall use a checklist, or equivalent, and photographs to document the site and BMP conditions. Records of all inspections shall be maintained a minimum of three years.

   The Permittee need not inspect facilities that have been inspected by the Regional Board within the past 12 months.

f. **Inspecting *commercial* facilities and activities**. The Permittee shall prioritize a commercial facilities inspection list (taken from commercial facilities identified in II.A.3.b) by the end of the second year of the permit term. Inspection priority shall be based on facility type, location, compliance or compliant history, or other factors. The Permittee shall inspect a minimum of 20% of these facilities each year, commencing in the fourth year of the permit term. Inspectors shall be trained to readily identify deficiencies, assess potential impacts to receiving waters, and evaluate the appropriateness and effectiveness of deployed BMPs and SWPPPs, if applicable. At a minimum, the inspectors shall ensure compliance with all local ordinances. Inspectors shall use a checklist, or equivalent, and photographs to document the site and BMP conditions. Records of all inspections shall be maintained a minimum of three years.

g. **Facilities with no exposure to storm water runoff**. The Permittee may remove facilities from the industrial and commercial inventory if an inspection conducted under Part C.6.e or C.6.f reveals the facility's industrial or commercial processes are meet the requirements for a conditional exclusion for "no exposure" under 40 CFR §122.26(g), other than the requirements to complete, sign and submit a "no exposure" certification. The Permittee may not remove any facility from the industrial and commercial inventory if the Regional Board or State Board has determined that the

facility causes, or has a reasonable potential to cause or contribute to, an in-stream excursion above an applicable WATER QUALITY STANDARDS, including beneficial uses.

g. **Enforcement of commercial/industrial discharge management program**. The Permittee shall enforce appropriate ordinances and permits at all commercial and industrial facilities as necessary to maintain compliance with this Order. The Permittee shall develop and implement a written progressive enforcement policy to ensure facilities are brought into compliance. The Permittee's ordinances or other regulatory mechanisms shall contain sanctions to ensure compliance. Sanctions may include the following or their equivalent: Non-monetary penalties, fines, bonding requirements, and/or permit denials or suspension for non-compliance. A copy of the progressive enforcement policy shall be included with the SWMP.

h. **Process to refer non-filers and noncompliance to Regional Board**. In the advent the Permittee has exhausted their use of sanctions and cannot bring a facility or activity compliance with their ordinances or this Order, or otherwise deems the facility or activity to pose an immediate and significant threat to water quality, the Permittee shall provide oral notification to the Regional Board <u>within five (5) business days of such determination</u>. Such oral notification shall be followed by written notification within <u>10 business days of the incident</u>.

For industrial facilities requiring coverage under the General Industrial Permit, the Permittee shall refer non-filers (i.e., those projects that cannot demonstrate that they have submitted an NOI or received a WDID number) to the Regional Board <u>within ten (10) business days of discovery</u>. In making such referrals, the Permittee shall include, at a minimum, the following information:

- Facility name and location;
- Facility contact;
- Facility SIC code; and
- Records of communication with the facility regarding filing requirements.

i. **Training**. The Permittee shall provide <u>annual training</u> for employees in targeted positions (whose jobs or activities are engaged in industrial or commerical inspections) regarding the requirements of this Order. This training shall include storm water BMP installation and maintenance techniques, good housekeeping measures, inspection procedures, enforcement procedures, and information on the requirements in the General Industrial Permit including elements in an effective SWPPP.

V. Municipal Maintenance Component

Within the second year of the permit, the Permittee shall develop and implement a municipal maintenance program to reduce to the MEP the discharge of pollutants

from all Permittee-owned facilities, roads, parking lots, municipal waste facilities, and the storm water collection system. The program shall include:

a. **Storm Water Collection System Inventory and Maintenance Schedules**. The Permittee shall develop a comprehensive inventory and map of all inlets to the MS4 and outlets (or outfalls) to receiving waters. Although not required, the Permittee is encouraged to establish the inventory in a GIS. The inventory shall include the location, type, maintenance requirements and maintenance schedules for:
   i. Each inlet to the MS4.
   ii. Each existing structural treatment control.
   iii. Each outfall to receiving waters.
   iv. The collection system pipes

   The inventory shall be developed and submitted to the Regional Board for review <u>within 2 years of permit adoption</u>.

b. **Ensure the storm drain system is properly operated and maintained**. Maintenance requirements include:

   i. All catch basins, inlets, structural controls and outlets shall be inspected and cleaned as necessary as per the maintenance schedules identified under a.i above, but <u>in no case less than once per year</u>.
   ii. The storm drain "hot spots" (to be defined in the City's Storm Water Management Plan) shall be inspected and cleaned as per the identified maintenance schedules.
   iii. Wastes, debris, and water removed during normal and emergency maintenance activities shall not be placed into the MS4. Decant from vactor trucks shall be discharged to the sanitary sewer or an appropriately designed dewatering facility.
   iv. Include BMPs to minimize infiltration of plastics and other trash into the storm drain system.

c. **Inventory and maintenance of Permittee owned facilities, roads, and parking lots**. The Permittee shall develop a comprehensive inventory and establish maintenance requirements and schedules and for all such areas. The inventory shall be developed <u>within 180 days of permit adoption</u>. This shall include:
   i. The development and implementation of minimum designated BMPs for Permittee-owned vehicle maintenance facilities, material storage facilities, and maintenance yards. The minimum designated BMPs shall be designated and fully implemented <u>within one year of permit adoption</u>.
   ii. The sweeping of all Permittee-owned roads <u>quarterly</u>. Permittee shall develop a maintenance schedule for cleaning trash, sediment, oil and other applicable pollutants from municipally-owned parking lots. The parking lot maintenance schedule shall be submitted with the Storm Water Management Program.

Removed material, debris, and decant water shall be disposed of in such a manner as to eliminate the potential for storm water pollution.

d. **BMPs for municipal maintenance activities**. The Permittee shall designate and ensure the implementation of minimum BMPs for all municipal maintenance activities. Examples of such activities include, but are not limited to: paving and road repairs, saw cutting, concrete work, curb and gutter replacement, buried utility repairs and installation, vegetation removal, street and parking lot striping, flood channel cleaning, etc. The BMPs should be combined into a manual, or equivalent, so as to facilitate use by field staff. The minimum designated maintenance and housekeeping BMPs shall be developed and implemented within one year 90 days of permit adoption.

e. **Implement appropriate requirements for pesticide, herbicide, and fertilizer applications**. The Permittee shall implement BMPs to reduce the contribution of pollutants associated with the application, storage and disposal of pesticides, herbicides and fertilizers from municipal areas and activities to the MS4. Municipal areas and activities include, at a minimum, municipal facilities, public right-of-ways, parks, recreational facilities, golf courses, and landscaped areas.

   Such BMPs shall include, at a minimum: (1) educational activities, permits, certifications and other measures for municipal applicators; (2) integrated pest management measures that rely on non-chemical solutions; (3) the use of native vegetation; (4) schedules for irrigation and chemical application; and (5) the collection and proper disposal of unused pesticides, herbicides and fertilizers. The minimum designated BMPs shall be developed and implemented within one year of permit adoption. By the fifth year of the permit term, the Permittee will eliminate all use of pesticides listed on the State Water Resources Control Board 303(d) list for the lower Salinas River section.

   All Permittee employees or contractors applying restricted use pesticides shall be supervised by certified applicators. All Permittee employees applying non-registered pesticides, herbicides or fertilizers shall receive training on the BMPs annually. All Permittee employees and Permittee contractors shall verify that they have received, understand, and will abide by the Permittee's BMPs for pesticide, herbicide and/or fertilizer application guidelines.

f. **Develop and implement storm water pollution prevention plans**. The Permittee shall develop and implement storm water pollution prevention plans for all municipally-owned facilities within 18 months of permit adoption. At a minimum, SWPPPs shall be developed for facilities involved in vehicle or equipment maintenance, vehicle or equipment fueling, or chemical storage. The Permittee may develop template SWPPPs for facility types (i.e. Vehicle fueling site SWPPP), which

may be modified as needed for individual sites. If required, such facilities will apply for coverage under the statewide General Industrial Permit.

g. **Municipal Inspections**. Inspections of all Permittee-owned municipal facilities and activities shall occur on an annual basis. Inspectors shall be trained to readily identify deficiencies and shall also evaluate the appropriateness and effectiveness of deployed BMPs and SWPPPs, if applicable. At a minimum, the inspectors shall ensure compliance with local ordinances and this permit. Inspectors shall use a checklist, or equivalent, and photographs to document site and BMP conditions. Records of all inspections shall be maintained. Inspections shall commence within year 2 of permit adoption.

h. **Annual Review**. The Permittee shall review their municipal maintenance facility inventory, maintenance procedures and schedules, lists of minimum BMPs, and inspection frequencies on an annual basis and revise any item determined to be less than satisfactory in reducing storm water pollution. All revisions shall be implemented within 90 days and reported in the next annual report.

i. **Training**. The Permittees shall provide annual training for employees in targeted positions (whose jobs or activities are engaged in municipal maintenance activities) regarding the requirements of this Order. The training shall include information on maintenance BMPs for typical maintenance activities, maintenance schedules, and record keeping. The training shall also include illicit discharge investigation, remediation and spill response procedures as described in Provision C.8.

VI. Illicit Discharge Detection and Elimination Component

The Permittee shall implement an ongoing program to investigate and remove illicit discharges and improper disposal into the MS4. The Permittee shall prohibit non-storm water discharges to the MS4, other than those authorized under a separate NPDES permit.

Discharges and flows from emergency fire fighting activities need not be addressed by the Permittee's illicit discharge management program unless such discharges and flows are determined by the Permittee, or the Regional Board, as significant source of pollutants to waters of the State.

The Permittee shall develop and implement an illicit discharge management program to reduce to the MEP the unauthorized and illegal discharge of pollutants to the MS4. The program shall include:

a. **Collection System Inventory and Map**. The Permittee shall use the map developed under C.7.a to identify priority areas for illicit discharge screening, including concentrated areas of industrial and commercial facilities. This shall include the

mapping of industrial facilities identified in Part C.6.a. If feasible, the map should designate locations where illicit discharges or spills can be contained within the MS4 (e.g., locations where plugs or other diversions could be inserted). The map shall be of sufficient detail so as to assist the Permittee with tracing illicit discharges. The collection system inventory and map shall be submitted to the Regional Board for review within the third year permit term.

b. **Illicit Discharge Reporting System**. The Permittee shall continue to operate a hotline telephone number to be used for all illicit discharge reporting. The telephone number shall be printed on all education, training, and public participation materials required under Part C.9, and clearly listed in the telephone book and listed as spill reporting or equivalent. The Permittee shall maintain a log of illicit discharge and spill calls. In all cases, individuals designated to answer calls shall be trained in proper emergency and non-emergency procedures.

c. **Illicit Discharge Identification**. The Permittee shall conduct drive-by inspections of the priority areas for illicit discharge screening at least quarterly. Drive-by inspections may be conducted by properly-trained City staff. Records of the drive-by inspections shall be maintained along with information describing all observed or believed discharges, their cause or responsible party, and actions taken to eliminate. In each subsequent year, the Permittee shall review this information determine if specific areas and/or facilities require drive-by inspections at an increased frequency. If so determined, the Permittee shall increase the frequency of inspections at the designated locations. Drive-by inspections shall commence within 180 days of permit adoption.

d. **Dry weather screening**. The Permittee shall develop written procedures for dry weather analytical and field screening monitoring (consistent with 40 CFR part 136), including field observations, monitoring, and analyses to be conducted during the dry season. The dry weather analytical and field monitoring program shall be designed to emphasize frequent, geographically widespread monitoring to detect illicit discharges and illegal connections. At a minimum, the procedures must be based on the following guidelines and criteria:

   i. Collect samples for analysis according to the Monitoring and Reporting Plan, Attachment 5 of Order R3-2004-0135

   ii. Dry weather analytical and field screening monitoring shall be conducted at each identified (Attachment 5) station four times per year during dry weather, including at least once between May 1st and September 30th of each year.

   iii. If flow or ponded runoff is observed at a dry weather analytical monitoring station and there has been at least seventy-two (72) hours of dry weather, make observations and conduct the required field sampling (Attachment 5). Record general information such as time since last rain, quantity of last rain, site

descriptions (i.e., conveyance type, dominant watershed land uses), flow estimation (i.e., width of water surface, approximate depth of water, approximate flow velocity, flow rate), and visual observations (i.e., odor, color, clarity, floatables, deposits/stains, vegetation condition, structural condition, and biology).

v. The Permittee shall develop threshold levels for monitoring results whereby exceedance of the threshold will require follow-up investigations to be conducted to identify the source causing the exceedance.

vi. If the station is dry (no flowing or ponded runoff), the Permittee shall make and record all applicable observations.

e. **Contain, Control and Respond to Spills to the MS4**. The Permittee shall respond to, contain and clean up all sewage and other spills that are discharged into their MS4 from any source (including private laterals and failing sewage systems). Spill response teams shall contain and control entry of spills into the MS4 and contamination of surface water, ground water and soil to the maximum extent practicable. The Permittee shall coordinate spill prevention, containment and response activities throughout all appropriate departments, programs and agencies to ensure maximum water quality protection at all times.

The Permittee shall develop and implement a mechanism whereby they are notified of all sewage spills from private laterals and failing sewage systems that reach the MS4 (gutters, storm drains). The Permittee shall respond to, contain and clean up sewage from any such notification.

f. **Facilitate Disposal of Used Oil and Toxic Materials**. The Permittee shall coordinate with the Salinas Valley Solid Waste Authority (SVSWA) or other designate disposal company, who currently implements program(s) to facilitate the proper management and disposal of all used oil, vehicle fluids, toxic materials, and other household hazardous wastes. The Permittee shall, through its Public Education and Participation Component (described below) include educational activities, public information activities, and establishment of collection sites operated by the Permittee or a private entity. The program(s) shall be implemented <u>within one year of permit adoption</u>.

g. **Enforce the local ordinance to eliminate illicit discharges**. The Permittee shall use the progressive enforcement policy developed under Part C.4.f above with the intent to eliminate all known illicit discharges within the Permittee's jurisdiction, and enforce against all known responsible party(s). The Permittee shall use all appropriate sanctions to ensure compliance including, but not limited to, non-monetary penalties, and fines. The Permittee shall review the existing municipal ordinances and other regulations to ensure proper authority exists to implement the

requirements listed in this part. If needed, all revisions must be made and adopted within two (2) years of permit adoption.

VII. Public Education and Participation Component

The Permittee shall implement a Public Outreach Program using any media appropriate to increase the knowledge of target businesses and communities regarding MS4s, impacts of urban runoff on receiving waters, and potential BMP solutions for the target audience. The intended outcome of public outreach is a change in the behavior of targeted groups to reduce pollutant discharges in storm water runoff to the MS4 to the MEP. The Permittee shall incorporate a mechanism for public participation in the implementation of the SWMP (e.g., programs that engage the public in cleaning up creeks, removal of litter in river embankments, and storm drain stenciling). The Public Outreach Program, as presented in the SWMP, shall include at least the following components:

- Advertising;
- Media relations;
- Public service announcements;
- "How To" instructional material distributed in a targeted and activity-related manner;
- Business, community association, and environmental organization tie-ins; and
- Events targeted to specific activities and population subgroups.

To meet the SWMP objectives and requirements of this Order, at a minimum, public outreach shall include the following:

a. **Target Groups**. The Public Outreach Program shall target at least the following groups:

   i. Municipal departments and personnel
   ii. Construction site contractors, developers and landowners
   iii. Industrial owners and operators
   iv. Commercial owners and operators
   v. Residential community, general public, and school children
   vi. Communities and businesses with primary languages other than English
   vii. Quasi-governmental agencies and districts (e.g., educational institutions, water districts, and sanitation districts).

b. **Residential activities**. For residential communities, public outreach shall include the following activities:

   i. Automobile repair and maintenance;
   ii. Automobile washing;
   iii. Home and garden care and product use;
   iv. Disposal of household hazardous waste (e.g., paints and cleaning products);

v. Disposal of pet waste;
vi. Disposal of green waste; and
vii. Any other residential source that the Permittee determines may contribute a significant pollutant load to the MS4.

c. **Stenciling and signage**. The Permittee shall install signs and stencil storm drain inlets at selected high use public access points to creeks, channels and other relevant water bodies, particularly areas with a history of dumping problems within two years of permit adoption. Sign and stencil messages shall use language discouraging or prohibiting illegal dumping. Storm water protection postings shall be legible and maintained as necessary during the term of this Order.

d. **Media impressions**. The Permittee shall ensure that a minimum of 525,000 impressions per year are made on the general public about storm water quality issues via print, local TV access, local radio, or other appropriate media. Media outreach will commence in the second permit year.

e. **Classroom education**. The Permittee shall offer educational opportunities to a minimum of 75 percent of all school children in the third through sixth grades every two years on storm water pollution prevention through classroom presentations or other activities. Classroom education will begin the second year of the permit term.

f. **Business outreach**. The Permittee shall continue to implement a business outreach program to educate and inform business owners and operators about storm water regulations and BMPs. Business outreach shall be conducted not less than twice during the five-year term of this Order, with the first outreach contact for appropriate businesses to begin no later than one year after permit adoption.

Businesses targeted for outreach shall include those identified in the Commercial/Industrial Element. At a minimum, the business outreach program shall include (1) educating owners and operators about storm water regulations; (2) distributing and discussing educational materials regarding storm water pollution and BMPs; (3) providing owners and operators with suggestions to facilitate compliance with storm water regulations; and (4) explaining penalties for noncompliance.

g. **Small Construction Outreach**. The Permittee shall conduct outreach to residential and commercial builders with construction sites smaller than one acre. This program shall, at a minimum, educate this group of builders on (1) statutes and regulations prohibiting discharge of sediment and other pollutants from their sites and into MS4s; (2) guidance documents available for selecting and installing BMPs; and (3) penalties for noncompliance.

h. **Public Awareness Survey**. To monitor the effectiveness of the Public Outreach Program in increasing public awareness and changing attitudes about storm water

pollution, the Permittee shall conduct public awareness surveys at a minimum frequency of twice during the five-year term of this Order. Survey results and analysis of program effectiveness shall be presented in the Annual Reports.

The survey shall measure a respondent's knowledge regarding, at a minimum: 1) where storm water goes, 2) level of treatment provided, 3) types of pollutants and their causes, 4) the respondents activities that potentially affect water quality, and 5) practices available to the respondents to reduce pollution. The results of the survey shall be used to measure the effectiveness of the Permittee's SWMP and identify needed revisions and/or additional targeting of education and training.

i. **Annual Meetings**. Annually the Permittee shall conduct a publicly noticed presentation of the information to be included in the Annual Report and to report on the next year's activities.

VIII. Program Effectiveness

The Permittee shall assess the effectiveness of its SWMP in the Annual Reports. The assessment shall address specific direct and indirect measurements that the Permittee will use to track the long-term progress of its SWMP towards achieving improvements in receiving water quality. Direct and indirect measures of effectiveness shall include, but are not limited to, conformance with established performance standards, quantitative monitoring to assess the effectiveness of control measures, measurements or estimates of pollutant load reductions or increases, detailed accounting of SWMP accomplishments including a justification or reason for the level of accomplishment achieved, and funds expended or staff hours used.

At a minimum, the Permittee shall include measures to assess the effectiveness of the overall storm water management program and measures to assess each of the major program areas required in the SWMP.

The Permittee shall include proposed performance and effectiveness measures in the Revised SWMP submitted to the Regional Board for review (180 days after the effective date of this Order).

Annual Reports shall also include a compliance status update that summarizes the Permittee's compliance with the elements in this Order and the elements in the SWMP.

IX. Legal Authority

The Permittee shall include with the first Annual Report, due after the effective date of this Order, a verification that it possesses legal authority that satisfies the criteria listed above. The Permittee shall provide as evidence of authority, a list of all statutes,

ordinances, permits, contracts, orders or inter-jurisdictional agreements that they contend demonstrate the adequacy of their legal authority.

a. The Permittee shall establish, maintain, and enforce adequate legal authority to control pollutant discharges into and from its MS4 through ordinance, statute, permit, contract or similar means. This legal authority must, at a minimum, authorize the Permittee to:

(1) Prohibit the contribution of pollutants in discharges of runoff associated with industrial and construction activity to its MS4 and regulate the quality of runoff from industrial and construction sites. This requirement applies both to industrial and construction sites which have coverage under the statewide general industrial or construction storm water permits, as well as to those sites which do not. Grading ordinances shall be upgraded and enforced as necessary to comply with this Order.

(2) Prohibit unauthorized non-storm water discharges, including but not limited to the following:

i. Sanitary sewage overflows except as authorized or in compliance with Waste Discharge Requirements, General Permits or their equivalent that may be established by the Regional Board, the State Board, or USEPA;

ii. Discharges of wash water resulting from the hosing off or cleaning of gas stations, vehicle repair services, or other types of automotive service facilities;

iii. Discharges resulting from the storage, cleaning, repair, or maintenance of any type of equipment, machinery, or facility including, but not limited to, motor vehicles, cement-related equipment, and portable toilet servicing;

iv. Discharges of wash water from mobile operations including, but not limited to, mobile vehicle washing, steam cleaning, power washing, and carpet cleaning;

v. Discharges of wash water from the cleaning of impervious surfaces in municipal, industrial and commercial areas including, but not limited to, parking lots, streets, sidewalks, driveways, patios, plazas, work yards and outdoor eating or drinking areas;

vi. Discharges of runoff from material storage areas containing chemicals, fuels, grease, oil, or other hazardous materials;

vii. Discharges of pool or fountain water containing chlorine, biocides, or other chemicals and discharges of pool or fountain filter backwash water;

viii. Discharges of sediment, pet waste, vegetation clippings, or other landscape or construction-related wastes;

ix. Discharges of food-related wastes (e.g., grease, fish processing, and restaurant kitchen mat and trash bin wash water);

x. Discharge of runoff from washing toxic materials from paved or unpaved areas; and

xi. Discharge of materials such as litter, landscape debris, construction debris, or any state or federally banned pesticides.

(3) Prohibit illicit connections to the MS4;

(4) Prohibit the discharge of spills, dumping, or disposal of materials other than storm water to its MS4;

(5) Use escalating enforcement mechanisms, including monetary fines, to obtain compliance with the Permittees' storm water ordinances, permits, contracts and orders;

(6) Prohibit the contribution of pollutants from one portion of the shared MS4 to another portion of the MS4 through interagency agreements with other local, state and federal agencies such as Caltrans. The RWQCB may assist in developing and negotiating interagency agreements to ensure that proximate MS4 communities are not discharging or allowing the discharge of pollutants into neighboring communities;

(7) Carry out inspections, surveillance, and monitoring necessary to determine compliance and noncompliance with this Order, local ordinances, and permits, including the prohibition of illegal discharges to the MS4. The Permittee must have authority to enter, sample, inspect, review records, and require regular reports and, as needed, relevant operational information from industrial facilities and construction sites discharging into its MS4;

(8) Require the use of BMPs to prevent or reduce the discharge of pollutants to MS4s; and

(9) Require that treatment control BMPs be properly operated and maintained.

Appendix B: Model LID Ordinance

City of Salinas Model Low Impact Development Ordinance

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City of Salinas Model Low Impact Development Ordinance

Section 1. General Provisions

1.1. Findings of Fact

It is hereby determined that:

Land development projects and associated increases in impervious cover alter the hydrologic response of local watersheds and increase storm water runoff rates and volumes, flooding, stream channel erosion, and sediment transport and deposition;

This storm water runoff also contributes to increased quantities of water-borne pollutants, and;

Storm water runoff, soil erosion and nonpoint source pollution can be controlled and minimized through the regulation of storm water runoff from development sites. These goals are achieved by designing sites that disturb only the smallest area necessary, minimize soil compaction and imperviousness, preserve natural drainages, vegetation and buffer zones, and utilize on-site, lot sized storm water treatment techniques; these principles and techniques are collectively known as Low Impact Development (LID). Because LID techniques are effective, feasible, and economically practical, they meet the maximum extent practicable (MEP) standard as defined in Section 2 of this ordinance.

Therefore, the ***City of Salinas*** establishes this set of water quality and quantity policies applicable to all surface waters to provide reasonable guidance for the regulation of storm water runoff for the purpose of protecting local water resources from degradation. It is determined that the regulation of storm water runoff discharges from land development projects and other construction activities in order to control and minimize increases in storm water runoff rates and volumes, soil erosion, stream channel erosion, and nonpoint source pollution associated with storm water runoff is in the public interest and will prevent threats to public health and safety.

1.2. Purpose

The purpose of this ordinance is to establish minimum storm water management requirements and controls to protect and safeguard the general health, safety, and welfare of the public residing in watersheds within this jurisdiction. This ordinance seeks to meet that purpose through the following objectives:

1) Minimize increases in storm water runoff from any development in order to reduce flooding, siltation, increases in stream temperature, and streambank erosion and maintain the integrity of stream channels;

2) Minimize increases in nonpoint source pollution caused by storm water runoff from development which would otherwise degrade local water quality;

3) Minimize the total annual volume of surface water runoff which flows from any specific site during and following development to not exceed the pre-development hydrologic regime to the maximum extent practicable;

4) Reduce storm water runoff rates and volumes, soil erosion and nonpoint source pollution, wherever possible, through storm water management controls and to ensure that these management controls are properly maintained and pose no threat to public

safety.

5) Meet the requirements of its National Pollutant Discharge Elimination System (NPDES) Permit ***(NPDES Permit No. CA0049981, Regional Board Order No. R3-2004-0135)*** that allows the discharge of storm water from the municipal separate storm sewer systems (MS4).

1.3. Applicability

This ordinance shall be applicable to all subdivision or site plan applications, unless eligible for an exemption or granted a waiver by the ***City of Salinas*** under the specifications of Section 4 of this ordinance. The ordinance also applies to land development activities that are smaller than the minimum applicability criteria if such activities are part of a larger common plan of development that meets the following applicability criteria, even though multiple separate and distinct land development activities may take place at different times on different schedules. In addition, all plans must also be reviewed by local environmental protection officials to ensure that established water quality standards will be maintained during and after development of the site and that post construction runoff levels are consistent with any local and regional watershed plans.

To prevent the adverse impacts of storm water runoff, the Central Coast Regional Water Quality Control Board has developed a set of performance standards that must be met at new development and significant redevelopment sites. These standards apply to any construction activity disturbing one or more acres of land and all new development and significant redevelopment projects that create or add 5,000 square feet or more of impervious surfaces within the jurisdictional authority of the ***City of Salinas*** and falling under the Priority Project Categories listed below.

The following activities may be exempt from these storm water performance criteria:

1) Any logging and agricultural activity which is consistent with an approved soil conservation plan or a timber management plan prepared or approved by the appropriate agency, as applicable;

2) Additions or modifications to existing single family structures;

3) Developments that disturb less than one acre of land or create or add less than 5,000 square feet of impervious surfaces, <u>provided they are not part of a larger common development plan</u>;

4) Repairs to any storm water treatment practice deemed necessary by City of Salinas.

The performance standards shall apply to the following Priority Project Categories:

1) Home subdivisions with ten housing units or more. This category includes single-family homes, multi-family homes, condominiums, and apartments.

2) Commercial developments. This category is defined as any development on private land that is not for heavy industrial or residential uses where the impervious land area for development is 100,000 square-feet or more. The category includes, but is not limited to hospitals, laboratories and other medical facilities, educational institutions, recreational

facilities, commercial nurseries, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses, and other light industrial facilities.

3) Automotive repair shops. This category is defined as a facility that is categorized by one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539, where the total impervious area for development is 5,000 square feet or more.

4) 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) and has 5,000 or more feet of impervious area.

5) Hillside developments 5,000 square feet or more of impervious area. This category is defined as any development that creates 5,000 square feet of impervious surface in an area with known erosive soil located in an area with natural slopes having a twenty-five percent or greater grade.

6) Parking lots exposed to rainfall that are 5,000 square feet or more, or with 25 or more parking spaces. This category is defined as an uncovered impervious area for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.

7) Street, roads, highways, and freeways. This category includes any paved surface five acres or greater used by automobiles, trucks, motorcycles, and other vehicles.

8) Retail Gasoline Outlets. "Retail Gasoline Outlet" is defined as any facility engaged in selling gasoline with 5,000 square feet or more of impervious surface area.

When a site development plan is submitted that qualifies as a Priority Project Category new development or significant redevelopment project, decisions on permitting and on-site storm water treatment requirements shall be governed by the numeric sizing criteria found in the current version of the ***City of Salinas*** Development Standards Plan. This criterion is dependent on the amount of impervious area created by the project and its impact on water quality. Final authorization of all Priority Project Category development projects will be determined after a review by the ***City of Salinas***. The term "significant redevelopment" is defined in Section 2 of this ordinance.

1.4. Compatibility with Other Permit and Ordinance Requirements

This ordinance is not intended to interfere with, abrogate, or annul any other ordinance, rule or regulation, stature, or other provision of law. The requirements of this ordinance should be considered minimum requirements, and where any provision of this ordinance imposes restrictions different from those imposed by any other ordinance, rule or regulation, or other provision of law, whichever provisions are more restrictive or impose higher protective standards for human health or the environment shall be considered to take precedence. If any other ordinance is found to impose different restrictions and provide lower protective standards for human health or the environment, then this ordinance shall take precedence and the City of Salinas shall revise the applicable standard and/or ordinance.

1.5. Severability

If the provisions of any article, section, subsection, paragraph, subdivision or clause of this ordinance shall be judged invalid by a court of competent jurisdiction, such order of judgment shall not affect or invalidate the remainder of any article, section, subsection, paragraph, subdivision or clause of this ordinance.

1.6. Development of a Development Standards Plan

The ***City of Salinas*** may furnish additional policy, criteria and information including specifications and standards, for the proper implementation of the requirements of this ordinance and may provide such information in the form of a Development Standards Plan.

This Development Standards Plan will include a list of acceptable storm water treatment practices, including the specific design criteria and operation and maintenance requirements for each storm water treatment practice. The Development Standards Plan may be updated and expanded from time to time, at the discretion of the local review authority, based on improvements in engineering, science, monitoring and local maintenance experience. Storm water treatment practices that are designed and constructed in accordance with the design and sizing criteria presented in the Development Standards Plan will be presumed to meet the minimum water quality performance standards.

Section 2. Definitions

"Accelerated Erosion" means erosion caused by development activities that exceeds the natural processes by which the surface of the land is worn away by the action of water, wind, or chemical action.

"Applicant" means a property owner or agent of a property owner who has filed an application for a storm water management permit.

"**Building"** means any structure, either temporary or permanent, having walls and a roof, designed for the shelter of any person, animal, or property, and occupying more than 100 square feet of area.

"Channel" means a natural or artificial watercourse with a definite bed and banks that conducts continuously or periodically flowing water.

"Dedication" means the deliberate appropriation of property by its owner for general public use.

"**Detention**" means the temporary storage of storm runoff in a storm water management practice with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

"Detention Facility" means a basin or alternative structure designed for the purpose of temporary storage of stream flow or surface runoff and gradual release of stored water at controlled rates.

"Developer" means a person who undertakes land disturbance activities.

"Drainage Easement" means a legal right granted by a landowner to a grantee allowing the use of private land for storm water management purposes.

"Erosion and Sediment Control Plan" means a plan that is designed to minimize the accelerated erosion and sediment runoff at a site during construction activities.

"Fee in Lieu" means a payment of money in place of meeting all or part of the storm water performance standards required by this ordinance.

"Flow-based Treatment Control BMPs" means structural treatment controls designed to convey, treat or infiltrate the maximum flow rate produced by a rain event equal to two times the 85th percentile hourly rainfall intensity based on local rainfall records. Examples of flow-based treatment control BMPs include vegetated swales and buffer strips.

"**Hotspot**" means an area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water.

"**Hydrologic Soil Group (HSG)**" means a Natural Resource Conservation Service classification system in which soils are categorized into four runoff potential groups. The groups range from A soils, with high permeability and little runoff production, to D soils, which have low permeability rates and produce much more runoff.

"**Impervious Cover**" means those surfaces that cannot effectively infiltrate rainfall (e.g., building rooftops, pavement, sidewalks, driveways, etc).

"**Industrial Storm Water Permit**" means an National Pollutant Discharge Elimination System permit issued to a commercial industry or group of industries which regulates the pollutant levels associated with industrial storm water discharges or specifies on-site pollution control strategies.

"**Infiltration**" means the process of percolating storm water into the subsoil.

"**Infiltration Facility**" means any structure or device designed to infiltrate retained water to the subsurface. These facilities may be above grade or below grade.

"**Jurisdictional Wetland**" means an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation.

"Land Disturbance Activity" means any activity which changes the volume or peak flow discharge rate of rainfall runoff from the land surface. This may include the grading, digging, cutting, scraping, or excavating of soil, placement of fill materials, paving, construction, substantial removal of vegetation, or any activity which bares soil or rock or involves the diversion or piping of any natural or man-made watercourse.

"Landowner" means the legal or beneficial owner of land, including those holding the right to purchase or lease the land, or any other person holding proprietary rights in the land.

"Low Impact Development (LID)" means the principles and techniques used in designing sites (starting from site layout, and grading and compaction phases of construction) that disturb only the smallest area necessary, minimize soil compaction and imperviousness, preserve natural drainages, vegetation, and buffer zones, and utilize on-site, lot sized storm water treatment techniques. LID sites reduce and compensate for development's impact(s) on hydrology and water quality.

"**Maintenance Agreement**" means a legally recorded document that acts as a property deed restriction, and which provides for long-term maintenance of storm water management practices.

"Maximum Extent Practicable (MEP)" is generally a result of emphasizing pollution prevention and source control best management practices (BMPs) as the first lines of defense in combination with structural treatment control BMPs where appropriate serving as additional lines of defense. The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility. MEP is defined by what is required in the NPDES Permit, EPA guidance, and current applied and available methods and financially feasible technology.

"**Nonpoint Source Pollution"** means pollution from any source other than from any discernible, confined, and discrete conveyances, and shall include, but not be limited to, pollutants from agricultural, silvicultural, mining, construction, subsurface disposal and urban runoff sources.

"Offset Fee" means a monetary compensation paid to a local government for failure to meet pollutant load reduction targets.

“Off-Site Facility” means a storm water management measure located outside the subject property boundary described in the permit application for land development activity.

“On-Site Facility” means a storm water management measure located within the subject property boundary described in the permit application for land development activity.

“Recharge” means the replenishment of underground water reserves.

“Significant Redevelopment” means the creation or addition of at least 5,000 square feet of impervious surfaces on an already developed site. It also includes, but is not limited to expansion of a building footprint, or replacement of a structure; replacement of impervious surface that is not part of a routine maintenance activity; and land-disturbing activities related to structural or impervious surfaces.

“Stop Work Order” means an order issued which requires that all construction activity on a site be stopped.

“Storm Water Management” means the use of structural or non-structural practices that are designed to reduce storm water runoff pollutant loads, discharge volumes, peak flow discharge rates and detrimental changes in stream temperature that affect water quality and habitat.

“Storm Water Retrofit” means a storm water management practice designed for an existing development site that previously had either no storm water management practice in place or a practice inadequate to meet the storm water management requirements of the site.

"**Storm Water Runoff**" means flow on the surface of the ground, resulting from precipitation.

“**Storm Water Treatment Practices (STPs)**” means measures, either structural or nonstructural, that are determined to be the most effective, practical means of preventing or reducing point source or nonpoint source pollution inputs to storm water runoff and water bodies.

“Volume-based Treatment Control BMPs” means structural treatment controls designed to capture, treat or infiltrate the volume produced by the local 24-hour, 85th percentile storm event or 80% of the volume of annual runoff. Examples of volume-based treatment control BMPs include extended detention basins, infiltration basins and trenches, and bioretention basins. Numerically the volume will vary as a function of geographic location and long term rainfall statistical data.

“Watercourse” means a permanent or intermittent stream or other body of water, either natural or man-made, which gathers or carries surface water.

Section 3. Permit Procedures and Requirements

3.1. Permit Required

No land owner or land operator shall receive any of the building, grading or other land development permits required for land disturbance activities without first meeting the requirements of this ordinance prior to commencing the proposed activity.

3.2. Application Requirements

Unless specifically excluded by this ordinance, any land owner or operator desiring a permit for a land disturbance activity shall submit to the ***City of Salinas*** a permit application on a form provided for that purpose.

Unless otherwise accepted by this ordinance, a permit application must be accompanied by the following documents in order for the permit application be considered: a storm water management concept plan; a maintenance agreement; and a non-refundable permit review fee.

A project site specific Storm Water Control Plan (SWCP) shall be prepared to meet the requirements of Sec. 5 of this ordinance, the maintenance agreement shall be prepared to meet the requirements of Sec. 9 of this ordinance, and fees shall be those established by the ***City of Salinas***.

3.3. Application Review Fees

The fee for review of any land development application shall be based on the amount of land to be disturbed at the site and the amount of new impervious surfaces to be created, and the fee structure shall be established by the ***City of Salinas***. All of the monetary contributions shall be credited to a local budgetary category to support local plan review, inspection and program administration, and shall be made prior to the issuance of any building permit for the development.

3.4. Application Procedure

1) Applications for land disturbance activity permits must be filed with the ***City of Salinas*** on any regular business day.

2) Permit applications shall include the following: two copies of the storm water management concept plan, two copies of the maintenance agreement, and any required review fees.

3) Within **20** business days of the receipt of a complete permit application, including all documents as required by this ordinance, the ***City of Salinas*** shall inform the applicant whether the application, plan and maintenance agreement are approved or disapproved.

4) If the permit application, Storm Water Control Plan (SWCP), or maintenance agreement are disapproved, the applicant may revise SWCP or agreement. If additional information is submitted, the ***City of Salinas*** shall have **15** business days from the date the additional information is received to inform the applicant that the plan and maintenance agreement are either approved or disapproved.

5) If the permit application, final SWCP and maintenance agreement are approved by the ***City of Salinas***, all appropriate land disturbance activity permits shall be issued.

3.5. Permit Duration

Permits issued under this section shall be valid from the date of issuance through the date the ***City of Salinas*** notifies the permit holder that all storm water management practices have passed the final inspection required under permit condition.

All applicable plans including but not limited to storm water reports, LID design drawings, as-built drawings, maintenance agreements and other pertinent agreements, will be retained on file by the ***City of Salinas*** for a minimum of 5 years.

Section 4. Waivers to Storm Water Management Requirements

4.1. Waivers for Providing Storm Water Management

Every applicant shall provide for storm water management as required by this ordinance, unless a written request is filed to waive this requirement. Requests to waive the project site specific Storm Water Control Plan (SWCP) requirements shall be submitted to the City of Salinas for approval.

The minimum requirements for storm water management may be waived in whole or in part upon written request of the applicant, provided that at least one of the following conditions applies:

1) It can be demonstrated that the proposed development is not likely to impair attainment of the objectives of this ordinance.

2) Alternative minimum requirements for on-site management of storm water discharges have been established in a SWCP that has been approved by the ***City of Salinas*** and the implementation of the plan is required by local ordinance.

3) Provisions are made to manage storm water by an off-site facility. The off-site facility is required to be in place, to be designed and adequately sized to provide a level of storm water treatment and control that is equal to or greater than that which would be afforded by on-site practices and there is a legally obligated entity responsible for long-term operation and maintenance of the storm water practice.

4) The ***City of Salinas*** finds that meeting the minimum on-site management requirements is not feasible due to the natural or existing physical characteristics of a site.

5) Non-structural practices will be used on the site that reduce: a) the generation of storm water from the site, b) the size and cost of storm water storage, and c) the pollutants generated at the site. These non-structural practices are explained in detail in the current Development Standards Plan and the amount of credit available for using such practices shall be determined by the ***City of Salinas***.

In instances where one of the conditions above applies, the ***City of Salinas*** may grant a waiver from strict compliance with these storm water management provisions, as long as acceptable mitigation measures are provided. However, to be eligible for a variance, the applicant must demonstrate to the satisfaction of the ***City of Salinas*** that the variance will not result in the following impacts to downstream waterways:

- Deterioration of existing culverts, bridges, dams, and other structures;
- Degradation of biological functions or habitat;
- Accelerated streambank or streambed erosion or siltation;
- Increased threat of flood damage to public health, life, property.

Furthermore, where compliance with minimum requirements for storm water management is waived, the applicant will satisfy the minimum requirements by meeting one of the mitigation

measures selected by the ***City of Salinas***. Mitigation measures may include, but are not limited to, the following:

1) The purchase and donation of privately owned lands, or the grant of an easement to be dedicated for preservation and/or reforestation. These lands should be located adjacent to a stream corridor in order to provide permanent buffer areas to protect water quality and aquatic habitat,

2) The creation of a storm water management facility or other drainage improvements on previously developed properties, public or private, that currently lack storm water management facilities designed and constructed in accordance with the purposes and standards of this ordinance,

3) Monetary contributions (Fee-in-Lieu) to fund storm water management activities such as research and studies (e.g., regional wetland delineation studies, stream monitoring studies for water quality and macroinvertebrates, stream flow monitoring, threatened and endangered species studies, hydrologic studies, and monitoring of storm water management practices.

4.2. Fee in Lieu of Storm water Management Practices

Where the ***City of Salinas*** waives all or part of the minimum storm water management requirements, or where the waiver is based on the provision of adequate storm water facilities provided downstream of the proposed development, the applicant shall be required to pay a fee in an amount as determined by the ***City of Salinas***.

When an applicant obtains a waiver of the required storm water management, the monetary contribution required shall be in accordance with a fee schedule (unless the developer and the ***City of Salinas*** agree on a greater alternate contribution) established by the ***City of Salinas***, and based on the cubic feet of storage required for storm water management of the development in question. All of the monetary contributions shall be credited to an appropriate capital improvements program project, and shall be made by the developer prior to the issuance of any building permit for the development.

4.3. Dedication of land

In lieu of a monetary contribution, an applicant may obtain a waiver of the required storm water management by entering into an agreement with the ***City of Salinas*** for the granting of an easement or the dedication of land by the applicant, to be used for the construction of an off-site storm water management facility. The agreement shall be entered into by the applicant and the ***City of Salinas*** prior to the recording of plats or, if no record plat is required, prior to the issuance of the building permit.

Section 5. General Performance Criteria for Storm Water Management

Unless judged by the ***City of Salinas*** to be exempt or granted a waiver, the following performance criteria shall be addressed for storm water management at all sites:

(A). All site designs shall establish storm water management practices to control the peak flow rates of storm water discharge associated with specified design storms and reduce the generation of storm water. All site designs shall also use LID design to minimize the amount of impervious surfaces and directly connected impervious surfaces in areas of new development and redevelopment and use on-site infiltration of runoff in areas with appropriate soils where the infiltration of storm water would not pose a potential threat to groundwater quality. These practices should seek to utilize pervious areas for storm water treatment and to infiltrate storm water runoff from driveways, sidewalks, rooftops, parking lots, and landscaped areas to the maximum extent practical to provide treatment for both water quality and quantity.

(B). All storm water runoff generated from new development and significant redevelopment shall not discharge untreated storm water directly into a jurisdictional wetland or local water body without meeting all applicable storm water treatment and permit requirements. All applicable sites shall also implement pollution prevention methods supplemented by pollutant source controls, and if source controls are not practicable, by treatment controls. Where practical, use strategies that control the sources of pollutants or constituents to minimize the transport of storm water and pollutants offsite and into MS4s. Where such discharges are proposed, the impact of the proposal on wetland functional values shall be assessed using a method acceptable to the ***City of Salinas***. In no case shall the impact on functional values be any less than allowed by the Army Corp of Engineers (ACE) or the Central Coast Regional Water Quality Control Board. Areas that provide important water quality benefits, such as riparian corridors, wetlands and buffer zones shall be preserved, and where possible, created or restored. All applicable sites shall also implement source and/or treatment controls as necessary to protect downstream receiving water quality from increased pollutant loads in runoff flows and from erosion from increased runoff rates, velocities and volumes from new development and significant redevelopment.

(C). Annual groundwater recharge rates shall be maintained, by promoting infiltration through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site shall mimic the annual recharge from pre-development site conditions.

(D). For new development and significant redevelopment projects that create or add 5,000 square feet or more of impervious surfaces and fall under the Priority Project Categories listed in Section 1.3 of this ordinance, structural treatment control BMPs shall be designed based on the required Numeric Sizing Criteria presented in the current ***City of Salinas*** NPDES permit.. It is presumed that a structural treatment control BMP complies with this performance standard if it is:

- designed according to the criteria outlined in the current Development Standards Plan,
- constructed properly, and
- maintained regularly.

(E). To prevent or reduce downstream erosion, and to protect stream habitat, the ***City of Salinas*** shall implement controls to limit post-development storm water run-off discharge rates, velocities and volumes to pre-development conditions. Disturbances of natural water bodies and natural drainage systems caused by development within the jurisdictional authority of the ***City of Salinas***, including roads, highways, and bridges, shall be minimized and the current applicable BMPs developed by Caltrans will be implemented. These include, but are not limited to, construction BMPs to be implemented when working in streams and wetlands, and temporary and permanent streambank stabilization BMPs. Development in areas that are particularly susceptible to erosion and sediment loss shall be developed per the LID requirements of the current Development Standards Plan.

(F). Storm water discharges to critical areas with sensitive resources (i.e., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs) may be subject to additional performance criteria, or may need to utilize or restrict certain storm water management practices.

(G). Certain industrial sites are required to prepare and implement a storm water pollution prevention plan, and shall file a notice of intent (NOI) under the provisions of the National Pollutant Discharge Elimination System (NPDES) general permit. The storm water pollution prevention plan requirement applies to both existing and new industrial sites.

(H). Storm water discharges from land uses or activities with higher potential pollutant loadings, known as “hotspots”, may require the use of specific structural STPs and pollution prevention practices.

(I). Prior to design, applicants are required to consult with the ***City of Salinas*** to determine if they are subject to additional storm water design requirements.

(J). Developers are required to prepare and submit studies analyzing pre- and post-project pollutant loads (including sediment) and flows resulting from projected future development. Incorporation of structural and non-structural BMPs to mitigate the projected increases in pollutant loads in runoff are required.

(K). Appropriate BMPs for pollutants of concern or activities of concern as listed in the current ***City of Salinas*** Development Standards Plan shall be required.

Section 6. Basic Storm Water Management Design Criteria

6.1. Minimum Control Requirements

All storm water management practices will be designed so that the specific storm frequency storage volumes (e.g., recharge, water quality, channel protection, 10 year, 100 year) as identified in the current Development Standards Plan are met, unless the ***City of Salinas*** grants the applicant a waiver or the applicant is exempt from such requirements. Storm water management practices to meet these requirements include LID design and LID techniques.

In addition, if hydrologic or topographic conditions warrant greater control than that provided by the minimum control requirements, the ***City of Salinas*** reserves the right to impose any and all additional requirements deemed necessary to control the volume, timing, rate and pollutant loading of runoff.

6.2 Site Design Feasibility

Storm water management practices for a site shall be chosen based on the physical conditions of the site. The factors that should be considered include the following:

1) Topography
2) Maximum Drainage Area
3) Depth to Water Table
4) Soils
5) Slopes
6) Terrain
7) Hydraulic head
8) Location in relation to environmentally sensitive features or ultra-urban areas

Applicants shall consult the current ***City of Salinas*** Development Standards Plan for guidance on the factors that determine site design feasibility when selecting a storm water management practice.

6.3. Conveyance Issues

All storm water management practices shall be designed to convey storm water to allow for the maximum removal of pollutants and reduction in flow velocities. This shall include, but not be limited to:

1) Maximizing of flow paths from inflow points to outflow points
2) Protection of inlet and outfall structures
3) Elimination of erosive flow rates, velocities and volumes
4) Providing of underdrain systems, where applicable

The current ***City of Salinas*** Development Standards Plan shall provide detailed guidance on the requirements for conveyance for each of the approved storm water management practices.

6.4. Pretreatment Requirements

Every storm water treatment practice shall have an acceptable form of water quality pretreatment, in accordance with the pretreatment requirements found in the current ***City of Salinas*** Development Standards Plan. Certain storm water treatment practices, as specified in the current ***City of Salinas*** Development Standards Plan, are prohibited even with pretreatment in the following circumstances:

1) Storm water is generated from highly contaminated source areas known as "hotspots"

2) Storm water is carried in a conveyance system that also carries contaminated, non-storm water discharges

3) Storm water is being managed in a designated groundwater recharge area.

4) Certain geologic conditions exist that prohibit the proper pretreatment of storm water.

6.5. Treatment/Geometry Conditions

All storm water management practices shall be designed to capture and treat storm water runoff according to the specifications outlined in the current ***City of Salinas*** Development Standards Plan. These specifications will designate the water quantity and quality treatment criteria that apply to an approved storm water management practice.

6.6. Landscaping Plans Required

All storm water management practices must have a landscaping plan detailing both the vegetation to be planted in the management practice, and how and who will manage and maintain this vegetation. This plan must be prepared by a registered landscape architect or soil conservation district.

6.7. Maintenance Agreements

All storm water treatment practices shall have an enforceable operation and maintenance agreement to ensure the system functions as designed. This agreement will include any and all maintenance easements required to access and inspect the storm water treatment practices, and to perform routine maintenance as necessary to ensure proper functioning of the storm water treatment practice. In addition, a legally binding covenant specifying the parties responsible for the proper maintenance of all storm water treatment practices shall be secured prior to issuance of any permits for land disturbance activities.

The ***City of Salinas*** shall require that all developments that fall under the Priority Project Categories listed in Section 1.3 of this ordinance provide verification of maintenance provisions for post-construction structural treatment control BMPs. Verification shall include the developer's signed statement accepting responsibility for maintenance until the maintenance responsibility is legally transferred to another party and one or more of the following as applicable:

1) Written conditions in the sales or lease agreement that require the recipient to assume responsibility for maintenance; or

2) Written text in project conditions, covenants and restrictions for residential properties assigning maintenance responsibilities to a home owner's association, or other appropriate group, for maintenance of structural and treatment control BMPs; or

3) Any other legally enforceable agreement that assigns responsibility for maintenance of structural or treatment control BMPs.

6.8. Non-Structural Storm Water Practices

The use of non-structural storm water treatment practices is encouraged in order to minimize the reliance on structural practices. Credit in the form of reductions in the amount of storm water that must be managed can be earned through the use of non-structural practices that reduce the generation of storm water from the site. These non-structural practices are explained in detail in the current ***City of Salinas*** Development Standards Plan and applicants wishing to obtain credit for use of non-structural practices must ensure that these practices are documented and remain unaltered by subsequent property owners.

Section 7. Requirements for Storm Water Control Plan Approval

7.1. Storm Water Control Plan Required for All Developments

No application for development will be approved unless it includes a project site specific Storm Water Control Plan (SWCP) detailing in concept how runoff and associated water quality impacts resulting from the development will be controlled or managed. This plan must be prepared by an individual approved by the ***City of Salinas*** and must indicate whether storm water will be managed on-site or off-site and, if on-site, the general location and type of practices.

The SWCP shall be referred for comment to all other interested agencies, and any comments must be addressed in a final SWCP. This final plan must be signed by a California licensed professional civil engineer, who will verify that the design of all storm water management practices meet the submittal requirements outlined in the Submittal Checklist found in the current ***City of Salinas*** Development Standards Plan. No building, grading, or sediment control permit shall be issued until a satisfactory final SWCP, or a waiver thereof, shall have undergone a review and been approved by the ***City of Salinas*** after determining that the plan or waiver is consistent with the requirements of this ordinance.

7.2. Storm Water Management Concept Plan Requirements

A storm water management concept plan shall be required with all permit applications and will include sufficient information (e.g., maps, hydrologic calculations, etc) to evaluate the environmental characteristics of the project site, the potential impacts of all proposed development of the site, both present and future, on the water resources, and the effectiveness and acceptability of the measures proposed for managing storm water generated at the project site. The intent of this conceptual planning process is to determine the type of storm water management measures necessary for the proposed project, and ensure adequate planning for management of storm water runoff from future development. To accomplish this goal the following information shall be included in the concept plan:

1) A map (or maps) indicating the location of existing and proposed buildings, roads, parking areas, utilities, structural storm water management and sediment control facilities. The map(s) will also clearly show proposed land use with tabulation of the percentage of surface area to be adapted to various uses; drainage patterns; locations of utilities, roads and easements; the limits of clearing and grading; A written description of the site plan and justification of proposed changes in natural conditions may also be required.

2) Sufficient engineering analysis to show that the proposed storm water management measures are capable of controlling runoff from the site in compliance with this ordinance and the specifications of the current ***City of Salinas*** Development Standards Plan.

3) A written or graphic inventory of the natural resources at the site and surrounding area as it exists prior to the commencement of the project and a description of the watershed and its relation to the project site. This description should include a discussion of soil conditions, forest cover, topography, wetlands, and other native vegetative areas on the site. Particular attention should be paid to environmentally sensitive features that

provide particular opportunities or constraints for development.

4) A written description of the required maintenance burden for any proposed storm water management facility.

5) The ***City of Salinas*** may also require a concept plan to consider the maximum development potential of a site under existing zoning, regardless of whether the applicant presently intends to develop the site to its maximum potential.

For development or redevelopment occurring on a previously developed site, an applicant shall be required to include within the storm water concept plan measures for controlling existing storm water runoff discharges from the site in accordance with the standards of this Ordinance to the maximum extent practicable (MEP).

7.3. Final Storm Water Control Plan Requirements

After review of the conceptual Storm Water Control Plan (SWCP), and modifications to that plan are completed as deemed necessary by the ***City of Salinas***, a final SWCP must be submitted for approval. The final SWCP, in addition to the information from the concept plan, shall include all of the information required in the final SWCP checklist found in the current ***City of Salinas*** Development Standards Plan. This includes:

1. Contact Information

   The name, address, and telephone number of all persons having a legal interest in the property and the tax reference number and parcel number of the property or properties affected.

2. Topographic Base Map

   A 1" = 200' topographic base map of the site which extends a minimum of **100** feet beyond the limits of the proposed development and indicates existing surface water drainage including streams, ponds, culverts, ditches, and wetlands; current land use including all existing structures; locations of utilities, roads, and easements; and significant natural and manmade features not otherwise shown.

3. Calculations

   Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this ordinance. Such calculations shall include:

   a) A description of the design storm frequency, intensity and duration,

   b) Time of concentration calculations,

   c) Soil Curve Numbers or runoff coefficients,

   d) Peak runoff rates and total runoff volumes for each watershed area,

   e) Existing site soil infiltration rates, where applicable,

   f) Culvert capacities,

   g) Flow velocities,

h) Data on the increase in rate and volume of runoff for the design storms referenced in the current ***City of Salinas*** Development Standards Plan, and

i) Documentation of sources for all computation methods and field test results.

4. Soils Information

If a storm water management control measure depends on the hydrologic properties of soils (e.g., storm water infiltration basins and existing site soil infiltration rates), then a soils report shall be submitted. The soils report shall be based on on-site boring logs or soil pit profiles and percolation testing results. The number and location of required soil borings or test pits shall be determined based on what is needed to determine the suitability and distribution of soil types present at the location of the proposed storm water infiltration structural treatment control BMPs.

5. Maintenance and Repair Plan

The design and planning of all storm water management facilities shall include detailed maintenance and repair procedures to ensure their continued function. These plans will identify the parts or components of a storm water management facility that need to be maintained and the equipment and skills or training necessary. Provisions for the periodic review and evaluation of the effectiveness of the maintenance program and the need for revisions or additional maintenance procedures shall be included in the plan.

6. Landscaping Plan

The applicant must present a detailed plan for management of vegetation at the site after construction is finished, including who will be responsible for the maintenance of vegetation at the site and what practices will be employed to ensure that adequate vegetative cover is preserved. This plan must be prepared by a registered landscape architect or by the soil conservation district.

7. Maintenance Easements

The applicant must ensure access to all storm water treatment practices at the site for the purpose of inspection and repair by securing all the maintenance easements needed on a permanent basis. These easements will be recorded with the plan and will remain in effect even with transfer of title to the property.

8. Maintenance Agreement

The applicant must execute an easement and an inspection and maintenance agreement binding on all subsequent owners of land served by an on-site storm water management measure in accordance with the specifications of this ordinance.

9. Erosion and Sediment Control Plans for Construction of Storm Water Management Measures

The applicant must prepare an erosion and sediment control plan for all construction activities related to implementing any on-site storm water management practices.

10. Other Environmental Permits

The applicant shall assure that all other applicable environmental permits have been acquired for the site prior to approval of the final storm water design plan.

7.4. Performance Bond/Security

The ***City of Salinas*** may, at its discretion, require the submittal of a performance security or bond prior to issuance of a permit in order to insure that the storm water practices are installed by the permit holder as required by the approved Storm Water Control Plan (SWCP). The amount of the installation performance security shall be the total estimated construction cost of the storm water management practices approved under the permit, plus 25%. The performance security shall contain forfeiture provisions for failure to complete work specified in the SWCP.

The installation performance security shall be released in full only upon submission of "as built plans" and written certification by a California licensed professional civil engineer that the storm water practice has been installed in accordance with the approved plan and other applicable provisions of this ordinance. The ***City of Salinas*** will make a final inspection of the storm water practice to ensure that it is in compliance with the approved plan and the provisions of this ordinance. Provisions for a partial pro-rata release of the performance security based on the completion of various development stages can be done at the discretion of the ***City of Salinas***.

Section 8. Construction Inspection

8.1. Notice of Construction Commencement

The applicant must notify the ***City of Salinas*** in advance before the commencement of construction. Regular inspections of the storm water management system construction shall be conducted by the staff of the ***City of Salinas*** or certified by a California licensed professional civil engineer or their designee who has been approved by the ***City of Salinas***. All inspections shall be documented and written reports prepared that contain the following information:

1) The date and location of the inspection;

2) Whether construction is in compliance with the approved Storm Water Control Plan

3) Variations from the approved construction specifications

4) Any violations that exist

If any violations are found, the property owner shall be notified in writing of the nature of the violation and the required corrective actions. No added work shall proceed until any violations are corrected and all work previously completed has received approval by the ***City of Salinas***.

8.2. As Built Plans

All applicants are required to submit actual "as built" plans for any storm water management practices located on-site after final construction is completed. The plan must show the final design specifications for all storm water management facilities and must be certified by a California licensed professional civil engineer. A final inspection by the ***City of Salinas*** is required before the release of any performance securities can occur.

8.3. Landscaping and Stabilization Requirements

Any area of land from which the natural vegetative cover has been either partially or wholly cleared or removed by development activities shall be revegetated within ten (10) days from the substantial completion of such clearing and construction. The following criteria shall apply to revegetation efforts:

a) Reseeding must be done with an annual or perennial cover crop accompanied by placement of straw mulch or its equivalent of sufficient coverage to control erosion until such time as the cover crop is established over ninety percent (90%) of the seeded area.

b) Replanting with native woody and herbaceous vegetation must be accompanied by placement of straw mulch or its equivalent of sufficient coverage to control erosion until the plantings are established and are capable of controlling erosion.

c) Any area of revegetation must exhibit survival of a minimum of seventy-five percent (75%) of the cover crop throughout the year immediately following revegetation. Revegetation must be repeated in successive years until the minimum seventy-five percent (75%) survival for one (1) year is achieved.

In addition to the above requirements, a landscaping plan must be submitted with the final design describing the vegetative stabilization and management techniques to be used at a site

after construction is completed. This plan will explain not only how the site will be stabilized after construction, but who will be responsible for the maintenance of vegetation at the site and what practices will be employed to ensure that adequate vegetative cover is preserved. This plan must be prepared by a registered landscape architect or by the soil conservation district, and must be approved prior to receiving a permit.

Section 9. Maintenance and Repair of Storm Water Facilities

9.1. Maintenance Easement

Prior to the issuance of any permit that has a storm water management facility as one of the requirements of the permit, the applicant or owner of the site must execute a maintenance easement agreement that shall be binding on all subsequent owners of land served by the storm water management facility. The agreement shall provide for access to the facility at reasonable times for periodic inspection by the ***City of Salinas***, or their contractor or agent, and for regular or special assessments of property owners to ensure that the facility is maintained in proper working condition to meet design standards and any other provisions established by this ordinance. The easement agreement shall be recorded by the ***City of Salinas*** in the land records.

9.2. Maintenance Covenants

Maintenance of all storm water management facilities shall be ensured through the creation of a formal maintenance covenant that must be approved by the ***City of Salinas*** and recorded into the land record prior to final plan approval. As part of the covenant, a schedule shall be developed for when and how often maintenance will occur to ensure proper function of the storm water management facility. The covenant shall also include plans for periodic inspections to ensure proper performance of the facility between scheduled cleanouts.

The ***City of Salinas***, in lieu of a maintenance covenant, may accept dedication of any existing or future storm water management facility for maintenance, provided such facility meets all the requirements of this chapter and includes adequate and perpetual access and sufficient area, by easement or otherwise, for inspection and regular maintenance.

9.3. Requirements for Maintenance Covenants

All storm water management facilities must undergo, at the minimum, an annual inspection to document maintenance and repair needs and ensure compliance with the requirements of this ordinance and accomplishment of its purposes. These needs may include; removal of silt, litter and other debris from all catch basins, inlets and drainage pipes, grass cutting and vegetation removal, and necessary replacement of landscape vegetation. Any maintenance needs found must be addressed in a timely manner, as determined by the ***City of Salinas***, and the inspection and maintenance requirement may be increased as deemed necessary to ensure proper functioning of the storm water management facility.

9.4. Inspection of Storm Water Facilities

Inspection programs may be established on any reasonable basis, including but not limited to: routine inspections; random inspections; inspections based upon complaints or other notice of possible violations; inspection of drainage basins or areas identified as higher than typical sources of sediment or other contaminants or pollutants; inspections of businesses or industries of a type associated with higher than usual discharges of contaminants or pollutants or with discharges of a type which are more likely than the typical discharge to cause violations of state or federal water or sediment quality standards or the NPDES storm water permit; and joint inspections with other agencies inspecting under environmental or safety laws. Inspections may include, but are not limited to: reviewing maintenance and repair records; sampling discharges, surface water, groundwater, and material or water in drainage control facilities; and evaluating the condition of drainage control facilities and other storm water treatment practices.

9.5. Right-of-Entry for Inspection

When any new drainage control facility is installed on private property, or when any new connection is made between private property and a public drainage control system, sanitary sewer or combined sewer, the property owner shall grant to the ***City of Salinas*** the right to enter the property at reasonable times and in a reasonable manner for the purpose of inspection. This includes the right to enter a property when it has a reasonable basis to believe that a violation of this ordinance is occurring or has occurred, and to enter when necessary for abatement of a public nuisance or correction of a violation of this ordinance.

9.6. Records of Installation and Maintenance Activities

Parties responsible for the operation and maintenance of a storm water management facility shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least___ years. These records shall be made available to the ***City of Salinas*** during inspection of the facility and at other reasonable times upon request.

9.7 Failure to Maintain Storm Water Management Practices

If a responsible party fails or refuses to meet the requirements of the maintenance covenant, the ***City of Salinas***, after reasonable notice, may correct a violation of the design standards or maintenance needs by performing all necessary work to place the facility in proper working condition. In the event that the storm water management facility becomes a danger to public safety or public health, the ***City of Salinas*** shall notify the party responsible for maintenance of the storm water management facility in writing. Upon receipt of that notice, the responsible person shall have **30** days to affect maintenance and repair of the facility in an approved manner. After proper notice, the ***City of Salinas*** may assess the owner(s) of the facility for the cost of repair work and any penalties; and the cost of the work shall be a lien on the property, or prorated against the beneficial users of the property, and may be placed on the tax bill and collected as ordinary taxes by the county.

Section 10. Enforcement and Penalties

10.1. Violations

Any development activity that is commenced or is conducted contrary to this Ordinance, may be restrained by injunction or otherwise abated in a manner provided by law.

10.2. Notice of Violation

When the ***City of Salinas*** determines that an activity is not being carried out in accordance with the requirements of this Ordinance, it shall issue a written notice of violation to the owner of the property. The notice of violation shall contain:

1) The name and address of the owner or applicant;
2) The address when available or a description of the building, structure or land upon which the violation is occurring;
3) A statement specifying the nature of the violation;
4) A description of the remedial measures necessary to bring the development activity into compliance with this Ordinance and a time schedule for the completion of such remedial action;
5) A statement of the penalty or penalties that shall or may be assessed against the person to whom the notice of violation is directed;
6) A statement that the determination of violation may be appealed to the municipality by filing a written notice of appeal within fifteen (15) days of service of notice of violation.

10.3. Stop Work Orders

Persons receiving a notice of violation will be required to halt all construction activities. This "stop work order" will be in effect until the ***City of Salinas*** confirms that the development activity is in compliance and the violation has been satisfactorily addressed. Failure to address a notice of violation in a timely manner can result in civil, criminal, or monetary penalties in accordance with the enforcement measures authorized in this ordinance.

10.4. Civil and Criminal Penalties

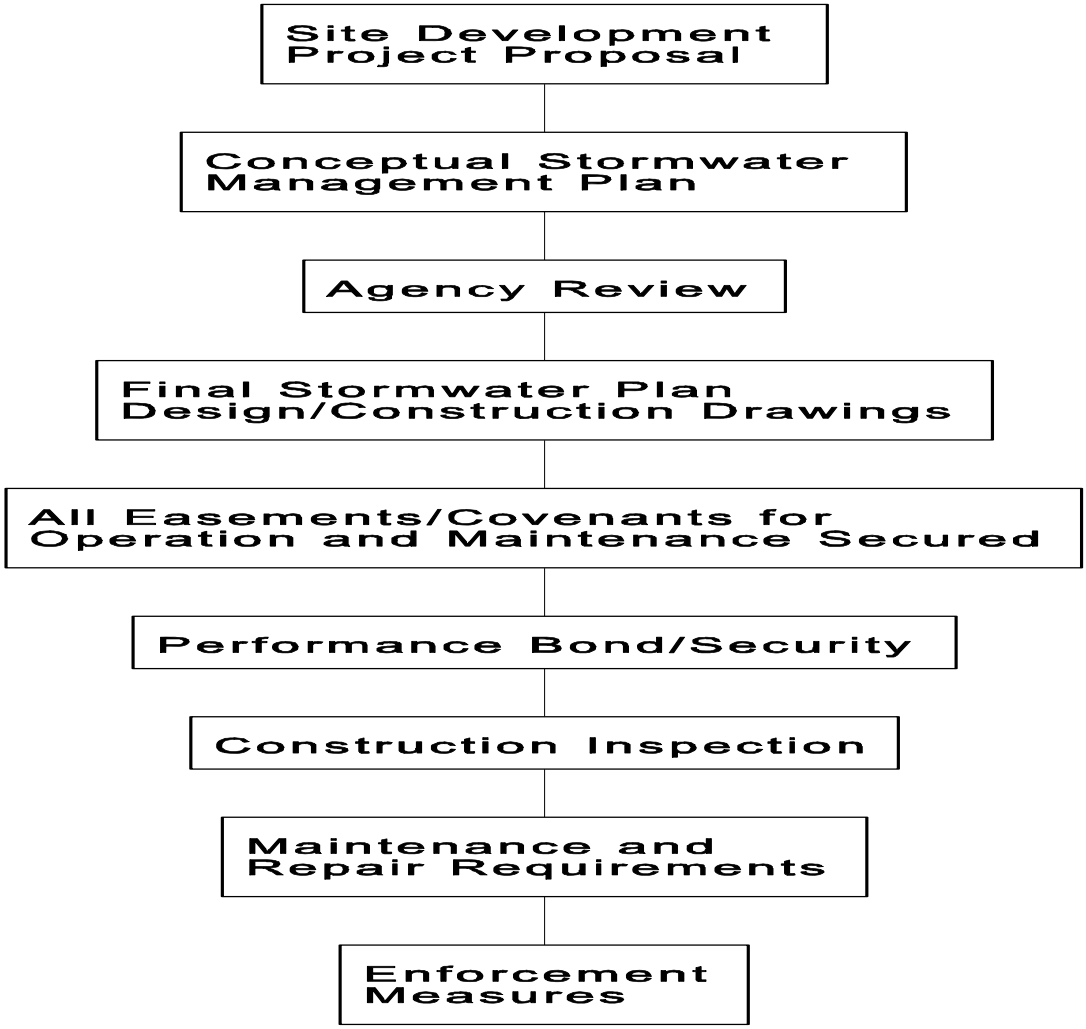
In addition to or as an alternative to any penalty provided herein or by law, any person who violates the provisions of this Ordinance may be referred to the Central Coast Regional Water Quality Control Board for additional enforcement. Pursuant to the California Water Code, the Central Coast Regional Water Quality Control Board may impose a civil liability of up to $10,000 per day for each day in which the violation occurs.

10.5. Restoration of Lands

Any violator may be required to restore land to its undisturbed condition. In the event that restoration is not undertaken within a reasonable time after notice, the ***City of Salinas*** may take necessary corrective action, the cost of which shall become a lien upon the property until paid.

10.6. Holds on Occupation Permits

Occupation permits will not be granted until corrections to all storm water practices have been made and accepted by the ***City of Salinas***.


Site Development Project Proposal
Conceptual Stormwater Management Plan
Agency Review
Final Stormwater Plan Design/Construction Drawings
All Easements/Covenants for Operation and Maintenance Secured
Performance Bond/Security
Construction Inspection
Maintenance and Repair Requirements
Enforcement Measures

Appendix C: Glossary

Appendix C: Glossary

Following are selected terms from the Salinas DSP and their associated definitions:

Anti-Seep Collar – means an impermeable diaphragm, usually of sheet metal or concrete, constructed within the zone of saturation along the conduit of a principal spillway or outlet, installed to prevent piping or seepage along the conduit.

Amended Soils – means materials added to soils to improve its physical and/or chemical properties. They are typically mixed into soils to provide a better environment for plant roots.

Aquatic Bench – means a 10 to 15 foot wide bench located around the inside perimeter of the permanent pool of a structural treatment control BMP or an LID practice and is normally vegetated with aquatic plants.

Baffles – means guides, grids, grating, fencing or similar devices placed in a detention basin, storm water wetland or pond to deflect or regulate flow and create a longer flow path.

Berm – means a shelf that breaks the continuity of a slope; a linear embankment or dike.

Best Management Practice (BMP) – means any procedure or practice designed to prevent or reduce the discharge of pollutants to the storm drain system. Storm water BMPs include schedules of activities, prohibitions of practices, maintenance procedures, structural devices and other management practices designed to help achieve storm water management control objectives at a designated site. Storm water BMPs can be classified in three general ways; temporary construction BMPs, source control BMPs and structural treatment control BMPs. See Section 2.5 for additional information.

Biochemical Oxygen Demand (BOD) – means a measurement of the amount of oxygen utilized by the decomposition of organic material, over a specified time period (usually 5 days) in a water sample.

Biofilters – means a vegetated or grassed channel designed to treat the water quality flow (WQ_F) of urban runoff primarily by physical filtering. Engineered soils and an underdrain system can be added to increase pollutant removal effectiveness.

Bioretention – means a water quality practice that utilizes landscaping and soils to treat urban runoff by collecting it in shallow depressions, before filtering through an engineered planting soil media. If underlying soils have slow infiltration characteristics, an underdrain system is necessary to drain the facility within 72 hours.

Buffer – means a vegetated or natural area adjacent to a shoreline, wetland or stream where stable vegetated soils should be preserved to provide filtering of urban runoff and development and other earth disturbing activities should be restricted or prohibited.

California Association of Storm water Quality Agencies (CASQA) – means the publisher of the California Storm water Best Management Practices Handbooks, available at www.cabmphandbooks.com

CASQA Method – means the method used to determine the required volume of storm water for volume-based of treatment control BMPs. The CASQA Method is presented in Section 4.3.0 of the Salinas DSP and in Section 5.5.1 of the California Storm water BMP Handbook (New Development) (CASQA, 2003).

Check Dam – means a small dam constructed in a swale or other small watercourse to decrease the stream flow velocity (by reducing the channel gradient), minimize channel scour, and promote deposition of sediment and groundwater recharge.

Clean Water Act (CWA) – Formerly known as the Federal Water Pollution Act, the CWA is the federal legislation, which provides statutory authority for both NPDES pretreatment and storm water programs.

Compensatory Mitigation Treatment – means the policy applied to allow an equivalent pollutant loading or quantity of storm water runoff or other equivalent water quality benefit, created where no other requirement for treatment exists, in lieu of on-site treatment facilities.

Conditions of Approval (COAs) – means the requirements a municipality may adopt for a project in connection with a discretionary action (e.g., adoption of an EIR or negative declaration or issuance of a use permit). COAs may include features to be incorporated into the final plans for the project and may also specify uses, activities, and operational measures that must be observed over the life of the project.

Construction BMP – means a temporary source control (e.g. cover soil stockpiles) and/or treatment control (e.g. silt fence, temporary detention basin) BMPs intended to minimize pollutants from storm water during project construction.

Design Storm – means a synthetic rainstorm defined by analyses of local rainfall data (intensities, durations and frequencies).

Detention – means the practice of holding storm water runoff in ponds, vaults, within berms, or in depressed areas and letting it discharge slowly to the storm drain system. See definitions of infiltration and retention.

Detention Basin – means a basin designed for the purpose of capturing and temporarily storing stream flow or surface runoff and gradual releasing it at controlled rates to reduce downstream peak flow rates. Extended detention basins are designed to provide prolonged detention of urban runoff to facilitate the gravity settling of fine sediment and other pollutants.

Direct Storm Water Infiltration – means any structure that is designed to infiltrate storm water into subsurface soils and bypass the natural filtration/groundwater protection from surface or near-surface soils. Examples include infiltration trenches and basins, which are structural treatment control BMPs designed for direct infiltration of storm water.

Directly Connected Impervious Area (DCIA) – means any impervious surface which drains directly into a catch basin, storm drain inlet, storm drain pipe or other conveyance structure without first allowing flow across pervious areas (e.g. lawns).

Discharge – when used as a verb, means to allow pollutants to directly or indirectly enter storm water, or to allow storm water or non-storm water to directly or indirectly enter the storm drain

system from an activity or operation. When used as a noun, "discharge" means the pollutants, storm water and/or non-storm water that are discharged to a receiving water body.

Drainage Area – or catchment areas means the area that contributes all precipitation falling within its boundaries, and the subsequent runoff produced, to a single common outflow point. The boundaries of drainage areas are defined by topographic high points or divides.

Drainage Sub-Area – means a smaller portion of a drainage area.

Drawdown Time – means the time required for a storm water detention or infiltration facility to drain and return to a pre-storm condition. For detention facilities, drawdown time is a function of basin volume and orifice size on the outlet structure. For storm water infiltration facilities, drawdown time is a function of basin volume, the surface area of the facility, and the infiltration rate of the underlying soils.

Energy Dissipater – A designed device such as an apron of rip-rap or a concrete structure placed at the end of a water transmitting apparatus such as pipe, paved ditch or paved chute for the purpose of reducing the velocity, energy and turbulence of the discharged water.

Engineered Soils – means a specific mix of soil materials and amendments (topsoil, sand and compost or peat moss) developed for the purpose of infiltrating and treating urban runoff while producing a favorable environment for plants.

Erosion – Detachment and movement of soil or rock fragments by water, wind, ice or gravity.

Exemption – means an exemption from the requirement to provide compensatory mitigation may be allowed for projects that meet certain criteria set by the Regional Board. These projects must, however, show impracticability (see definition of impracticable) of on-site treatment facilities and also show that the costs of compensatory mitigation would place an “undue burden” on the project.

Extended Detention – means a structural treatment control BMP designed to capture and gradually release the water quality volume of urban runoff over a 12 to 48 hour interval. The extended slow release is intended to increase the settling of fine sediment and associated urban pollutants. Extended detention basins can also be designed to control peak discharge for flood control and protect downstream channels from frequent storm events.

Filter Media – means the sand, soil, organic material or manufactured media in a filtration device used to provide a permeable surface for pollutant and sediment removal.

Filter Strips – means a vegetated area that treats sheet flow and/or interflow by removing sediment and other pollutants. The area may be grass-covered, forested or of mixed vegetative cover.

Fines (Soil) – means the silt and clay size particles in soil.

Hazardous Substance – means **a**ny substance, other than oil, which, when discharged in any quantities into waters of the U.S., presents an imminent and substantial danger to the public health or welfare, including but not limited to fish, shellfish, wildlife, shorelines and beaches (Section 311 of the CWA); identified by EPA as the pollutants listed under 40 CFR Part 116.

Head – means difference in elevation between different components of the storm drain system (e.g. between a catch basin inlet and outlet pipe) or storm water treatment BMPs (e.g. the curb inlet opening and the underdrain pipe). Head in hydraulics is the energy represented as a difference in water surface elevation.

Heavy Metals – means the metallic elements with high atomic weights (e.g. mercury, chromium, cadmium, arsenic, and lead) that can damage living things at low concentrations and tend to accumulate in the food chain.

Hydrograph – means a graph of runoff flow rate plotted as a function of time.

Hydrologic Soil Group (HSG) – means the classification of soils by the Natural Resources Conservation Service (NRCS – formerly the SCS) into A, B, C, and D groups which are based on soil hydrologic properties including runoff, drainage, and infiltration characteristics at soil saturation. HSG A soils generally have relatively high infiltration rates and low runoff potential (e.g. sandy soils) whereas HSG D soils generally have relatively low infiltration rates and high runoff potential (e.g. clayey soils).

Illicit Connections – means Illegal and/or unauthorized connections that result in untreated wastewater or industrial process water discharges into storm drainage systems and receiving waters.

Illicit Discharge – means any discharge to the storm sewer system that is not composed entirely of storm water, except for discharges allowed under an NPDES permit or waters used for certain emergency situations.

Imperviousness – means the characteristic of a material, which allows or prevents the effective infiltration or passage of water or other liquids through it.

Impervious Surfaces – means a hard surface area that prevents or retards the entry of water into the soil mantle and causes water to run off the surface in greater quantities or at a greater rate of flow than under natural pre-developed conditions. Impervious surfaces include but are not limited to building rooftops, roads, streets, driveways, parking lots, rooftops, patios, sidewalks and compacted soils. Gravel pavement over sandy soils is highly permeable and is not considered an impervious surface. However gravel pavement over clay soils is considered an impervious surface. Open, uncovered retention or detention facilities are not considered impervious surfaces.

Indirect Storm Water infiltration – means the transport of storm water into subsurface soils by first filtering it through vegetation, sand and amended or engineered soils. Structural treatment controls/LID practices such as porous pavement with a sand sub-base and bioretention systems or vegetated swales with amended or engineered soils provide indirect storm water infiltration. These LID practices are expressly designed to detain or convey urban runoff and allow it to filter through vegetation and engineered soils prior infiltration into shallow existing subsurface soils, generally less than 5 feet below ground surface. Using this type of infiltration, treated storm water runoff may percolate to groundwater or may be underdrained through subsurface pipes to the conventional storm drain system.

Infiltration - means the process of transporting water downward into the subsurface soils (also see the definition for percolation). Infiltration rates are estimates of the time it takes a unit of

water to enter a surface soil. Infiltration rates are generally reported in units such as inches of water infiltrated per hour (in/hr).

In-Line – means a storm water management device designed to manage storm water in its original stream or drainage channel or a device that does not have an upstream weir or diversion structure that limits flows from entering the device during large storm events.

Integrated Management Practice (IMP) – means a small-scale on-lot structural treatment control BMP that is integrated into site layout, landscaping and drainage design. See Low Impact Development.

Integrated Pest Management (IPM) – means an approach to pest management that relies on information about the life cycles of pests and their interaction with the environment. Pest control methods are applied with the most economical means and with the least possible hazard to people, property, and the environment.

Low Impact Development (LID) – means an integrated site design methodology that uses small-scale on-lot BMPs (Integrated Management Practices, or IMPs) to replicate pre-existing site hydrological conditions and reduce pollutant discharges to the storm drain system (MS4). See Section 2.0 for additional information.

Manufactured (Proprietary) Structural Treatment Control BMPs - means patented devices that are engineered, constructed and distributed by private companies.

Maximum Extent Practicable (MEP) – is a standard established by the 1987 amendments to the Clean Water Act, for the implementation of municipal storm water pollution prevention programs. MEP emphasizes the use of pollution prevention and source control BMPs as the first lines of defense used in combination with structural treatment control BMPs where appropriate serving as additional lines of defense. The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility. See Section 2.5 for additional information.

Municipal Separate Storm Sewer System (MS4) – means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, county, city, town, district, association, or other public body (created by or pursuant to state law) having jurisdiction over the disposal of sewage, industrial wastes, storm water, or other wastes, that discharges to waters of the United States. [40 CFR 122.26(b)(8)]. See Section 2.5 for additional information.

National Pollutant Discharge Elimination System (NPDES) – means the permitting system established as part of the 1972 Clean Water Act, to regulate the discharge of pollutants from municipal sanitary sewers and industries. The NPDES was expanded in 1987 to incorporate permits for storm water discharges as well.

Nomograph – means a chart that aids engineering calculations by representing the relationship among three variables. Nomographs in the California BMP Handbooks represent the relationship among percent annual capture, watershed imperviousness, and unit water quality volume.

Non-Point Source (NPS) Pollution – means pollution comes from many diffuse sources. It differs from point source pollution from industrial and sewage treatment plants. Non-point source pollution is caused by rainfall or snowmelt moving over the ground that picks up and transports natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and underground sources of drinking water. Common non-point sources are agriculture, forestry, urban areas, mining, construction, dams, unprotected channels, land disposal, saltwater intrusion, and city streets.

Non-Storm Water Discharges – means flows or discharges that are not entirely composed of storm water. Permitted non-storm water discharges without pollutants can include uncontaminated groundwater and natural springs. Non-storm water discharges that may contain low levels of pollutants can include car washing, air conditioner condensate, and hydrant flushing water.

Non-Structural Storm Water BMPs – means management practices and measures designed to reduce pollutant levels in storm water, which do not require construction efforts, and promote pollutant reduction by eliminating the pollutant source.

NPDES Storm Water Permit – means a permit issued by a Regional Water Quality Control Board (see definition) to local government agencies (Dischargers) placing provisions on allowable discharges of municipal storm water to waters of the state.

Numeric Sizing Criteria – means hydraulic sizing design criteria to for structural treatment control BMPs. It can be either volume-based or flow-based, depending on the primary process or function of the for structural treatment control BMP. See Section 4.3 for additional information.

Off-Line – means a storm water management system designed to manage a storm event by diverting a percentage of storm water events from a stream or storm drainage system.

One Hundred Year Storm – means a precipitation event, which statistically has a 1% chance on average of occurring in any given year.

Open Space – means a portion of a development site, which is permanently set aside for public or private use and will not be developed with homes, commercial or industrial structures. The space may be used for passive or active recreation, or may be reserved to protect or buffer natural areas.

Operation and Maintenance (O&M) – means the regular procedures and actions necessary to remove the sediment, debris and other pollutants from structural treatment control BMPs such that they continue to function as designed. O&M of structural treatment control BMPs may include regular inspections and preventative or corrective maintenance and measures conducted in perpetuity as required by a maintenance agreement.

Ordinance – means a law, statute, or decree enacted by a municipal body, such as a city council or county commission. Ordinances often govern matters not already covered by state or federal laws (such as local zoning, safety and building regulations), but may also be used to require stricter standards in local communities than those imposed by state or federal law.

Organic Filter – means a filtering practice that uses an organic medium such as peat moss or compost in the engineered soils of bioretention systems to filter storm water runoff.

Outfall – means the point where water discharges from a conduit, pipe, or drain to a stream, river, lake or another waterbody.

Outlet – means the point at which water discharges from a structure such as a basin, a trench or a concrete structure to another structure or a pipe or channel.

Overflow Chamber – means a design feature of some in-line structural treatment control BMPs that captures larger flows than are not treated by the practice, and passes them to the storm drain system.

Peak Flow Rate – means the maximum instantaneous rate of flow that occurs in response to a storm event as measured or calculated at a point of interest in a drainage area.

Perennial Stream – means a stream channel that has running water throughout the year.

Percolation – means the process of downward transport of water through soil layers or other materials. Percolation rates are estimates of the time it takes a unit of water to move through the subsurface soils and may be governed by a restrictive shallow soil layer in a soil column (e.g. a clayey layer). Percolation rates are typically reported in units of minutes per inch (min/inch or mpi). Percolation testing has historically been conducted to estimate the long-term ability of soils to absorb water from the leach fields of septic systems.

Permeability – means the rate of water movement through the soil column under saturated conditions. Permeable materials are those that allow water to pass through them relatively easily. Permeability values are a function of the size of soil pores or voids and the degree to which they are interconnected.

Permeable (or Porous) Pavements – means pavements for roadways, parking lots, driveways, sidewalks, or plazas that are pervious and designed to infiltrate storm water runoff. They include pervious concrete, pervious asphalt, unit pavers- on-sand, and crushed gravel and are typically installed with an underlying stone reservoir which temporarily stores urban runoff before it infiltrates into the subsoil or an underdrain system. It can be used to replace conventional impermeable asphalt and concrete.

Pervious – means a property of a material that allows for the passage of liquid through it.

Point Source – means any discernible, confined, and discrete conveyance or container, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, or tank from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

Pollutant – means dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, dirt, and industrial, municipal, and agricultural waste discharged into water [40 CFR 122.2].

Porosity – means is the ratio of void space volume to the total volume of soil or rocks. Generally the higher the soil porosity, the greater the ability to hold, transmit and infiltrate water.

Post-Construction BMP – means permanent source control and/or structural treatment control BMPs intended to be in place to treat storm water and minimize pollutants discharged to the City's storm drain collection system **after** the project is constructed. If a Project Specific Storm Water Management Plan (SWMP) is required for a site, then information as to the design, operation, and maintenance of the Post-Construction BMPs must be included in the SWMP.

Pretreatment – means techniques employed in storm water practices to provide storage or filtering to help trap coarse materials before they enter structural treatment control BMPs.

Project Specific Storm Water Management Plan (SWMP) – means a plan specifying and documenting permanent site features, BMPs, and facilities designed to control pollutants for the life of the project. The Project Specific SWMP also details long-term operation and maintenance requirements for all structural treatment control BMPs incorporated into a project. An acceptable Project Specific SWMP must be submitted before the building permit is made final and a Certificate of Occupancy is issued.

Public Domain Structural Treatment Control BMPs – means devices/facilities that can be designed by an engineer and have been implemented and tested by numerous communities throughout the nation. Public domain structural treatment control BMPs are not patented devices and can be constructed using locally available materials and contractors.

Rain Barrel – means a temporary storage device connected to a roof downspout, typically including a hose attachment to allow for reuse and later landscape irrigation.

Rational Method – means an engineering method used to estimate peak flow rates for tributary drainage areas of 100 acres or less. Runoff peak flow rates are based on drainage area (in acres), the percent imperviousness (the "C" runoff coefficient), statistical calculations of rainfall intensity (in inches/hour), and the time it takes a theoretical drop of water to travel from the most distant location in the drainage area to the point of interest.

Recharge Rate – means the annual amount of rainfall that infiltrates through surface soils and contributes to groundwater.

Redevelopment - means land-disturbing activity that result in the creation, addition, or replacement of impervious surface area on an already developed site. Redevelopment includes, but is not limited to the expansion of a building footprint; addition or replacement of a structure; replacement of impervious surface area that is not part of a routine maintenance activity; and land disturbing activities related to structural or impervious surfaces.

Regional (or Watershed) Storm Water Treatment Control BMP – means a facility that treats runoff from more than one project or parcel. Participation in a regional facility may be in lieu of on-site treatment controls, subject to the requirements of Salinas NPDES permit.

Regional Water Quality Control Board (Regional Board or RWQCB) – means the California agency responsible for implementing the pollution control provisions of the Clean Water Act and California Water Code within their jurisdiction. There are nine Regional Boards in and the Central Coast Regional Board is responsible for the Salinas area.

Retention – means the practice of holding storm water in ponds or basins and allowing it to slowly infiltrate to groundwater with some portion lost to evaporation. Retention is the amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff. It also refers to the amount of storm water that is retained in a treatment control and is not slowly released to the storm drain system. (See also definitions for infiltration and detention).

Retrofit – means the installation of a new structural treatment control BMP in an existing developed area or the improvement of an existing one.

Restrictive Layer – means a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restricts roots or otherwise provides an unfavorable root environment. Examples are bedrock, cemented layers, and significant increases in clayey soil textures between surface and subsurface layers.

Riparian – means the land area that borders a stream or river that typically supports water dependent vegetation and a diverse biological community. Riparian corridors and are often directly affected by adjacent developments that change flow rates, volumes and water quality. This land area often coincides with the maximum water surface elevation of the 100-year storm.

Riser – means a vertical pipe which extends from the bottom of a structural treatment control BMP that houses discharge control devices such as weirs, orifices or multiple perforations.

Runoff – means that part of precipitation, snow melt, irrigation or wash water that runs off the land into the storm drain system, streams or other surface-waters.

Run-on – means the flow of storm water from an upgradient area onto an area where potential pollutants may exist.

Sanitary Sewer – means a pipe or conduit intended to carry wastewater or water-borne wastes from homes, businesses, and industries to the publicly owned treatment works (POTW) facility.

Secondary Containment – means a structural containment feature that is external and separate from the primary containment device (e.g. a concrete dike, wall, barrier or berm around a bin, drum, or tank).

Sediment – means the solid particulate material, both mineral and organic, that can be transported from its site of origin by air, water, gravity, or ice.

Sedimentation Chamber – means a section of a structural treatment control BMP that provides for the settling out of relatively large sediment particles from suspension in storm water.

Setbacks – means the minimum distance requirements for location of a structural treatment control BMP in relation to roads, wells, septic fields, other structures. See Section 4.1.0 for additional information on setbacks for storm water infiltration BMPs

Sheet Flow – means water, usually storm runoff, flowing in a thin layer over the ground surface prior to the development of channelized flow.

Side Slopes – means the slope of the sides of a channel, dam or embankment. It is customary to name the horizontal distance first, as 3H:1V, meaning a horizontal distance of 3 feet to 1 foot vertical.

Source Control BMPs – means any schedule of activities, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent storm water pollution by reducing the potential for contamination at the source of pollution.

Spillway – means an open or closed channel, or both, used to safely convey excess water from a basin, pond or reservoir over a dam or embankment.

Stilling Basin – means an open structure or excavation at the foot of an outfall, conduit, chute, drop, or spillway to reduce the energy of the descending stream of water.

Storm Water = Stormwater – means rain and snow melt runoff and drainage associated with precipitation events [40 CFR 122.26(b)(13)].

Storm Water Hot Spots – means land-uses or activities that generate highly contaminated runoff. Examples include fueling stations and airport de-icing facilities.

Storm Water Management – means the process of collecting, conveying, storing, treating, and disposing of storm water to ensure control of the magnitude and frequency of runoff to minimize the hazards associated with flooding and the impact on water quality caused by manmade changes to the land.

Storm Water Pollution Prevention Plan (**SWPPP**) – means a plan identifying the temporary BMPs that will be used to manage erosion, sediment transport and storm water discharges during the construction phase of a project. A SWPPP is intended to facilitate a process whereby the operator evaluates potential pollutant sources at the site and selects, implements the appropriate temporary construction BMPs, and identifies the permanent structural treatment control measures to be constructed as part of the project.

Stream Buffers – means zones of variable width, which are located along both sides of a stream and are designed to provide a protective natural area along a riparian corridor.

Structural Treatment Control BMPs – means any engineered system designed to remove pollutants from urban runoff by gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process.

Toe (of slope) – means the location where the slope stops or levels out (bottom of the slope).

Total Maximum Daily Load (TMDL) – means a tool for establishing the allowable loadings of a given pollutant in a surface water resource from point sources and non-point sources that must be maintained to meet predetermined water quality standards.

Total Suspended Solids (TSS) – means a measure of the filterable solids present in a water sample, as determined by the method specified in 40 CFR Part 136.

Trash Rack – means a grill, grate or other device at the intake of a channel, pipe, drain or spillway installed for the purpose of preventing oversized debris from entering the structure.

Treatment – means the use of designed and/or engineered systems, which use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to filtration, gravity settling, media absorption, biodegradation, biological uptake, chemical oxidation and ultraviolet (UV) radiation.

Ultra-Urban – means a region dominated by highly developed areas in which very little pervious surface exists.

Variance – means **a** special allowance granted to a developer, which permits the use of designs different from the requirements of the current code.

Water Quality Flow Rate (WQ_F) – means the flow rate representing the frequently occurring rainfall/runoff events determined using the Rational Method with two times the local 85th percentile hourly rainfall intensity drainage. See Section 4.3.1 for additional information.

Water Quality Standard – means a law or regulation that consists of the beneficial use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

Water Quality Volume (WQ_V) – means the storage volume required to capture and treat the 24-hour 85th percentile storm event or 80% of the average annual storm water runoff volume.

Watershed: All the land area that contributes runoff to a particular point along a waterway. Watersheds typically consist of numerous drainage areas defined by either natural or manmade topographic divides.

Sources:

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Appendix D: List of Acronyms

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Below are the commonly used acronyms in the Salinas DSP and their associated definitions:

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
CASQA	California Stormwater Quality Association
CC&R's	Conditions, Covenants and Restrictions
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CWA	Clean Water Act
DCIA	Directly Connected Impervious Area
DSP	Development Standards Plan
EPA	U.S. Environmental Protection Agency
HOA	Home Owner's Association
IMP	Integrated Management Practice
LID	Low Impact Development
MDE	Maryland Department of the Environment
MEP	Maximum Extent Practicable
MIT	Minimum Inter-event Time
MS4	Municipal Separate Storm Sewer System
mg/l	milligrams per Liter
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NURP	Nationwide Urban Runoff Program
NWS	National Weather Service
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PMF	Probable Maximum Flood
ppm	parts per million
ROW	Right Of Way
SPF	Standard Project Flood
SUSMP	Standard Urban Stormwater Mitigation Plan
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load

Appendix D: List of Acronyms

TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UDFCD	Urban Drainage and Flood Control District
UIC	Underground Injection Control
µg/l	micrograms per Liter
WQ_F	Water Quality Flow
WQ_V	Water Quality Volume
WRCC	Western Regional Climate Center