Member Agencies:

Alameda

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Berkeley

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Fremont

Hayward

Livermore

Newark

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Pleasanton

San Leandro

Union City

Unincorporated
Alameda County

Alameda County
Flood Control and
Water Conservation
District

Zone 7 of the
Alameda County Flood
Control and
Water Conservation
District

Alameda Countywide
Clean Water Program
A Consortium of Local Agencies

C.3 Stormwater Technical Guidance

A handbook for developers, builders and project applicants

August 31, 2006

Version 1.0

Local Contacts

Contact information for each of ACCWP's member agencies is given below. Please contact the local agency with any questions regarding requirements specific to the local jurisdiction.

Alameda:	Public Works Department, 510.749.5840
Albany:	Community Development and Environmental Resources Department 1000 San Pablo Avenue, Albany, CA 94706. 510.528.5760
Berkeley:	510.981.7451
Dublin:	925.833.6632
Emeryville:	Civic Center, 1333 Park Ave, Emeryville, CA 94608 510.596.3728, www.ci.emeryville.ca.us/planning/stormwater.html
Fremont:	Community Development, 39550 Liberty Street, Fremont CA 94538 510.494.4570, www.fremont.gov
Hayward:	Engineering and Transportation Division, 510.583.4785
Livermore:	925.960.8100 (Inspection/reporting), 925.960-4500 (C.3 Technical Info) Permit Center, 1052 South Livermore, Ave. Livermore, CA 94550
Newark:	Michael Carmen or Soren Fajeau, City Hall – Public Works, 37101 Newark Boulevard, 1st Floor, Newark CA 94560, 510-794-2320
Oakland:	Permit Center, 250 Frank H. Ogawa Plaza, 2nd Floor, Oakland, CA 94612 510.238.3911, www.oaklandnet.com
Piedmont:	Public Works Counter, City Hall, 120 Vista Avenue, Piedmont, CA 94611; 510.420.3050; www.ci.piedmont.ca.us
Pleasanton:	Utility Engineer, 925.931.5508
San Leandro:	Engineering and Transportation Department, Civic Center- 835 East 14th Street, San Leandro, CA 94577 Jagtar Dhaliwal, 510.577.3417, jdhaliwal@ci.san-leandro.ca.us OR Keith Cooke, 510.577.3439, kcooke@san-leandrol.ca.us
Union City:	York R. Gorzolla, 34009 Alvarado-Niles Blvd., Union City, CA 94587 510.675.5362

Unincorporated Alameda County: 510.670.5543
951 Turner Court, Hayward, CA 94545 OR
339 Elmhurst Street, 1st Floor, Permit Center, Hayward, CA 94544

Alameda County Flood Control and Water Conservation District: 510.670.5543
951 Turner Court, Hayward, CA 94545 OR
339 Elmhurst Street, 1st Floor, Permit Center, Hayward, CA 94544

Zone 7 Water Agency: 925.454.5036

Credits

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C.3 Technical Guidance Work Group
Diamera Bach, Alameda County
Jim Barse, City of Alameda
Kaushik Bhatt, City of Pleasanton
Karen Borrmann, Alameda County
Steven Buckley, Alameda County
Mary Lim, Zone 7 Water Agency
Maritoni Maravilla, Alameda County
Darin Ranelletti, City of Oakland
Jim Scanlin, ACCWP
Peter Schultze-Allen, City of Emeryville
Marty Wayne, City of Fremont
Shannan Young, City of Fremont

New Development Subcommittee
Steve Aguiar, City of Livermore
Saied Aminian, City of Dublin
Claudine Asbagh, City of Piedmont
Diamera Bach, Alameda County
Jim Barse, City of Alameda
Kaushik Bhatt, City of Pleasanton
Michael Carmen, City of Newark
Robert Claire, City of Alameda
Grant Cramond, City of Union City
Amber Curl, City of Albany
Jagtar Dhaliwal, City of San Leandro
Nate French, City of Berkeley
York Gorzolla, City of Union City
Billy Gross, City of Albany
Kevin Jackson, City of Piedmont
Diana Keena, City of Emeryville
James Lear, City of Hayward
Mary Lim, Zone 7 Water Agency
Pamela Lung, City of Livermore
Darin Ranelletti, City of Oakland
Jim Scanlin, ACCWP
Peter Schultze-Allen, City of Emeryville
Shannan Young, City of Fremont

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Table of Contents

List of Tables

List of Figures

Glossary of Terms

Alameda Countywide Clean Water Program (ACCWP) ACCWP is established by a memorandum of understanding among the 14 Alameda County cites, Alameda County (Unincorporated Area), the Alameda County Flood Control and Water Conservation District, and the Zone 7 Water Agency. All these agencies are listed as Co-permittees in a municipal stormwater NPDES permit adopted by the Regional Water Quality Control Board. ACCWP implements common tasks and assists the member agencies to implement their local stormwater pollution prevention programs.

Bay Area Hydrology Model (BAHM) A computer software application currently being developed that will be available for downloading from ACCWP's website to assist project applicants in sizing specialized detention facilities that will allow a project to meet the Flow Duration Control standard where required by ACCWP's Hydrograph Modification Management Plan (HMP).

Beneficial Use A waterbody's beneficial uses are the resources, services, and qualities of aquatic systems that are the ultimate goals of protecting and achieving high water quality. The beneficial uses of surface waters, groundwaters, marshes, and mudflats are legally defined in the San Francisco Bay Basin Water Quality Control Plan and serve as a basis for establishing water quality objectives and the discharge prohibitions or conditions necessary to attain them.

Best Management Practice (BMP) Any program, technology, process, siting criteria, operational method or measure, or engineered system, which when implemented prevents, controls, removes, or reduces pollution. Includes schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce water pollution. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, litter or waste disposal, or drainage from raw material storage.

Bioretention Area System designed to filter pollutants from runoff using a combination of vegetated buffer strip, sand bed, ponding area, organic layer, planting soil, and plants.

Buffer Strip or Zone Strip of erosion-resistant vegetation over which stormwater runoff is directed.

C.3 Provision of the Alameda Countywide Municipal Stormwater NPDES Permit that requires each Discharger to change its development review process to control the flow of stormwater and stormwater pollutants from new development and redevelopment sites.

California Association of Stormwater Quality Agencies (CASQA) Publisher of the California Stormwater Best Management Practices Handbooks, available at www.cabmphandbooks.com. Successor to the Storm Water Quality Task Force (SWQTF).

Clean Water Act (CWA) The Federal Water Pollution Prevention and Control Act, or Clean Water Act (33 U.S. Code 1251 *et seq.*) is intended to control or eliminate surface water pollution and establishes the National Pollutant Discharge Elimination System, which regulates surface water discharges from municipal storm drains, publicly-owned treatment works and industrial discharges.

Complete Application Applications that have been accepted by the Planning Department and have not received a letter within 30 calendar days stating that the application is incomplete (consistent with the Permit Streamlining Act). Where an application has not been accepted by the Planning Department and the applicant has received a letter within 30 days stating that the application is incomplete, the application will be deemed complete if the additional requested information is submitted to the satisfaction of the Planning Department.

Conditions of Approval (COAs) Requirements the City 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.

Conduit/Conveyance System/ Culvert Channels or pipes for collecting and directing the flow of water. Conduits and conveyance systems may be open channels, covered channels or pipes. Culverts are covered channels or large diameter pipes.

Constructed Wetland Constructed detention basins that have a permanent pool of water throughout the year and capacity for temporary additional storage of runoff that is released via an outlet structure. They differ from wet ponds in that they are typically shallower and have greater vegetation coverage.

Construction General Permit A NPDES permit issued by the State Water Resources Control Board (SWRCB) for the discharge of stormwater associated with construction activity from soil disturbance of one (1) acre or more.

Design Storm A hypothetical rainstorm defined by rainfall intensities and durations.

Detention The temporary storage of stormwater runoff in ponds, vaults, within berms, or in depressed areas to allow treatment by sedimentation and metered discharge of runoff at reduced peak flow rates. See Infiltration and retention.

Directly-Connected Impervious Area (DCIA) The area covered by a building, impermeable pavement, and/or other impervious surfaces, which drains directly into the storm drain without first flowing across permeable land area (e.g., turf buffers).

Directly Discharging Outflow from a drainage conveyance system that is composed entirely or predominantly of flows from the subject property, development, subdivision, or industrial facility, and not commingled with flows from adjacent lands.

Direct Infiltration Infiltration via methods or devices, such as dry wells or infiltration trenches, designed to bypass unsaturated surface soils and transmit runoff directly to groundwater.

Discharge A release or flow of stormwater or other substance from a conveyance system or storage container.

Dischargers The agencies named in the stormwater NPDES permit.

Drawdown Time The time required for a stormwater detention or infiltration BMP to drain and return to the dry-weather condition. For detention BMPs, drawdown time is a function of basin volume and outlet orifice size. For infiltration BMPs, drawdown time is a function of basin volume and infiltration rate.

Dry Weather Flow Flows that occur during periods without rainfall. In a natural setting, dry weather flows result from precipitation that infiltrates into the soil and slowly moves through the soil to the stream channel. Dry weather flows in storm drains may result from human activities, such as over-irrigation.

Dry Well Structure placed in an excavation or boring, or excavation filled with open-graded rock, that is designed to collect stormwater and infiltrate into the subsurface soil.

Erosion The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or timber cutting.

Extended Detention Basin Constructed basins with drainage outlets that are designed to detain runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow settling of sediment and pollutants.

Filter Fabric Geotextile of relatively small mesh or pore size that is used to: (a) allow water to pass through while keeping sediment out (permeable); or (b) prevent both runoff and sediment from passing through (impermeable).

Flow-based Treatment Measures Stormwater treatment measures that treat pollutants from a moving stream of water through filtration, infiltration, and/or biological processes.

Flow Duration Either a) the total hours that surface flow from a watershed or drainage area occurs at a specified magnitude in response to a long-term time history of rainfall inputs, or b) the cumulative percentage of total hours that flows exceed the specified magnitude (as used in the BAHM). The overall distribution of flow durations is then expressed by a histogram or cumulative distribution curve, showing flow durations for equal subdivisions of the full range of flow magnitudes occurring over time.

Flow Duration Control An approach to mitigating development-caused hydromodification which involves developing continuous simulation models of runoff from both pre-project and post-project site conditions, comparing flow durations for a designated range of flows, and designing specialized detention and discharge structures to reduce excess post-project flow duration for flows in the designated range (See Chapter 7).

Flow-Through Planter Box Structure designed to treat stormwater by intercepting rainfall and slowly draining it through filter media and out of planter.

Grading The cutting and/or filling of the land surface to a desired shape or elevation.

Green Roof/ Roof Garden Vegetated roof systems that retain and filter stormwater prior to drainage off building rooftops.

Groundwater Subsurface water that occurs in soils, and geologic formations that are fully saturated.

Hazardous Waste By-products of human activities that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (flammable, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Head In hydraulics, energy represented as a difference in elevation. In slow-flowing open systems, the difference in water surface elevation, e.g., between an inlet and outlet.

High-Flow Bypass In stormwater treatment measures, a pipe, outlet, or other structure designed to convey flood flows directly to the storm drain systems without entering the treatment measure.

Hydrograph Runoff flow rate plotted as a function of time.

Hydromodification "Hydrograph modification", or more generally the changes in natural watershed hydrological processes and runoff characteristics caused by urbanization or other land use changes that result in increased stream flows and sediment transport.

Hydrograph Modification Management Plan, or Hydromodification Management Plan (HMP)) Required by the C.3 provisions to the stormwater NPDES permit, the HMP, once approved by the Water Board, will be implemented so that post-project runoff shall not exceed estimated pre-project rates and/or durations, where the exceedance would result in increased potential for erosion or other adverse impacts to beneficial uses. (See Chapter 7.)

Hydrologic Soil Group Classification of soils by the Natural Resources Conservation Service (NCRS) into A, B, C, and D groups according to infiltration capacity.

Imperviousness A term applied to surfaces – roads, sidewalks, rooftops, and parking lots – that prevent or inhibit rainfall from sinking into groundcover and groundwater.

Indirect Infiltration Infiltration via facilities, such as swales and bioretention areas, that are expressly designed to hold runoff and allow it to percolate into surface soils. Runoff may reach groundwater indirectly or may be underdrained through subsurface pipes.

Infiltration Seepage of runoff through the soil to mix with groundwater. See retention.

Infiltration Trench Long narrow trench filled with permeable material (e.g., gravel), designed to store runoff and infiltrate through the bottom and sides into the subsurface soil.

Inlet An entrance into a ditch, storm sewer, or other waterway

Integrated Management Practice (IMP) A stormwater treatment measure that meets both stormwater treatment and hydromodification management objectives.

Integrated Pest Management (IPM) An approach to pest control that utilizes regular monitoring to determine if and when treatments are needed and employs physical, mechanical, cultural, biological, and educational tactics to keep pest numbers low enough to prevent unacceptable damage or annoyance.

Maintenance Plan A plan detailing operation and maintenance requirements for stormwater treatment measures and/or structural hydromodification measures incorporated into a project.

Maximum Extent Practicable (MEP) Standard, established by the 1987 amendments to the Clean Water Act, for the implementation of municipal stormwater pollution prevention programs. ACCWP uses a continuous improvement approach, regularly updating its performance standards to achieve MEP.

Media Filter Two-chambered systems that include a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media.

National Pollutant Discharge Elimination System (NPDES) As part of the 1972 Clean Water Act, Congress established the NPDES permitting system to regulate the discharge of pollutants from municipal sanitary sewers and industries. The NPDES was expanded in 1987 to incorporate permits for stormwater discharges as well.

New Development Land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and/or land subdivision.

Non-Stormwater Discharge Any discharge to municipal separate storm drain that is not composed entirely of stormwater. Some types of non-stormwater discharges may be authorized by NPDES permits and others prohibited.

Notice of Intent (NOI) A formal notice to State Water Resources Control Board submitted by the owner/developer that a construction project is about to begin. The NOI provides information on the owner, location, and type of project, and certifies that the permittee will comply with the conditions of the State Construction General Permit.

NPDES Permit An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of the National Pollutant Discharge Elimination System (NPDES) program. As part of the 1972 Clean Water Act, Congress established the NPDES permitting system to regulate the discharge of pollutants from municipal sewers and industries. The NPDES program was expanded in 1987 to incorporate permits for stormwater discharges as well. Regional Water Quality Control Boards issue stormwater NPDES Permits to local government agencies placing provisions on allowable discharges of municipal stormwater to waters of the state.

Numeric Criteria Sizing requirements for stormwater treatment controls established in Provision C.3.d. of the ACCWP stormwater NPDES permit.

Operation and Maintenance (O&M) Refers to requirements in the stormwater NPDES permit to inspect treatment BMPs and implement preventative and corrective maintenance in perpetuity. See Chapter 8.

Operational Source Control Measure Low technology, low cost activities, procedures, or management practices designed to prevent pollutants associated with site functions and activities from being discharged with stormwater runoff. Examples include good housekeeping practices, employee training, standard operating practices, inventory control measures, etc.

Outfall/ Outlet The point where stormwater discharges from a pipe, channel, ditch, or other conveyance to a waterway.

Percentile Rainfall Intensity A method of designing flow-based treatment controls that ranks long-term hourly rainfall intensities and selects the 85^{th} percentile value, and then doubles this value.

Permeability A property of soil that enables water or air to move through it. Usually expressed in inches/hour or inches/day.

Pervious Surface Permeable hardscape or paved surface that allows surface runoff to infiltrate into surface soil (e.g., turf block, brick, natural stone, cobbles, gravel).

Perviousness The permeability of a surface that can be penetrated by stormwater to infiltrate the underlying soils.

Point of Compliance For design to meet Flow Duration Control requirements for hydromodification management, the point at which pre-project runoff is compared to post-project runoff, usually near the point where runoff leaves the project area.

Pollutant A substance introduced into the environment that adversely affects or potentially affects the usefulness of a resource.

Post-Construction Stormwater Control See Stormwater Control.

Precipitation Any form of rain or snow.

Provision C.3 A reference to the requirements added in February 2003, by the Regional Water Quality Control Board to the ACCWP's municipal stormwater NPDES permit requiring ACCWP to change its development review process to control the flow of stormwater and stormwater pollutants from new and redevelopment sites.

Rational Method A method of calculating runoff flows based on rainfall intensity and the amount of runoff from the tributary area.

Redevelopment A project on a previously developed site that results in the addition or replacement of impervious surface on such an already developed site. The NPDES permit excludes interior remodels and routine maintenance or repair, including roof or exterior surface replacement, pavement resurfacing, repaving and road pavement structural section rehabilitation within the existing footprint, and any other reconstruction work within a public street or road right-of-way where both sides of the right-of-way are developed.

Regional Water Quality Control Board, San Francisco Bay Area Water Board (RWQCB) One of nine California Regional Water Boards, the Regional Water Board for the San Francisco Bay Region is responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within the area that drains to San Francisco Bay. Also referred to as Water Board.

Retention The storage of stormwater to prevent it from leaving the development site; may be temporary or permanent.

Runoff Water originating from rainfall and other sources (e.g., sprinkler irrigation) that is found in drainage facilities, creeks, streams, springs, seeps, ponds, lakes, wetlands, and shallow groundwater.

Sedimentation The process of depositing soil particles, clays, sands, or other sediments that were picked up by runoff

Sediments Soil, sand, and minerals washed from land, roofing material, and pavements into water usually after rain, which accumulate in reservoirs, rivers, and harbors.

Self-Treating Area A portion of a development site in which infiltration and natural processes remove pollutants from stormwater. Examples of self-treating areas include conserved natural spaces, areas of landscaping, and areas paved with turf block. Self-treating areas treat only the stormwater they generate. They are not hydraulically sized to treat runoff from impervious areas.

Site Design Measures Site planning techniques to conserve natural spaces and/or limit the amount of impervious surface at new development and significant redevelopment projects in order to minimize runoff and the transport of pollutants in runoff.

Source Control Measures Any schedules of activities, structural devices, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent stormwater pollution by reducing the potential for contamination at the source of pollution.

Storm Drains Above and belowground structures for transporting stormwater to creeks or outfalls for flood control purposes.

Storm Event A rainfall event that produces more than 0.1 inch of precipitation and is separated from the previous storm event by at least 72 hours of dry weather.

Stormwater Stormwater runoff, snow-melt runoff, surface runoff, and drainage, excluding infiltration and irrigation tailwater.

Stormwater Control A design feature of a development or redevelopment project, or a routinely-conducted activity that is intended to prevent, minimize or treat pollutants in stormwater, or to reduce erosive flows during the life of the project. Stormwater control is a term that collectively refers to site designs to promote water quality, source control measures, stormwater treatment measures, and hydromodification management measures. Also referred to as "post-construction stormwater control" or "post-construction stormwater measure."

Stormwater Pollution Prevention Plan (SWPPP) A plan providing for temporary measure to control sediment and other pollutants during construction.

Storm Water Quality Task Force (SWQTF) Publisher of the 1993 California Storm Water BMP Handbooks. See California Association of Stormwater Quality Agencies (CASQA).

Stormwater Treatment Measure Any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process. Sometimes called a treatment control, treatment control measure, or treatment control BMP.

Treatment The application of engineered systems that use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to, filtration, gravity separation, media adsorption, biodegradation, biological uptake, and infiltration.

Vector Control Any method to limit or eradicate the vectors of vector born diseases, for which the pathogen (e.g. virus or parasite) is transmitted by a vector which can be mammals, birds or arthropods, especially insects, and more specifically mosquitoes. For the purposes of this document, vector control refers to mosquito control.

Vegetated Filter Strip Linear strips of vegetated surfaces that are designed to treat sheet runoff flow from adjacent surfaces.

Vegetated Swale Open, shallow channels with vegetation covering side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points.

Volume-Based Stormwater Treatment Measures Stormwater treatment measures that detain stormwater for a certain period and treat primarily through settling and infiltration.

Water Quality Inlet Systems that contain one or more chambers that promote sedimentation of coarse materials and separation of undissolved oil and grease from stormwater. Also referred to as oil/water separators.

Water Quality Volume (WQV) For stormwater treatment measures that depend on detention to work, the volume of water that must be detained to achieve maximum extent practicable pollutant removal. This volume of water must be detained for a specified drawdown time.

WEF Method A method for determining the required volume of treatment BMPs, recommended by the Water Environment Federation and American Society of Civil Engineers. Described in Urban Runoff Quality Management (WEF/ASCE, 1998).

Wet Pond Constructed detention basins that have a permanent pool of water throughout the year and capacity for temporary additional storage of runoff that is released via an outlet structure. They differ from constructed wetlands in that they typically have a greater average depth and less vegetation.

Chapter

1

Introduction / How to Use this Handbook

This Chapter describes the purpose of this handbook and gives an overview of its contents.

1.1 Purpose of this Handbook

This countywide handbook is meant to help developers, builders, and project sponsors include post-construction stormwater controls in their projects, in order to meet local municipal requirements. The municipalities have to require post-construct stormwater controls as part of their obligations under Provision C.3 of the countywide municipal stormwater National Pollutant Discharge Elimination System ***(NPDES) permit***, which is similar to other municipal stormwater permits in the Bay Area. In California, the responsibility for implementing the NPDES permit program has been delegated to the State Water Resources Board and its regional Water Boards.

The term "***post-construction stormwater control***" refers to permanent features included in a project to reduce pollutants in stormwater "and/or erosive flows during the life of the project – after construction is completed. This handbook does not provide information on the construction best management practices (BMPs) that protect stormwater during construction activities. Internet links to information on construction BMPs can be found in Appendix A.

> ***"Post-construction stormwater controls"*** are permanent features included in a project to reduce pollutants in stormwater "and/or erosive flows after construction is completed.

Post-construction stormwater controls are required for both private and public projects. Although this handbook is written primarily for sponsors of private development projects, its technical guidance also applies to publicly-sponsored projects. Municipalities may also find the handbook useful for training municipal staff and consulting plan checkers.

1.2 What is the ACCWP?

The Alameda Countywide Clean Water Program (ACCWP) is an association of the agencies in Alameda County that manage separate storm drain systems and creek channels that discharge urban runoff to San Francisco Bay. ACCWP has 17 member agencies: the 14 cities in the County, Unincorporated Alameda County, Zone 7 Water Agency, and the Alameda County Water Conservation and Flood Control Division.

ACCWP's member agencies are joint permit holders of the countywide municipal stormwater NPDES permit, which is issued by the San Francisco Bay Regional Water Quality Control Board (Water Board). Each member agency is individually responsible for implementing the municipal stormwater permit requirements, but participating in ACCWP helps them collaborate on countywide initiatives that benefit all members. More information on the ACCWP is available on its website, at http://cleanwaterprogram.org.

1.3 How to Use this Handbook

Some requirements in this countywide guidance document ***may vary*** from one local jurisdiction to the next.

When using this countywide guidance document, please keep in mind that ***some requirements may vary from one local jurisdiction to the next.*** In the very early stages of project planning, contact the municipal planning staff to schedule a pre-application meeting to learn how the C.3 requirements – and other planning, zoning and building requirements – will apply to your project. Also, because regulatory requirements may change, be sure to ask the local municipal staff to provide any updates of information or requirements.

It's important to note that post-construction stormwater design requirements are complex and technical: most projects will require the assistance of a qualified civil engineer, architect, landscape architect, and/or geotechnical engineer.

To help you get started, a synopsis of the handbook's chapters and appendices is provided below:

- Chapter 2 explains how development affects stormwater quality, how post-construction stormwater measures help reduce these impacts, and gives a detailed explanation of ***Provision C.3 requirements***..
- Chapter 3 gives an overview of how the post-construction stormwater requirements fit into a typical development review process, and offers ***step-by-step instructions*** on how to incorporate stormwater control designs into planning permit and building permit application submittals for your project.

- Chapter 4 presents information on ***site design measures***, including technical guidance for site design measures such as green roofs and pervious paving, which can help reduce the size of stormwater treatment measures.
- Chapter 5 provides ***general technical guidance for stormwater treatment measures***, including hydraulic sizing criteria, the applicability of non-landscape-based treatment measures, manufactured treatment measures, using "treatment trains," infiltration guidelines, plant selection and maintenance, mosquito control, and integrating stormwater treatment with hydromodification management.
- Chapter 6 gives technical guidance for ***specific types of stormwater treatment measures***, including vegetated swales, vegetated buffer strips, tree well filters, media filters, flow-through planter boxes, bioretention areas, infiltration trenches, and extended detention basins.
- Chapter 7 explains the requirements for ***hydromodification management measures***, which keep the flow rates and volumes of certain post-construction stormwater flows at pre-construction levels, in order to minimize development-induced erosion in creek channels.
- Chapter 8 explains the ***operation and maintenance*** requirements for stormwater treatment measures.
- Chapter 9 describes ACCWP's draft model ***alternative compliance*** program, which is being reviewed by the Regional Water Quality Control Board. Once it's approved, municipalities may use this program to allow eligible projects to contribute to off-site alternative compliance projects instead of constructing on-site stormwater treatment measures.
- Appendix A lists the ***Internet links*** that are referred to in various chapters of the document, as well as other useful stormwater links.
- Appendix B includes a ***list of plants*** appropriate for use in landscape-based treatment measures. It also offers general guidance on plant selection and maintenance.
- Appendix C presents ***example scenarios***, showing how site design, source controls and treatment measures can be incorporated into projects.
- Appendix D is a placeholder in which each agency may include its own ***agency-specific requirements***, such as the agency's conditions of approval, Source Control Measures List, and Impervious Surface Form.
- Appendix E consists of the ***Mean Annual Precipitation Map*** for Alameda County.
- Appendix F describes manufactured stormwater treatment measures that may have ***limited applicability***, including inlet filters, oil/water separators and hydrodynamic separators.
- Appendix G presents guidelines for using stormwater controls that promote on-site ***infiltration*** of stormwater.

- Appendix H provides guidance for ***controlling mosquito production*** in stormwater treatment measures.
- Appendix I includes templates for preparing stormwater treatment measures ***maintenance plans***.

Chapter

2

Background / Regulatory Requirements

This Chapter summarizes stormwater problems resulting from development and explains the post-construction requirements for development projects.

2.1 Stormwater Problems in Developed Areas

Throughout the country, stormwater runoff is a leading source of pollutants for water bodies that fail to meet water quality standards[1]. In the San Francisco Bay watershed, urban and agricultural runoff are generally considered to be the ***largest source of pollutants*** to aquatic systems.[2] Although stormwater runoff is part of the natural hydrologic cycle, human activities can alter the natural drainage patterns, introduce pollutants, and increase erosion, degrading the natural habitats.

2.1.1 Stormwater Runoff in a Natural Setting

The natural water cycle circulates the earth's water from sky, to land, to sea, to sky in a never-ending cycle. In a pristine setting, soil is covered with a complex matrix of mulch, roots and pores that absorb rainwater. As ***rainwater infiltrates slowly into the soil***, natural biologic processes remove impurities. Because most rainstorms are not large enough to

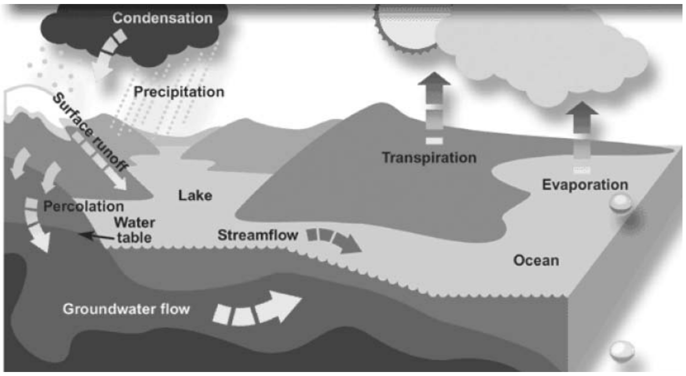

Figure 2-1: The Water Cycle (NGRDC/GDNR, 2005/06)

[1] See the USEPA's list of Stormwater Frequently Asked Questions, at http://cfpub.epa.gov/npdes/faqs.cfm?program_id=6

[2] San Francisco Bay Regional Water Quality Control Board, Basin Plan, 2004, http://www.waterboards.ca.gov/sanfranciscobay/basinplan.htm

fully saturate the soil, only a small percentage of annual rainwater flows over the surface as runoff. The natural vegetation tends to slow the runoff in a meandering fashion, allowing suspended particles and sediments to settle. In the natural condition, the hydrologic cycle creates a stable supply of groundwater, and surface waters are naturally cleansed of impurities. Sediment is carried with the flow of stormwater runoff, but in a natural setting, creeks typically find an equilibrium in which they manage normal sediment flows with no impairment of their vital functions.

2.1.2 Stormwater Runoff in Urban or Urbanizing Areas

In developed areas, impervious surfaces – such as roads, parking lots and rooftops – prevent water from infiltrating into the soil. ***Most of the rainfall remains on the surface***, where it washes debris, dirt, vehicle fluids, chemicals, and other pollutants into the local storm drain systems. Once in the storm drain, polluted runoff flows directly into creeks and other natural bodies of water. Figure 2-2 contrasts the percentage of rainfall that becomes stormwater runoff in a natural and an urban setting.

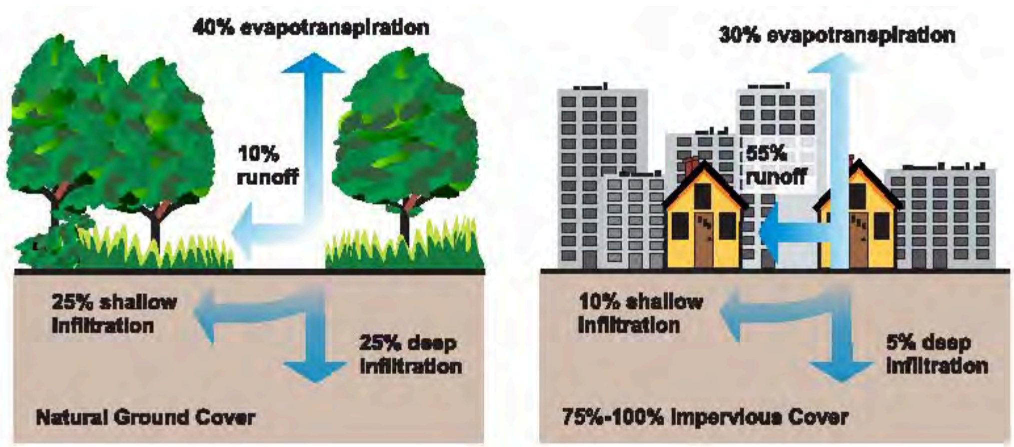

Figure 2-2: Change in volume of stormwater runoff after development. (USEPA, 2003)

Not only does urban stormwater runoff ***wash pollutants into local waterways***, but it can also cause natural creek channels to erode. When impervious surfaces are built, rainwater runs off at ***faster rates and in larger volumes*** than in the natural condition. Natural creek channels must suddenly handle much greater volumes of water traveling at much faster rates, greatly increasing the duration of erosive forces on their bed and banks. In response to these changes, creek channels enlarge by eroding and may also become less stable. This effect is called hydrograph modification or hydromodification. Figures 2-3 and 2-4 contrast creek channels in the natural condition and creek channels subject to hydromodification.

2.2 Post-Construction Stormwater Controls

Various permanent control measures have been developed in order to ***reduce the long-term impacts*** of development on stormwater quality and creek channels. These permanent control measures are often called post-construction stormwater controls or post construction best management practices (BMPs) to distinguish them from the temporary construction BMPs that are used to control sedimentation and erosion while a project is being constructed.

Figure 2-3: Creek with Natural Banks

Figure 2-4: Creek Subject to Hydromodification

Post-construction stormwater control measures can be divided into four categories: site design measures, source control measures, stormwater treatment measures, and hydromodification management measures. Each of these categories is described below.

2.2.1 Site Design Measures

Site design measures are ***site planning technique***s that help reduce stormwater pollutants and increases in the peak runoff flow and duration, by protecting existing natural resources and reducing impervious surfaces of development projects. Some examples of site design measures include:

- Minimize land disturbance and preserve high-quality open space;
- Minimize impervious surfaces by using narrow streets, driveways and sidewalks;
- Minimize impervious surfaces that are directly connected to the storm drain system (unless the connection includes a stormwater treatment measure). One example of "disconnecting" impervious surfaces is to direct roof downspouts to splash blocks or "bubble-ups" in landscaped areas;
- Cluster structures and paved surfaces; and
- Use landscaping as a drainage feature.

2.2.2 Source Control Measures

Source control measures consist of either structural project features or operational "good housekeeping" practices that ***prevent pollutant discharge and runoff*** at the source, and keeping pollutants from coming into contact with stormwater. Examples of structural source controls include:

- Roofed trash enclosures,

- Berms that control runon to or runoff from a potential pollutant source, and
- Indoor mat/equipment washracks that are connected to the sanitary sewer. (Note that any sanitary sewer connections must be approved by the local permitting authority.)

Examples of operational source controls include:

- Street sweeping and
- Regular inspection and cleaning of storm drain inlets.

2.2.3 Stormwater Treatment Measures

Stormwater treatment measures are engineered systems that are designed to ***remove pollutants from stormwater*** using natural processes such as filtration, infiltration, flotation and sedimentation. Stormwater treatment measures must be sized to comply with one of the hydraulic design criteria listed in the municipal stormwater permit's Provision C.3.d, which are described in Section 5.1 of this guidance document. Stormwater treatment measures can be categorized according to whether they are landscape-based or non-landscape-based. Because landscape-based treatment measures have generally been found to be more effective than non-landscape based, the use of landscape-based treatment measures is encouraged. Although other types of stormwater treatment measures may be used, Chapter 6 provides technical guidance specific to the following treatment measures:

- Bioretention areas,
- Extended detention basins,
- Flow-through planter boxes,
- Infiltration trenches,
- Media filters,
- Tree well filters,
- Vegetated buffer strips, and
- Vegetated swales.

2.2.4 Hydromodification Management Measures

Hydromodification management (HM) measures include site design and source control measures that promote infiltration or otherwise ***minimize the change in the rate and flow of runoff***, when compared to the pre-development condition. HM measures also include constructed facilities (such as basins, ponds, or vaults) that manage the flow rates of stormwater leaving a site, and under some conditions can also include re-engineering of at-risk channels downstream from the site. In some cases a single stormwater treatment measure may be used to meet both the treatment and HM objectives for a project. A dual-use measure of this type is sometimes called an "integrated management practice," or IMP.

2.3 Municipal Stormwater Permit Requirements

The development or redevelopment of property represents an opportunity to incorporate post-construction controls that can reduce water quality impacts over the life of the project. Since the first countywide municipal stormwater permit was adopted in 1991, the ACCWP municipal agencies have required new development and redevelopment projects to incorporate post-construction stormwater site design, source control, and treatment measures in their projects to the maximum extent practicable (MEP). To meet the MEP standard, municipalities must employ stormwater control measures that are technically feasible (that is, are likely to be effective) and are not cost prohibitive.

When it was reissued in 2003, the countywide municipal stormwater permit included more prescriptive requirements for incorporating post-construction stormwater control measures into new development and redevelopment projects, similar to other Bay Area municipal stormwater permits. The full text of the municipal stormwater permit is available at the following link: www.cleanwaterprogram.org/ACCWP_NPDESOrderR2-2003-0021.pdf, and Provision C.3 is described below.

2.3.1 Do the C.3 Requirements Affect My Project?

Provision C.3.c establishes thresholds at which new development and redevelopment projects must comply with Provision C.3, although it also states that "all projects regardless of size should consider incorporating appropriate source control and site design measures that minimize stormwater pollutant discharges to the maximum extent practicable [MEP]…". Regardless of a project's need to comply with Provision C.3, municipalities apply the MEP standard, including standard ***stormwater conditions of approval*** for projects that receive development permits. These conditions of approval require appropriate site design, source control measures, and, in some cases, treatment measures.

> Regardless of a project's need to comply with Provision C.3, municipalities apply standard ***stormwater conditions of approval*** to projects that receive development permits.

PROVISION C.3 THRESHOLDS

The thresholds for determining whether Provision C.3 applies to a project are based on the amount of impervious surface that is created and/or replaced by a project, as described below.

- Since February 15, 2005, private or public projects that create and/or replace ***one acre or more or impervious surface*** have had to comply with Provision C.3, unless an applicable development permit application was "deemed complete" by February 15, 2005, or another exclusion applies. ("Impervious surface," "deemed complete," and projects excluded from Provision C.3 are discussed below.)
- Beginning August 15, 2006, private or public projects that create and/or replace ***10,000 square feet or more*** of impervious surface must comply with Provision C.3, unless an applicable development permit application is "deemed complete" by August 15, 2006.

CALCULATING IMPERVIOUS SURFACE

An "impervious surface" is any material that prevents or substantially ***reduces infiltration of water into the soil.*** This includes building roofs, driveways, patios, parking lots, impervious decking, streets, sidewalks, and any other area where material is placed on the ground and prevents or substantially reduces the infiltration of water into the soil. Impervious surface is calculated in terms of square feet or, for larger sites, in acres. When calculating the area of building roofs, be sure to include not only the footprint of the main building or structure, but also any garages, carports, sheds, or other miscellaneous structures. If your project includes areas of "pervious paving," such as pervious asphalt, pervious concrete, or unit pavers, these areas must be included when calculating the total amount of impervious area on the site. Areas of turf block are not included in the calculation of impervious surface. The municipalities use an "Impervious Surface Form" to help project applicants with these calculations. ***Contact your local jurisdiction*** to obtain its impervious surface form.

DEEMED COMPLETE

The California Permit Streamlining Act requires development permit applications to be "deemed complete" if they have been accepted by the municipal Planning Department and the applicant has not received a letter within 30 days stating that the application is incomplete. If the applicant has received a letter within 30 days stating that the application is incomplete, the application will be considered complete if the applicant submits the additional requested information to the satisfaction of the Planning Department.

ACCWP has developed the following policy for new development or redevelopment projects that create or replace 10,000 square feet or more of impervious surfaces and are not required to make a separate application to the planning department (or jurisdiction equivalent).

- If the applicant submits an application that is received by the Building Department (or jurisdiction equivalent) ***on after August 15, 2006***, the project ***is required*** to comply with the post-construction stormwater requirement to provide treatment of stormwater according to the NPDES permit's numeric criteria.
- If the applicant submits an application that is received by the Building Department (or jurisdiction equivalent) ***before August 15, 2006***, the project ***is NOT required*** to comply with the post-construction stormwater requirement to provide treatment of stormwater according to the numeric criteria. In these cases, the municipalities will require projects to implement stormwater controls to the maximum extent practicable.

HOWEVER, if the jurisdiction provides notification to the applicant that numeric criteria apply to the project, due to the project not receiving a building permit until August 15, 2006 (or after), then the project ***will be required*** to comply with the numeric sizing criteria for stormwater treatment.

EXCLUSIONS FROM PROVISION C.3

Provision C.3.c of the municipal stormwater permit excludes specific types of projects from Provision C.3 requirements, even if they meet the threshold requirements described above. The list of excluded project types is shown in Table 2-1.

Table 2-1
Projects Excluded from Provision C.3 Requirements

	Excluded Projects
Commercial, industrial or residential development	Construction of one single-family home that is not part of a larger common plan of development, with the incorporation of appropriate pollutant source control and design measures, and using landscaping to appropriately treat runoff from roof and house-associated impervious surfaces (e.g., runoff from roofs, patios, driveways, sidewalks, and similar surfaces).

Table 2-1
Projects Excluded from Provision C.3 Requirements

	Excluded Projects
Street, road, highway, and freeway projects that are under the Dischargers' jurisdiction	Sidewalks, bicycle lanes, trails, bridge accessories, guardrails, and landscape features that are part of a street, road, highway or freeway project. Note: these are not exempt when part of commercial, industrial or residential developments.
Significant Redevelopment projects	Interior remodels and routine maintenance or repair, such as roof or exterior surface replacement, pavement resurfacing, repaving and road pavement structural section rehabilitation within the existing footprint, and any other reconstruction work within a public street or road right-of-way where both sides of that right-of-way are developed.

Source: San Francisco Bay Regional Water Quality Control Board, February 2003

2.3.2 What is Required by Provision C.3?

Except for the excluded projects listed in Table 2-1, projects that create and/or replace ***10,000 square feet or more*** of impervious surface must incorporate the following stormwater controls.

- Site design measures,
- Source control measures, and
- Stormwater treatment measures that are hydraulically sized as specified by the municipal stormwater permit.

After ACCWP's Hydromodification Management Plan (HMP) is approved by the Water BoardProjects, projects that are not on the excluded list (Table 2-1) and create ***one acre or more*** of impervious surface will need to incorporate hydromodification management measures, if the project is located in an area susceptible to hydromodification.

REDEVELOPMENT PROJECTS

If your project is located on a previously developed site and will result in the ***replacement of impervious surface***, then it is considered a redevelopment project and the following special provisions apply to it:

- Redevelopment projects that replace 50 percent or less of existing impervious surface need to treat stormwater runoff only from the portion of the site that is redeveloped. Redevelopment projects that replace more than 50 percent of the existing impervious surface are required to treat runoff from the entire site.
- Redevelopment projects are only subject to HMP requirements if they increase the amount of impervious surface compared to the pre-redevelopment project conditions, and they are located in susceptible areas.

ALTERNATIVE COMPLIANCE

The municipal stormwater permit allows agencies to develop "alternative compliance" programs, by which the requirement to treat stormwater may be met offsite, and in some very restricted cases, exemptions from this requirement may be granted. ACCWP has prepared and submitted to the Water Board a model alternative compliance program, which is described in Chapter 9. After its approval by Water Board, the municipalities may choose to adopt the model alternative compliance program. If you're interested in alternative compliance, please read Chapter 9. If you think your project may meet the eligibility criteria described in Chapter 9, contact the local jurisdiction for the latest information about the program.

How Do Projects Meet the C.3 Requirements?

The project's development permit application submittals must include detailed information showing how the Provision C.3 stormwater requirements will be met. Chapter 3 provides step-by-step instructions for incorporating C.3 stormwater submittals into your permit applications. It also includes simple instructions for small sites in Section 3.4.

Chapter

3

Preparing Permit Application Submittals

This Chapter outlines the development review process and gives step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

3.1 The Development Review Process

The municipalities have integrated their review of post-construction stormwater contols into the development review process. If the C.3 requirements apply to your project, your planning permit application submittal must show how you have incorporated the required post-construction stormwater controls. Section 3.2 gives step-by-step instructions on how to do this, beginning at the earliest phases of project planning. Some smaller projects may not require planning permits; see Section 3.4 for ***simple instructions for small sites***.

Preparing the preliminary design of stormwater controls simultaneously with the ***preliminary site plan*** and the landscaping plan is advised to achieve the following benefits:

- Maximize the stormwater benefits of project landscaping.
- Reduce overall project costs.
- Improve site aesthetics and produce a better quality project
- Speed project review times.
- Avoid unnecessary redesign.

> Preparing the preliminary design of stormwater controls simultaneously with the ***preliminary site plan*** and the landscaping plan can help reduce overall project costs.

After the municipality issues your planning permit, you will need to incorporate the required stormwater information into your building permit application submittal. Section 3.3 gives step-by-step instructions for preparing this submittal. A simplified diagram of a sample development review process is shown in Figure 3-1. Please note that the actual development review process in any of the municipalities may differ from the example.

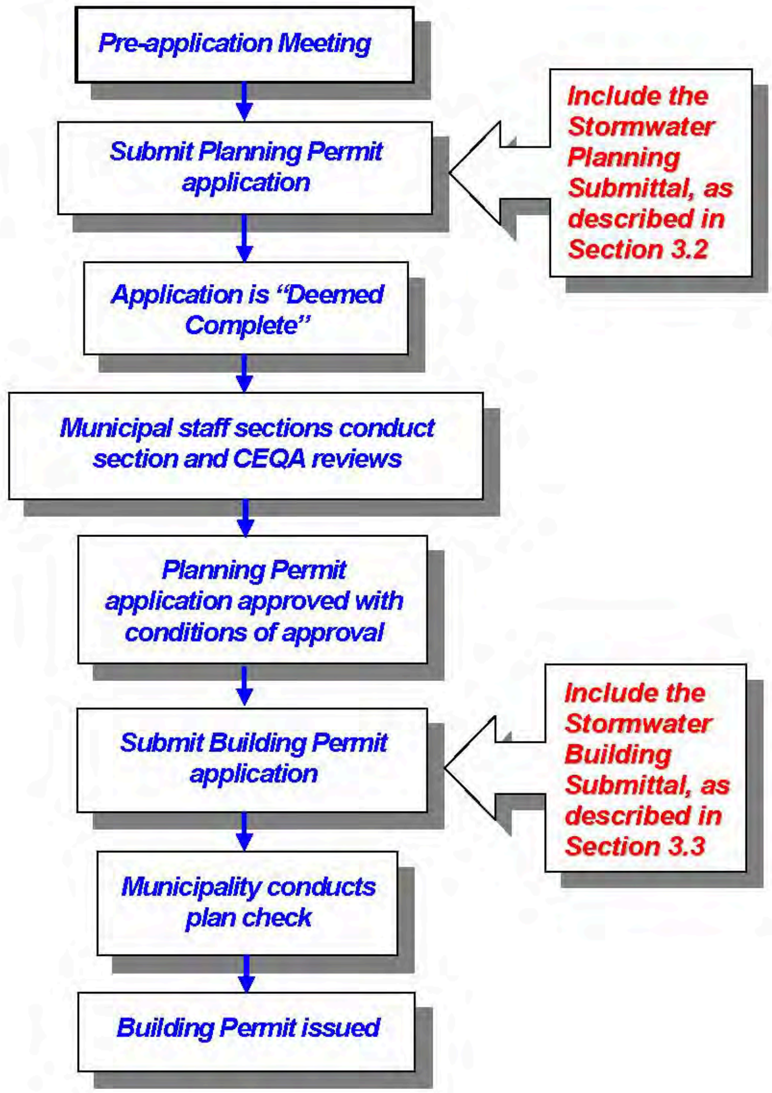

Figure 3-1: Sample Development Review Process

Although the development review process may vary from one municipality to the next, Figure 3-1 highlights the steps in the development review process at which municipalities typically require submittals showing how your project incorporates post-construction stormwater controls. These submittals are incorporated into your planning permit and building permit applications. Remember that the C.3 submittals show how the project will incorporate post-construction stormwater controls, to reduce pollutant loading and prevent increases in creek channel erosion during ***long-term project operations***. The municipality will require you to prepare separate documents to show how sedimentation and erosion will be controlled ***during construction***. Sections 3.2 and 3.3 presents step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

3.2 How to Prepare Planning Permit Submittals

C.3 submittals show how the project will reduce pollutant loading and prevent increases in creek channel erosion during ***long-term project operations***. You will need to prepare separate documents to show how sedimentation and erosion will be controlled during construction.

A Planning Permit Submittal Checklist is provided below to help identify the C.3 stormwater-related items that you will need to submit with your planning permit application, but it's important to contact the planning staff of your local jurisdiction to discuss the specific requirements that may apply to your project. After you have a complete list of submittal requirements, you can use the Step-by-Step instructions in this section to prepare your submittal. Applicants with smaller projects are encouraged to read Section 3.4, "***Simple Instructions for Small Sites***," before using the Step-by-Step instructions.

3.2.1 The Planning Permit Submittal Checklist

Table 3-1 presents a checklist of C.3 post-construction stormwater information that is typically submitted with planning permit applications. Please note that if runoff from your site discharges directly to a creek or wetland without flowing through a municipality-owned storm drain, you may need to submit additional information. Municipal staff may use this checklist to determine whether your submittal is complete, or some jurisdictions may use a modified checklist. The items included in this checklist are important to demonstrate that your project will:

- Incorporate ***site design measures*** to reduce impervious surfaces, promote infiltration and reduce water quality impacts;
- *Apply* ***source control measures*** to keep pollutants out of stormwater runoff;
- Use *stormwater* ***treatment measures*** to remove pollutants from stormwater; and
- Where applicable, manage ***hydromodification*** *(erosion-inducing flows)* by reducing the rate and amount of runoff.

Table 3-1
Planning Permit Submittal Checklist

Required?[1] Yes	No	Information on Project Drawings	Corresponding Planning Step (Section 3.2)
❑	❑	Existing natural hydrologic features (depressions, watercourses, relatively undisturbed areas) and significant natural resources.	Step 1
❑	❑	Soil types and depth to groundwater.	Step 1
❑	❑	Existing and proposed site drainage network and connections to drainage offsite.	Step 1
❑	❑	For more complex drainage networks, show separate drainage areas in the existing and proposed site drainage network.	Step 1
❑	❑	Existing condition, including pervious and impervious areas, for each drainage area.	Step 1
❑	❑	Proposed pervious surfaces, including sensitive natural areas to be preserved and protected from development (for each drainage area).	Step 2
❑	❑	Proposed impervious surfaces, e.g., roof, plaza, sidewalk, street, parking lot (for each drainage area).	Step 4
❑	❑	Proposed site design measures to minimize impervious surfaces and promote infiltration[2], which will affect the size of treatment measures.	Step 4
❑	❑	Proposed locations and approximate sizes of stormwater treatment measures and (if 1 acre or more of impervious surface is created) hydromodification management measures. Elevations should show sufficient hydraulic head for the treatment measures to work.[2]	Steps 6-8
❑	❑	Conceptual planting palette for stormwater treatment measures.[2]	Step 9
❑	❑	Pollutant source areas – including loading docks; food service areas; refuse areas; outdoor processes and storage; vehicle cleaning, repair or maintenance; fuel dispensing; equipment washing; etc. – and corresponding source controls from the local source control list.	Step 11
		Written Information on Municipal Forms or in Report Format	
❑	❑	Completed Impervious Surface Form (obtain from local agency).	Step 5
❑	❑	Preliminary calculations for each treatment or hydromodification management measures.	Step 8
❑	❑	Preliminary maintenance plan for stormwater treatment measures.	Step 10
❑	❑	List of source control measures included in the project.	Step 11

[1] Every item is not necessarily required for every project. Municipal staff may check the boxes in the "Required" column to indicate which items will be required for your project.

[2] Site design and treatment measures that promote stormwater infiltration should be consistent with recommendations of the project geotechnical engineer based on the soils boring data, drainage pattern and the current requirements for stormwater controls.

3.2.2 Planning Permit Submittals: Step-by-Step

Step-by-step instructions are offered below to help incorporate post-construction stormwater controls into your project from the very beginning of permit planning. The step-by-step instructions are intended to help you ***prepare the materials*** you will need to submit along with the planning permit application.

PLANNING PERMIT SUBMITTAL

Step 1: Collect Needed Information

Collecting the appropriate information is essential to selecting and siting post-construction stormwater measures. A list of the most ***commonly needed information*** is provided below, but municipal staff may request additional information as well.

- Existing natural features, especially ***hydrologic features*** including creeks, wetlands, watercourses, seeps, springs, ponds, lakes, areas of 100-year floodplain, and any contiguous natural areas. This information may be obtained by site inspections, a topographic survey of the site, and existing maps such as US Geologic Survey (USGS) quadrangle maps, Federal Emergency Management Agency (FEMA) floodplain maps, and US Fish and Wildlife Service (USFWS) wetland inventory maps.
- Existing site ***topography***, including the general direction of surface drainage, local high or low points or depressions, any steep slopes, outcrops, or other significant geologic features. This may be obtained from topographic maps and site inspections.
- ***Existing site drainage.*** For undeveloped sites, this would be identified based on the topographic information described above. For previously developed sites, information on drainage and storm drain connections may be obtained from municipal storm drain maps, plans for previous development, and site inspections.
- ***Soil types*** (including hydrologic soil groups) and ***depth to groundwater.*** If a soils report is not required for the project, planning-level information may be obtained from the Natural Resources Conservation Service (NRCS) Soils Survey. This information is used in determining the feasibility of onsite infiltration of stormwater.
- ***Existing impervious areas.*** Measuring the area of existing impervious surface is necessary to calculate the amount of impervious surface that will be replaced. ACCWP's NPDES stormwater permit requires that redevelopment projects that replace 50 percent or more of impervious surface treat the stormwater runoff from the entire site, not just the redeveloped area. If less than 50 percent of existing impervious surface is replaced, and the existing development was not subject to stormwater treatment measures, then only the affected portion must be included in treatment measure design.
- ***Zoning*** information, including but not limited to requirements for setbacks and open space.

> ***Constraints*** may include impermeable soils, high groundwater, steep slopes, geotechnical instability, high-intensity land use, or heavy vehicle traffic. ***Opportunities*** may include existing natural areas, low areas, oddly configured parcels, or landscape amenities.

Review the information collected in Step 1. Identify the principal constraints on site design and stormwater treatment measure selection, as well as opportunities to reduce imperviousness and incorporate stormwater controls into the site and landscape design. For example, ***constraints*** might include impermeable soils, high groundwater, steep slopes, geotechnical instability, high-intensity land use, heavy vehicular traffic, or safety concerns. ***Opportunities*** might include existing natural areas, low areas, oddly configured of otherwise unbuildable parcels, landscape amenities including open space and buffers (which can double as locations for stormwater treatment measures) and differences in elevation (which can provide hydraulic head for treatment measures). Prepare a table or brief written summary of constraints and opportunities can prove helpful in selecting and siting stormwater controls.

PLANNING PERMIT SUBMITTAL

Step 2: Minimize Site Disturbance and Protect Sensitive Areas

Design the site layout to minimize changes to the natural topography. Using the information collected in Step 1, identify any existing sensitive natural resources on the site that will be protected and preserved from development. These may include the following types of areas:

- Development should be set back from ***creeks and riparian habitat*** as required by the local jurisdiction. If your project involves impacts to creeks and riparian habitat, contact the Water Board staff regarding permit and mitigation requirements.
- If the project includes ***wetlands*** subject to Section 404 of the federal Clean Water Act, or habitat for ***special-status species*** protected by federal or State laws, these areas should be indicated, and evidence should be provided to demonstrate compliance with the applicable laws.
- The project will need to comply with any local tree preservation ordinances and other policies protecting ***heritage or significant trees***. Mature trees offer substantial stormwater benefits, and their preservation is recommended, where feasible, even if it is not required by law.
- The project needs to comply with any local restrictions on development of ***steep slopes*** and soils that are susceptible to ***erosion***. Even where not required by law, the avoidance of such areas is advisable in order to reduce stormwater impacts.

PLANNING PERMIT SUBMITTAL

Step 3: Incorporate Site Design Measures

Design the project to minimize the overall coverage of paving and roofs, with a special focus on reducing the amount of impervious area that is directly connected to the storm drain system. Using site design measures to reduce impervious surfaces on your site can ***reduce the size of stormwater treatment measures*** that you will need to install. But remember: even vegetated areas will generate some runoff. If runoff from landscaped areas flows to a stormwater treatment measure, that treatment measure will need to be sized to handle these relatively small amounts of runoff, as well as runoff from impervious surfaces. The use of self-treating areas (described below) can reduce the size of treatment measures even further.

> Using site design measures to reduce impervious surfaces on your site can ***reduce the size*** of stormwater treatment measures that you will need to install.

Some examples of site design measures are shown in Figures 3-2 and 3-3. You can find other photographs of site design measures in ACCWP's Guidebook of Post-Construction BMP Examples, at www.cleanwaterprogram.org/uploads/ACCWP_Site_Design_Guidebook_final.pdf. More information on site design measures is provided in Chapter 4, along with technical guidance for green roofs, pervious paving, unit pavers and turf block. A range of site design examples are described in the following list:

- Use ***alternative site layout techniques*** to reduce the total amount of impervious area. This may include designing compact, multi-story structures or clustering buildings. Some cities may allow narrow streets and (in very low-density neighborhoods) sidewalks on only one side of the street.

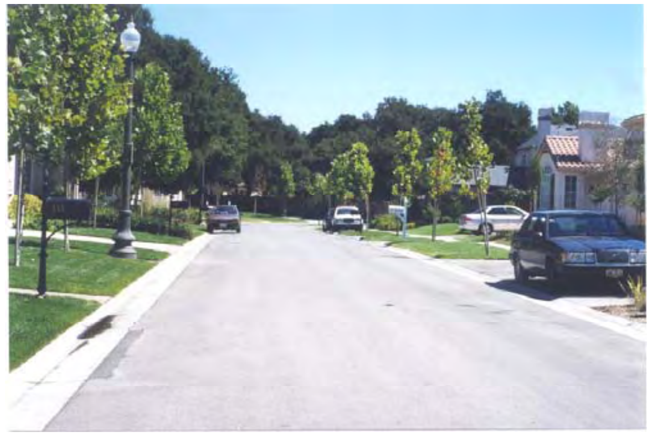

Figure 3-2: Narrow street with parking pull-outs, in Mountain View

- ***Minimize surface parking*** areas, in terms of the number and size of parking spaces.
- Use ***rainwater as a resource.*** Capturing and retaining roof runoff in cisterns can be a practical way to reduce the amount of runoff from the site and store rainwater for use in on-site irrigation. Stormwater storage provided by cisterns may be used to reduce the amount of stormwater that must be treated and, where applicable, retained on-site to meet hydromodification management requirements.
- Use ***drainage as a design element.*** Vegetated swales, depressed landscape areas, vegetated buffers, and bioretention areas can serve as visual amenities and focal points in the landscape design of your site.
- Direct ***runoff to depressed landscaped areas.*** A 2:1 ratio of impervious area to the receiving pervious area is generally acceptable, where soils permit. Much higher ratios are possible if the runoff is directed to a bioretention area or other landscape-based treatment measures.
- Include alternative, pervious surfaces. ***Green roofs*** can partially or fully replace traditional roofing materials. ***Pervious surfaces*** such as crushed aggregate, turf block, unit pavers, or pervious paving – for sidewalks, parking lots, and low-volume residential areas.

Figure 3-3: Pleasanton Sports Park includes this turf block fire access road.

- ***Maximize choices for mobility.*** Motor vehicles are a major source of pollutants in stormwater runoff. Projects should promote, or at least accommodate, modes of transportation other than the automobile.
- Identify ***self-treating areas.*** Some portions of your site may provide “self-treatment” if properly designed and drained. Such areas may include conserved

natural spaces, large landscaped areas (such as parks and lawns), and areas of turf block. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. As long as the self-treating areas do ***not receive runoff from impervious areas*** on the site, your drainage design may direct the runoff from self-treating areas directly to the storm drain system or other receiving water. More information on self-treating areas is given in Chapter 4.

PLANNING PERMIT SUBMITTAL

Step 4: Measure Pervious and Impervious Surfaces

Stormwater treatment is required for projects that create and/or replace ***10,000 square feet or more*** of impervious surface – with some exceptions that are listed in Chapter 2. After ACCWP's Hydromodification Management Plan (HMP) is approved by the Regional Water Quality Control Board, hydromodification management (HM) will be required for projects that create and/or replace one acre or more of impervious surface AND are located in susceptible areas identified in the Default Susceptibility Map. Section 7.1 describes this map, and Section 7.2 lists exceptions to the HMP requirements. Please note that, until the HMP is approved by the Water Board, it is subject to change.

The ***Impervious Surface Form*** that is provided by the local jurisdiction, must be completed as part of the planning permit application submittal. This form is used to calculate the amount of impervious surface that will be created and/or replaced, and determine whether treatment and/or HM measures are required. Impervious surfaces are those areas in which development prevents water from infiltrating into the ground and results in runoff. Impervious surfaces include but are not limited to:

- Footprints of all buildings and structures, including garages, carports, sheds, etc.;
- Driveways, patios, parking lots, decking;
- Streets and sidewalks.

Be sure to include any area of ***pervious paving and pavers*** in your project when calculating the total impervious area created and/or replaced. This is necessary because pervious paving is not as pervious as the natural ground. The use of pervious paving should, however, reduce the size of your project's treatment measures, because pervious paving generates less runoff (that is, it has a lower "C" factor) than standard paved surfaces. Table 5-3 in Chapter 5 presents the C-factors for pervious paving and other surfaces that may be used in your project.

Projects that create ***less than 10,000 square feet*** of impervious surface need to include stormwater treatment measures (Steps 5, 6, and 7) to the maximum extent practicable – and the Provision C.3 numeric sizing criteria may not apply. Check with the local jurisdiction to determine whether Steps 5 through 7 will apply to your project.

> ***Landscape-based treatment measures*** are preferred, based on effectiveness and ease of maintenance.

PLANNING PERMIT SUBMITTAL

Step 5: Select Treatment/HM Measures

There are many different types of treatment measures, each with particular advantages and disadvantages, and new innovative solutions continue to be developed. ***Chapter 6*** provides technical guidance for specific types of stormwater treatment measures that are commonly used in Alameda County. While other treatment measures may be approved, it may be possible to expedite the review of your project by closely following the guidance provided in Chapter 6.

Selecting the appropriate treatment measure(s) for a specific site is a matter of professional judgment. Some general factors to consider are offered below:

- ***Landscape-based treatment measures*** are preferred, based on effectiveness and ease of maintenance. If a system that is not landscape-based (i.e., an underground mechanical system) is selected, some local jurisdictions will require a demonstration that landscape-based solutions were not practicable.
- Is ***Hydromodification management*** (HM) required? If your project needs to meet both treatment and HM requirements, it is advisable to include at least one control measure that detains water at the site. This may include bioretention areas, flow-through planters, and extended detention basins. HM detention requirements are likely to exceed the volume required for treatment, and may also need to be coordinated with separate requirements for flood control detention. To the extent feasible, it is recommended that stormwater control measures be designed to meet both treatment and HM needs.
- ***Size of the project site.*** Some treatment measures, such as the extended detention basin, are very cost effective for larger projects, but impractical for ***smaller projects***. Other landscape-based treatment measures, such as flow-through planters and tree well filters, have been designed specifically for very small, urban sites. Bioretention areas may be suitable for many dense, urban settings because of their flexibility in fitting into whatever sizes and shapes of pervious areas are available.
- ***Soil suitability.*** Soils are classified into four hydrologic soil groups – A, B, C, and D – with the soils in each group having similar runoff potential under similar storm and cover conditions. Group A soils generally have the lowest runoff potential, and group D have the greatest.[1] Treatment measures that rely primarily on ***infiltration***, such as *infiltration trenches*, are unsuitable for use in group D soils (clay loam, sandy clay and clay) and have the potential to fail in group C (silt loam) soils. Swales and bioretention areas installed in group C and D soils typically require subdrains.
- ***Site slope.*** Opportunities for using landscape-based treatment measures on steep slopes are limited, because infiltration of stormwater runoff can cause geotechnical instability. ***Vegetated swales*** and ***bioretention areas*** may be used on shallow slopes. Media filters and some subsurface treatment measures may be feasible on steep slopes.
- Considerations for ***larger sites.*** For larger sites that can be divided into separate drainage areas, there are options to consider when developing the drainage and treatment strategy. All, or most, of the drainage could be routed to a single stormwater treatment measure, such as an ***extended detention basin***. Alternatively, a variety of smaller stormwater treatment measures could be dispersed throughout the site. Piping runoff to a single treatment area may be simpler and easier to design, but dispersing treatment measures – such as swales, flow-through planters, and bioretention areas – throughout the site may be more cost-effective and aesthetically pleasing.

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[1] Details of this soil classification can be found in the National Soil Survey Handbook, Part 618.35 (USDA, 2006), http://soils.usda.gov/technical/handbook.

- Consider ***maintenance requirements.*** The amount of maintenance that a stormwater treatment measure will require should be considered when selecting treatment measures. As described in Section 3.3, you will need to prepare and submit a ***maintenance plan*** for stormwater treatment measures with the building permit application. Section 8.2 provides information regarding the maintenance requirements for various treatment measures.

> The ***mosquito control guidance*** (Appendix H) needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water.

- ***Avoid mosquito problems.*** The mosquito control guidance provided in ***Appendix H*** needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water. This includes some types of media filters (such as the Delaware sand filter), manufactured media filters, and any extended detention basins that incorporate a permanent pool of water. Underground mechanical systems can be particularly problematic because many retain water that is not apparent from the surface.
- Potential for ***groundwater contamination.*** Before selecting an infiltration device, such as an infiltration trench, infiltration basin, or French drain, review the infiltration considerations presented in ***Appendix G*** to protect groundwater from contamination by pollutants in stormwater runoff.

PLANNING PERMIT SUBMITTAL

Step 6: Locate Treatment/HM Measures on the Site

Review the existing and proposed site drainage network and connections to drainage offsite, which were collected in Step 1. Selecting appropriate locations for treatment and HM measures involves a number of important factors, including the following:

- ***Design for gravity flow.*** If at all possible, treatment/HM measures should be designed so that drainage into and out of the treatment measure is by gravity flow. This promotes effective, low-maintenance operation and helps avoid mosquito problems. Pumped systems can be feasible, but they are more expensive, require more maintenance, and can introduce sources of underground standing water that attract mosquito breeding.
- Determine ***final ownership and maintenance responsibility.*** All treatment measures should be available for ready access by maintenance workers, inspectors from the local municipality, and staff from the Alameda County Mosquito Abatement District or the Alameda County Vector Control District. If the property will be subdivided, be sure to locate shared treatment measures in a common, accessible area – not on a private residential lot.
- Incorporate ***treatment measures in the landscape design.*** Almost every project includes landscaped areas. Most zoning districts require a certain amount of open space, and some

Figure 3-5: Playing Fields/Detention Area, Pacific Shores, Redwood City.

require landscaped setbacks or buffers. It may be possible to locate some or all of your projects' treatment/HM measures within required landscape areas.

- ***Plan for maintenance.*** Stormwater treatment measures will need to be accessible to the largest piece of equipment that will be needed for maintenance. For example, bioretention areas and vegetated swales need access for the types of machinery used for landscape maintenance. Large extended detention basins need to have a perimeter access road accessible by heavy vehicles for sediment removal and controlling emergent vegetation. Underground treatment measures and media filters may require special equipment for periodic cleanout and media replacement.

PLANNING PERMIT SUBMITTAL

Step 7: Preliminary Design of Treatment/HM Measures

Perform preliminary design of the stormwater treatment measures you have selected using the hydraulic sizing criteria in Section 5.1 and the technical guidance for specific types of treatment measures in Chapter 6. The technical guidance in this handbook is compatible with the Internet-based ***sizing tool*** that is being developed by the Bay Area Stormwater Management Agencies Association (BASMAA). The BASMAA tool is scheduled to be completed in 2006 and will be accessible through the BASMAA website, at www.basmaa.org. This guidance is also compatible with the ***Bay Area Hydrology Model*** (BAHM), a tool for sizing HM measures, which is being developed by ACCWP in cooperation with the Santa Clara Valley Urban Runoff Pollution Prevention Program and the San Mateo Countywide Stormwater Pollution Prevention Program. The BAHM is also scheduled to be completed in 2006, and information regarding the availability of the BAHM will be posted on the Developers page of ACCWP's website, at http://www.cleanwaterprogram.org/businesses_developers.htm. See Chapter 7 for more information on the BAHM and the design of HM measures.

Detailed construction drawings are typically not required for planning permit submittals, but drawings or sketches need to be included to illustrate the proposed design and sizing information based on runoff calculations.

PLANNING PERMIT SUBMITTAL

Step 8: Consider Planting Palettes for Treatment Measures

The selection of appropriate plant materials is an important part of designing a successful landscape-based stormwater treatment measure. Plants need to be hardy, low-maintenance, tolerant of saturated soils, and.selecting plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements***, although irrigation systems are typically required for landscape-based stormwater treatment measures. At the planning permit phase of the project a detailed planting plan is typically not required, but many municipalities require a conceptual planting palette. Appendix B provides guidance regarding the selection of plant materials for landscape-based treatment measures.

> Selecting plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements.***

PLANNING PERMIT SUBMITTAL

Step 9: Prepare a Preliminary Maintenance Plan (if required)

A stormwater treatment measure maintenance plan describes how stormwater treatment measures will be maintained during the years and decades ***after construction is completed.*** In some cases a municipality may require the submittal of a preliminary maintenance plan as part of the planning permit submittal. Otherwise, a maintenance plan is required only as part of the building permit submittal. ***Check with your local jurisdiction*** regarding the requirements for your project.

A preliminary maintenance plan identifies the ***proposed maintenance activities***, and the intervals at which they will be conducted, for each stormwater treatment measure included in the project. As part of the building permit submittal, applicants will also need to provide additional information that will be included in a maintenance agreement between the local municipality and the property owner. Chapter 8 provides more information about stormwater treatment measure operation and maintenance, including guidance on how to prepare a maintenance plan.

PLANNING PERMIT SUBMITTAL

Step 10: Use Applicable Source Control Measures

Pollutants are generated by many common activities that will occur after construction is completed. Each local jurisdiction has specific pollutant source control requirements for projects that include landscaping, swimming pools, vehicle washing areas, trash/recycling areas, and other sources of pollutants. These requirements are identified in the agency's ***Local Source Control Measures List.*** Be sure to obtain the current list from your local jurisdiction. The lists are typically divided in two parts: Part I - Structural Source Controls and Part II – Operational Source Controls. These two types of source controls are described as follows:

- ***Structural Source Controls*** - Structural source controls are permanent features that are designed and constructed as part of a project, such as sanitary sewer connections for restaurant wash areas that are large enough to wash the largest piece of equipment.
- ***Operational Source Controls*** – Operational source controls are "good housekeeping" activities that must be conducted routinely during the operations phase of the project – such as street sweeping and cleaning storm drain inlets.

Your project will need to incorporate the applicable source controls for any project activity that is included in the local source control lists. The following methods may be used to accomplish this.

- ***Review*** structural source controls in Part I of the local list and compare this list to your site plan. Identify any areas on the site that require structural source controls. Remember that some activities may not have been sited yet. For example, the Model List includes a requirement for enclosing and roofing refuse storage areas. If a designer was unaware of this requirement, it may not be shown on the project plans. .
- ***Incorporate*** all the required structural source controls on your project drawings.
- ***If required by the municipality,*** prepare and submit a table, listing in three columns the potential sources of pollutants, the permanent source control measures, and any

operational source control measures from Part II of the local list that apply to the project. Table 3-2 is an example Table of Source Controls.

Table 3-2
Example Table of Stormwater Source Controls

Potential Source of Pollutants	Structural Source Controls	Operational Source Controls
On-site storm drains	On-site storm drains shall be marked with the words "No Dumping! Flows to Bay" (or applicable water body) applied with thermoplastic.	All on-site storm drain inlets shall be cleaned at least once a year immediately prior to the rainy season.
Refuse areas	New or redevelopment projects, such as food service facilities, recycling facilities or similar facilities, shall provide a roofed and enclosed area for dumpsters and recycling containers. The area shall be designed to prevent water run-on to the area and runoff from the area and to contain litter and trash, so that it is not dispersed by the wind or runoff during waste removal.	None

NOTE: This table is included as an example only and is not intended for use in an actual submittal.

PLANNING PERMIT SUBMITTAL

Step 11: Coordinate with Other Project Requirements

When submitting the C.3 stormwater drawings with the planning permit submittal, the stormwater site design, source control, treatment and HM measures may be shown on a separate stormwater plan, or combined with the site plan, landscaping plan, or drainage plan – depending on the complexity of the project. Whether plans are combined or separate, there are a number of issues that must be carefully coordinated with other aspects of the project design. Some typical coordination considerations are listed below.

- ***Balance of Cut and Fill.*** When calculating the overall project balance of cut and fill, be sure to include the excavation of stormwater treatment measures (including the need to replace existing clay soils with group A or B soils).
- ***Soil Compaction during Construction.*** Compaction from construction traffic can severely restrict the infiltration capacity of soils at your site. In the construction staging plan, protect and limit operation in those portions of the site that will accommodate self-treating areas or stormwater treatment measures that rely on infiltration.
- ***Building Drainage.*** Building codes require that drainage from roofs and other impervious areas be directed away from the building. The codes also specify minimum sizes and slopes for roof leaders and drain piping. Any stormwater measure located in or on the building, or that may affect building foundations, must be designed to meet the minimum building code requirements. Stormwater treatment measures are also required to meet the requirements for detention or flow described in Section 5.1.

- ***Control of Elevations.*** Getting runoff to flow from impervious surfaces to landscaped surfaces may require greater attention to detailed slopes and elevations in grading and landscaping plans. For example:
  - ***Provide Adequate Change in Elevation*** between the pavement and vegetated areas. The landscaped area needs to be low enough so that runoff will flow into it even after the turf or other vegetation has grown up. If adequate reveal is not provided, runoff will tend to pond on the edge of the paved surface.
  - ***Provide for Differential Settlement.*** While the soil in landscaped-based stormwater treatment measures and self-treating areas must be left loose and uncompacted, concrete structures (such as inlets and outlets) must be supported on a firm foundation. Otherwise they may settle more than the surrounding ground, creating depressions that can hold standing water and contribute to nuisances such as mosquito breeding.
  - ***Prevent Erosion.*** There is potential for erosion to occur at points where the stormwater runoff flows from impervious areas into landscape-based treatment measures. Include in the project plans any proposed erosion controls, such as cobbles or splash blocks.

Figure3-6: Drain rock is used to prevent erosion of this vegetated swale at Zone 7 Water Agency's office building.

- ***Drainage Plans.*** The local building or engineering department may require a drainage plan, which typically focuses on preventing street flooding during a 10-year storm and demonstrating that flooding from 100-year storms can be managed. To meet the drainage plan requirements it may be necessary to include ***high flow bypasses*** in the design of stormwater treatment measures, in order to route ***flood flows*** directly to the storm drain system. Check with your local jurisdiction regarding the need to prepare a drainage plan, and whether it is required only as part of the building permit submittal, or if a preliminary drainage plan is needed with the planning permit submittal.
- ***Signage for Traffic and Parking.*** If your project includes depressed landscaped areas next to parking lots, driveways or roadways, it may be necessary to include bollards, striping or signs to guide traffic, particularly curbs are designed to be flush with the pavement. Traffic striping may not be practical for permeable pavements such as crushed aggregate and unit pavers. In these areas signs and bollards may be needed to help direct traffic.

PLANNING PERMIT SUBMITTAL

Step 12: Submit Planning Permit Application

Assemble all the items listed in Table 3-1 that municipal staff indicate are required for your project, and include them as attachments to the planning permit application for your project.

3.3 How to Prepare Building Permit Submittals

Except for projects on small sites, the principal differences between planning permit submittals and building permit submittals are:

- ***Construction level detail*** is needed, rather than preliminary plans;
- Changes are ***highlighted and explained***, if plans differ from the planning permit submittal;
- ***Detailed maintenance plans*** are included, along with documentation to support the maintenance agreement.

If your project ***does not require a planning permit***, your building permit application submittal will need to include items listed in both Tables 3-1 and 3-3.

The list of materials that may be required at this stage in the project is shown in Table 3-3, and brief step-by-step instructions follow.

Table 3-3
Building Permit Submittal Checklist

Required? Yes	No	Information on Project Drawings	Corresponds to Building Step (Sect. 3.3)
❑	❑	Sensitive natural areas to be preserved and protected from development. – highlighting any changes since the planning permit submittal.	Step 1
❑	❑	Proposed impervious surfaces, e.g., roof, sidewalk, street, parking lot (for each drainage area) – highlight anychanges since the planning permit submittal.	Step 1
❑	❑	Site design measures to minimize impervious surfaces and promote infiltration – construction level detail.	Step 1
❑	❑	Construction level detail of stormwater treatment measures and (if 1 acre or more of impervious surface is created) hydromodification management measures.	Step 1
❑	❑	Pollutant source areas and corresponding structural source controls from local source control list – construction level detail.	Step 1
❑	❑	Landscaping plan for stormwater treatment measures--construction level detail.	Step 1
❑	❑	Letter- or legal-sized conceptual or site plan showing locations of storm-water treatment measures, for inclusion in the Maintenance Agreement.	Step 2
		Written Information on Municipal Forms or in Report Format	
❑	❑	Completed Impervious Surface Form, showing any changes since planning permit submittal.	Step 1
❑	❑	Detailed hydraulic sizing calculations for each treatment and/or hydromodification management measure.	Step 1
❑	❑	List of source control measures included in the project, showing any changes since planning permit submittal.	Step 1
❑	❑	Detailed maintenance plan for stormwater treatment measures, including inspection checklists, as appropriate.	Step 2
❑	❑	A standard treatment measure O&M report form, to be attached to the Maintenance Agreement	Step 2

BUILDING PERMIT SUBMITTAL

Step 1: Update Project Documentation

Information regarding the design of stormwater measures that was submitted with the planning permit application must be updated, as necessary, for submittal with the building permit application. Specific requirements may vary in the various jurisdictions, but this is anticipated to include the following:

- Incorporate all ***stormwater-related conditions of approval*** that were applied during planning permit review.
- Highlight and explain any ***other stormwater-related changes*** that have been made since the planning review. This may include, but is not limited to, changes in the boundaries of sensitive areas to be protected, changes in the amount of impervious surface to be created/replaced, changes in the stormwater pollutant source areas, changes in the location or design of stormwater measures, etc.
- Prepare ***construction level detail*** for all stormwater measures included in the project.
- Prepare detailed ***hydraulic sizing calculations*** for stormwater treatment and HM measures, using the hydraulic sizing guidance provided in Section 5.1.
- Prepare construction-level ***planting plans*** for landscape-based stormwater treatment measures.

NOTE: Some ***smaller projects*** may not require a planning permit. If this is true for your project, your building permit application submittal will need to include items listed in both Table 3-1 and Table 3-3. Ask the building department staff to help you identify the specific items needed for your submittal.

BUILDING PERMIT SUBMITTAL

Step 2: Prepare Maintenance Documentation

Property owners are responsible for assuring the long-term operation and maintenance of a project's stormwater treatment measures, unless the applicable municipality approves other specific arrangements. Details may vary from one jurisdiction to another, but ***maintenance agreements*** generally require the property owner to assure that all stormwater treatment measures receive proper maintenance in accordance with an approved maintenance plan; that municipal, Water Board, Mosquito Abatement District, and Vector Control District staff be granted access, as needed, to ensure proper maintenance and operation; and if the property owner fails to maintain the treatment measure, municipal staff be allowed to enter the property, perform necessary emergency repairs, and charge the property owner for the necessary emergency repairs. Project applicants are typically required to provide the following documentation to support the maintenance agreement:

- A ***conceptual plan or site plan*** that is legible on letter- or legal-sized paper (8.5-by-11 inches or 8.5-by-14 inches) and shows the locations of the stormwater treatment measures that will be subject to the agreement. ***Some municipalities have specific requirements*** for these plans, such as requiring a conceptual plan that includes only the stormwater treatment measures. If more than one stormwater treatment measure is used, the treatment measures should be numbered for ease of identification (for example, Swale 1, Swale 2, etc.)

- A ***maintenance plan*** that includes specific long-term maintenance tasks and a schedule. Section 8.2 provides guidance for preparing a maintenance plan. If a preliminary maintenance plan was submitted with the planning permit application, this plan should be updated to respond to municipal staff comments and include a sufficient level of detail for implementation.
- A Standard Treatment Measure Operation and Maintenance ***Inspection Report Form***, which some municipalities require the property owner to complete and submitted to the municipality each year. The purpose the annual report is to help the municipality verify that appropriate O&M is occurring. A template for preparing this report form is included in Appendix I.
- ***O&M inspection checklists*** appropriate to the types of stormwater treatment measures that will be used on the property. Inspection checklists should be included in the maintenance plan. Inspection checklists for vegetated swales and extended detention basins are included in Appendix I. The purpose for including an O&M checklist specific to each type of stormwater treatment measures included in the project is to assist the property owner in conducting regular inspections of the stormwater treatment measures, to identify and correct any problems.

BUILDING PERMIT SUBMITTAL

Step 3: Submit Building Application

Assemble all the items listed in Table 3-3 that municipal staff has indicated are required for your project, and include them as attachments to your building permit application.

3.4 Simple Instructions for Small Sites

Until August 2006 many projects that created and/or replaced less than one acre of impervious surface were generally not required to incorporate stormwater treatment measures, so developers of these smaller projects may be less familiar with these requirements. If you are a qualified engineer, architect or landscape architect, you may be able to prepare the entire C.3 submittal yourself. If not, you will probably need to hire a ***qualified civil engineer, architect or landscape architect*** to prepare the submittal – or at least some of the more technical aspects of the submittal. Some tips for smaller projects are provided below:

- ***Review submittal checklists with municipal staff.*** If your project does not require a planning permit, you will need to include in your building permit application submittal some of the items that are listed in Table 3-1 (Planning Permit Submittal Checklist) and some from Table 3-3 (Building Permit Checklist). But remember, not every item in the checklists is required for every project. Make an appointment with a member of the building department staff to sit down and go through the checklists with you, to give you a ***reduced list*** of the items you will need for your small site. And make sure to get the list in writing, so you can refer to it, if necessary, in future conversations with municipal staff. If your project requires a planning permit, use this same strategy to get a list of required items from the planning staff.
- ***Maximize the use of site design measures.*** The less impervious surface area on the site, the smaller your stormwater treatment measures will need to be. Chapter 4 lists many strategies for reducing impervious surfaces, and it offers guidance for using self-treating

areas (for example, lawns, areas paved with turf block, or green roofs) to further ***reduce the size*** of treatment measures.

- ***Use landscape-based treatment measures.*** Even on small sites, landscape-based treatment measures are encouraged, based on effectiveness and ease of maintenance (described in Section 5.2), and before approving the use of underground treatment measures some municipalities may require a demonstration that landscape-based treatment measures were not practicable. Chapter 6 includes technical guidance for some landscape-based treatment measures, such as flow-through planters and tree well filters, which were developed specifically to fit into small sites in ***densely developed areas***. Bioretention areas also lend themselves well to small sites, as they can be squeezed into whatever space may be available on the property.
- ***Consider using simplified sizing methods.*** The technical guidance in Chapter 6 includes simplified sizing methods for several types of stormwater treatment measures, including vegetated swales, flow-through planters, and bioretention areas. The technical guidance for each of these treatment measures highlights the easy-to-follow calculations for sizing the treatment measures. Please note, however, that there is a trade-off for simplicity. The simplified sizing calculations may result in treatment measures that are conservatively large. If space is at a premium, it may be cost-effective to hire a civil engineer with experience sizing stormwater treatment measures and use the more detailed sizing calculations, in order to potentially reduce the amount of land needed for stormwater treatment.
- ***Use the planting guidance.*** Appendix B provides guidance for selecting appropriate plantings for landscape-based stormwater treatment measures. Municipal staff will check to confirm that the plants included in your design meet the criteria set forth in this guidance.


Figure3-7: Flow-through planter boxes are incorporated into the landscaping at this multi-story building in Portland, Oregon. (Source: City of Portland, 2004)

Chapter

4

Using Site Design Measures

This Chapter explains how site design measures can reduce the size of your project's stormwater treatment measures.

Site design measures for water quality protection are techniques employed in the design of a project site in order to reduce the project's impact on water quality and beneficial uses. Site design measures are not treatment measures. Including site design measures in a project does not meet the C.3 requirements for stormwater treatment, but it can help reduce the size of treatment measures (see Section 4.1). Site design measures can be grouped into two categories:

- Site design measures that ***preserve sensitive areas*** and high quality open space, and
- Site design measures that ***reduce impervious surfaces*** in a project.

This chapter focuses on site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into smaller treatment measures than would have been required without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. Site design measures to reduce stormwater runoff can be incorporated in your project in the following ways:

- Use ***self-treating*** areas.
- ***Reduce the size of impervious features*** in the project.
- Use cisterns or rain barrels to ***store rainwater*** onsite.
- Use ***alternative surfaces*** that allow infiltration into the soil.

> Site design measures used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures.

Where landscaped areas are designed to have a stormwater drainage function, they need to be carefully integrated with other landscaping features on the site early in project design. This may require coordinating separate designs prepared by different professionals.

Remember that any site design measures (including self-treating areas) used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures. For this reason, your municipality may require you to include site design measures in the maintenance agreement or maintenance plan for stormwater treatment measures, or otherwise record them with the deed. Depending on the municipality, site design measures may be subject to periodic operation and maintenance inspections. Check with the municipal staff regarding the local requirements.

4.1 Using Self-Treating Areas

Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, landscaped areas (such as parks and lawns), green roofs, and areas paved with turf block. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. As long as the self-treating areas are not used to receive runoff from other impervious areas on the site, your drainage design may route the runoff from self-treating areas ***directly to the storm drain*** system or other receiving water. Thus, the stormwater from the self-treating areas is kept separate from the runoff from paved and roofed areas of the site, which requires treatment.

> If self-treating areas do not receive runoff from impervious areas, runoff from self-treating areas may discharge ***directly*** to the storm drain.

Even vegetated areas will generate some runoff. If the runoff from self-treating areas is not kept separate from the runoff from impervious surfaces, your stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating areas and the impervious areas. ***Figure 4-1*** compares the size of the stormwater treatment measure that would be required to treat the runoff from a site, depending on whether or not the runoff from a self-treating area discharges directly to the storm drain system or other receiving water. In the first (upper) sequence, runoff from the self-treating area is directed to the stormwater treatment measure. In the second (lower) sequence, runoff from the self-treating area bypasses the treatment measure and flows directly to the storm drain system or other receiving water, resulting in a smaller volume of stormwater that will require treatment. This results in a ***smaller stormwater treatment measure***.

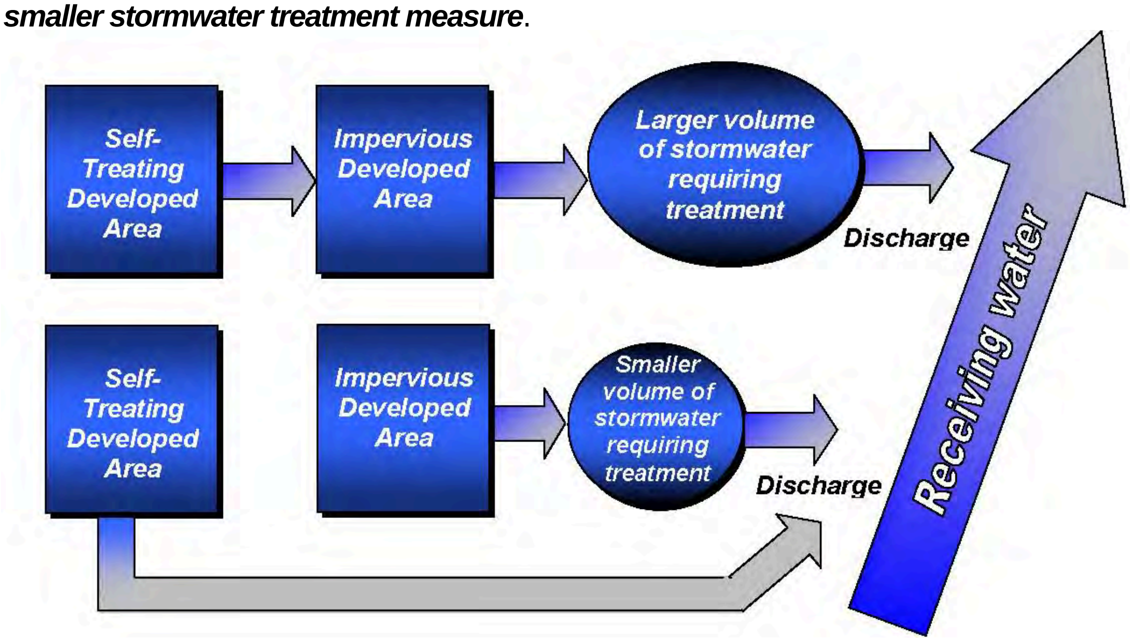
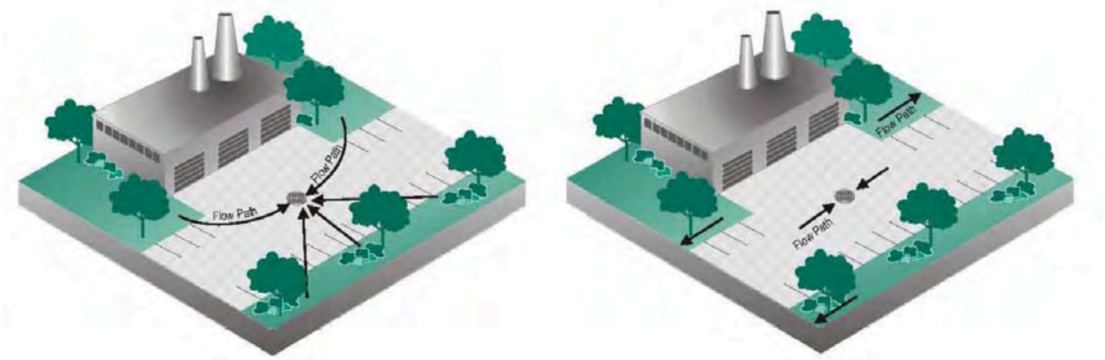


Figure 4-1: Self-Treating Area Usage (Source, BASMAA, 2003)

Figure 4-2 compares the conventional drainage approach to the self-treating area approach. The conventional approach combines stormwater runoff from landscaped areas with the runoff from impervious surfaces. Assuming the parking lot storm drain leads to a treatment measure, in the conventional approach, the treatment measure will need to be sized to treat runoff from the entire site. The ***self-treating area approach*** routes runoff from the landscaped areas directly to the storm drain system. In this approach, the treatment measure is sized to treat only the runoff from impervious areas.



Conventional Drainage Approach **Self-Treating Area Approach**

Figure 4-2: Commercial/Industrial Site Compared to Same Site with Self-Treating Areas (Source, BASMAA 2003)

Figure 4-3 shows an example site in which the runoff from impervious areas must flow to the stormwater treatment measure before discharging to the storm drain, while runoff from the self-treating area may discharge directly to the storm drain. This is allowable because the self-treating area does not accept runoff from the impervious portions of the site.

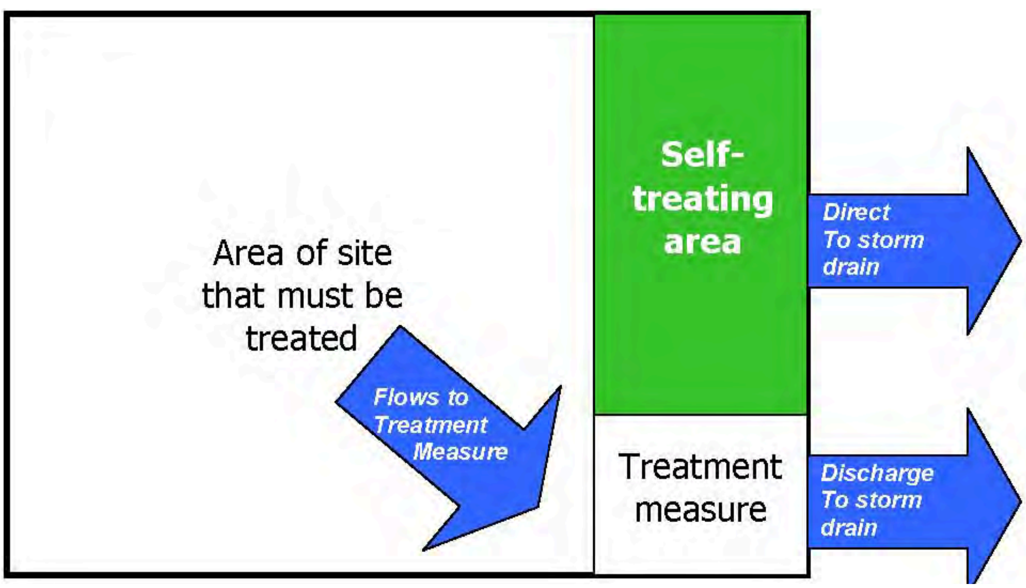


Figure 4-3: Schematic Drainage Plan for Site With a Self-Treating Area

4.2 Reducing the Size of Impervious Areas

A variety of project features can be designed so that they result in a smaller “footprint” of impervious surface. These techniques generally need to be incorporated very early in the project design. A number of techniques for reducing impervious surfaces are described below.

Alternative Site Layout Techniques

Check with your local jurisdiction regarding its policies regarding the following site design measures:

- Reduce building footprints by using compact, ***multi-story structures,*** as allowed by local zoning regulations.
- ***Cluster buildings*** to reduce the length of streets and driveways, minimize land disturbance, and protect natural areas.
- *Design* ***narrow streets*** and driveways, as allowed by the local jurisdiction.
- *Use* ***sidewalks on only one side*** of the street may be appropriate in areas with little pedestrian and vehicular traffic, as allowed by the local jurisdiction.

Minimize Surface Parking Areas

A variety of techniques can be used to minimize surface parking areas, in terms of the number and size of parking spaces, as allowed by the local jurisdiction. These solutions focus on either reducing the demand for parking, maximizing the efficiency of parking utilization, or implementing design solutions to reduce the amount of impervious surface per parking space.

- Reduce parking demand by ***separating the cost of parking*** from the cost of housing or leasable space. This allows the buyer or tenant to choose how much parking they actually need and are willing to pay for.
- Maximize efficiency of parking utilization with ***shared parking*** that serves different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evening, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends.
- ***Structured parking*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings that also house office or residential space, or include ground-floor retail lining the street. Shared parking strategies can work very well with structured parking.
- ***Parking lifts*** are another way to reduce the amount of impervious surface needed for parking. A parking lift stacks two to three cars using a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. With proper training for residents, employers, or parking attendants, this strategy can be a practical way to double or triple the parking capacity given a set amount of land.

- Another way to maximize the efficient use of parking area is ***valet parking***, where attendants park cars much closer and tighter in than individual drivers would in the same amount of parking space.

Figure 4-4: Parking Lifts in Parking Garage, Berkeley

4.3 On-Site Water Storage

Water storage systems ***collect rainwater from roofs*** and other impervious building surfaces, and store it so it may be released soon after a storm, or used for irrigation and other non-potable uses. As allowed by the local jurisdiction, these systems can be used to reduce the amount of stormwater that must be treated while attenuating peak flows and possibly conserving potable water. Water storage systems in proximity to the building may be subject to approval by the building official. The use of waterproofing as defined in the building code may be required for some systems, and the municipality may require periodic inspection. Check with municipal staff for the local jurisdiction's requirements.

Rainwater storage systems connect to a building's gutters and downspouts and convey the water to storage vessels, such as ***rain barrels*** or above- or below-ground ***cisterns***. In "metered detention and discharge," the collected stormwater is slowly released into the landscape beds in the hours following the storm, at a rate that allows for better filtration and is less taxing to the community storm drain. As allowed by the local jurisdiction, harvested rainwater may be used for toilet flushing, car washing, washing machines, and chlorinated swimming pools. For rainwater to serve as useful irrigation in the Bay Area, it may need to be stored until the dry season, requiring more storage capacity.

Water storage systems should include ***preventative measures for pollutants and mosquito control***. The initial rainfall of any storm often picks up the most pollutants from dust, bird droppings and other particles that accumulate on the roof surface between rain events. A roof washer device separates the dirtier, early rainfall and diverts it so that it does not mix with the cleaner runoff that follows. A roof washer will, though a simple valve design, automatically divert the first 0.02 inches of rainfall per 24-hour period per square foot of roof area away from the rainwater harvesting storage tanks or cisterns. In projects that must meet Provision C.3 requirements, the diverted water would be routed to a hydraulically-sized treatment measure. Roof washers should be installed in such a way that they will be easily accessible for regular maintenance. Also, water storage facilities should be equipped with covers with tight seals, to reduce mosquito-breeding risk.

Although ***most roofing materials are compatible with rainwater storage*** and harvesting systems, rainwater should not be collected from roofs with redwood, cedar, or treated wood shingles or shakes, which may pollute water and soil by leaching toxic materials when wet. In addition, food-producing gardens should not be watered with rainwater from roofs with asphalt shingles, tar, or other materials that may adversely affect food for human consumption.

4.4 Alternative Pervious Surfaces

It may be possible to use alternative, relatively pervious, surfaces for some features of your project. ***Green roofs*** can be used in place of traditional roof surfaces. Patios, sidewalks, or lightly traveled driveways and parking areas can be constructed of ***pervious surfaces***, such as crushed aggregate, turf block, unit pavers, pervious asphalt, or pervious concrete.

Each of these alternative surfaces will have a ***lower coefficient of runoff, or "C-factor,"*** than standard roofing or paving surfaces. The C-factor is a representation of a surface's ability to produce runoff. Surfaces that produce higher volumes of runoff, such as standard asphalt or concrete, are represented by higher C-factors, while surfaces that produce lower volumes of runoff, such as green roofs or pervious concrete, have lower C-factors. Typical C-factors for a variety of surfaces are shown in Table 5-3 in Section 5.1, which describes how treatment measures are sized using a composite C-factor, taking into consideration the percentage of the various types surfaces used in your project.

Sections 4.5 through 4.7 provide technical guidance for green roofs, pervious paving, and turf block and permeable joint pavers.

4.5 Green Roofs Technical Guidance

BEST USES

- For innovative architecture
- Urban centers

ADVANTAGES

- Minimizes roof runoff
- Reduces "heat island" effect
- Absorbs sound
- Provides bird habitat
- Low maintenance costs

LIMITATIONS

- Sloped roofs require steps
- Non-traditional design
- High installation costs

Figure 4-5: Parking Lot with Turf-Covered Roof at Google, Mountain View

A green roof can be either *extensive*, with a 3 to 7 inches of lightweight substrate and a few types of low-profile, low-maintenance plants, or *intensive* with a thicker (8 to 48 inches) substrate, more varied plantings, and a more garden-like appearance. The extensive installation at the Gap Headquarters in San Bruno (Figure 4-6), has experienced relatively few problems after nearly a decade in use. Green roofs may be considered "self-treating areas" and may drain directly to the storm drain, as allowed by the local municipality.

Design and Sizing Guidelines

- Extensive green roof systems contain several layers of protective materials to convey water away from the roof deck. Starting from the bottom up, a waterproof membrane is installed, followed by a root barrier, a layer of insulation (optional), a drainage layer, a filter fabric for fine soils, the engineered growing medium or soil substrate, and the plant material.
- Design and installation is typically completed by an established vendor.
- Slopes should not exceed 15%.
- Follow the manufacturer recommendations for slope, treatment width, and maintenance requirements.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred. See Appendix B for planting guidance.
- Green roof shall be free of gullies or rills.

Maintenance

Installations require inspection at least semiannually and may or may not require irrigation in the Bay Area semi-arid climate. See www.greenroofs.com for information about and more examples of green roofs.

Figure 4-6: Extensive Green Roof at Gap Corporate Headquarters, San Bruno

Figure 4-7: Intensive Green Roof at Kaiser Center, Oakland

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4.6 Pervious Paving Technical Guidance

Figure 4-8: Parking Lot with Pervious Pavement, Emeryville

BEST USES
- Parking areas
- Common areas
- Lawn/landscape buffers
- Pathways

ADVANTAGES
- Flow attenuation
- Removes fine particulates
- Reduces need for treatment

LIMITATIONS
- Needs periodic cleaning
- Weeds
- Lightly trafficked areas only
- Higher installation costs

Pervious paving is used for areas with light vehicle loading and lightly trafficked areas, such as automobile parking areas. The term pervious paving describes a system comprised of a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface is porous allowing water to infiltrate across the entire surface of the material (e.g., crushed aggregate, porous concrete or porous asphalt). Pervious paving is considered a site design measure, and its use can help reduce the size of treatment measures, but it is not a treatment measure. It may be possible to satisfy stormwater treatment numeric sizing requirements by installing a stormwater treatment measure, such as an infiltration trench, under an area of pervious paving.l

Design and Sizing Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and the layers' required operational life. To provide satisfactory performance, the following criteria shall be considered:

- The sub-grade shall be able to sustain traffic loading without excessive deformation.
- The granular capping and base layers shall give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.
- The base aggregate particles shall be selected based on strength and durability when saturated and subjected to wetting and drying.
- The sub-grade shall be either ungraded in-situ material with a percolation rate of 5-inches per hour, backfilled with coarser fill material, or installed with an underdrain that will remove detained flows within the pervious paving and base.

- The pavement materials shall not crack or suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.
- Pervious pavements require a single size grading to give open voids. Materials choice is therefore a compromise considering stiffness, permeability and storage capacity.
- Runoff coefficients for pervious pavements are listed on the Estimated Runoff Coefficients for Various Surfaces During Small Storms (1.5 to 2-year storm), Table 5-3 in Chapter 5. Because of base compaction, runoff rates are typically higher for pervious pavements than for landscaping. Pervious pavements by themselves do not treat runoff. However, because of the higher infiltration rates compared to an impervious surface, the size of downstream stormwater treatment measures can be reduced.
- Design calculations for the base shall quantify the following:
  - o Type of soil, type of fill if used, permeability of base, k-values (psi/cubic inch)
  - o Compressibility (clay and silt contents, organics, muck)
  - o Traffic loading (in 18,000 lb. single axle loads)
  - o Drainage routing of detained flows within the pervious pavement and base (infiltration through minimum 5-inch per hour sub-base into in-situ soils, or collection in underdrain if percolation rate cannot be met)
- Design shall be reviewed by the manufacturer or National Ready Mixed Concrete Association (NRMCA) (www.nrmca.org).
- Depth to groundwater shall be at least 10 feet from bottom of base.
- Slopes of pervious pavement should not exceed 8%, or up to 16% with underdrains.
- Installation shall be by contractors familiar with pervious paving installation. Only contractors with certification from NRMCA should be considered. More information can be found at www.concreteparking.org.

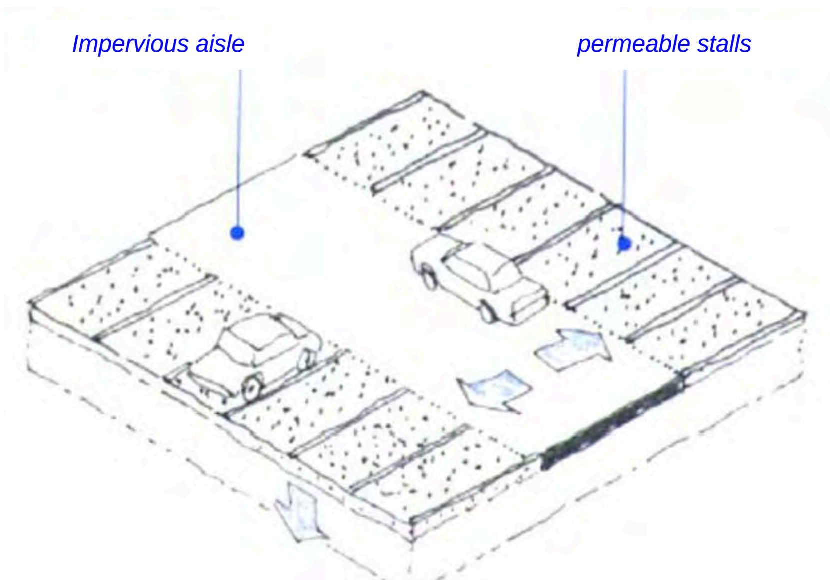

Figure 4-9: Surface and Side Views of Parking Lot with Pervious Paving in Lightly-Trafficked Areas (Source. BASMAA. Start at the Source. 1999)

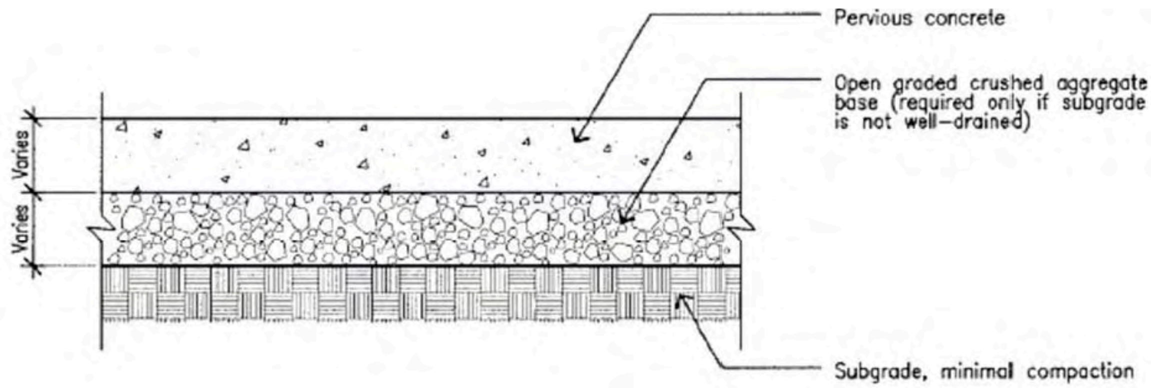

Figure 4-10: Side View of Parking Lot with Pervious Paving in Lightly-Trafficked Area (Source, BASMAA, Start at the Source, 1999) Depth of pervious concrete will vary with type of usage.

Maintenance

Standards for ongoing maintenance and upkeep:

- Keep landscaped areas well maintained
- Prevent soil from washing onto the pavement. The surface of the pervious pavement shall be vacuum cleaned using commercially available sweeping machines at the following times:
  - End of winter (April)
  - Mid-summer (July / August)
  - After autumn leaf-fall (November)
- Inspect outlets yearly, preferably before the wet season. Remove accumulated trash and debris.
- When vacuum cleaning is conducted, inspect pervious paving for any signs of hydraulic failure.

As needed maintenance:

- If routine cleaning does not restore infiltration rates, then reconstruction of part of the pervious surface may be required.
- The surface area affected by hydraulic failure should be lifted, if possible, for inspection of the internal materials to identify the location and extent of the blockage.
- Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement.
- Sub-surface layers may need cleaning and replacing.
- Removed silts may need to be disposed of as controlled waste.

4.7 Turf Block and Permeable Joint Pavers Technical Guidance

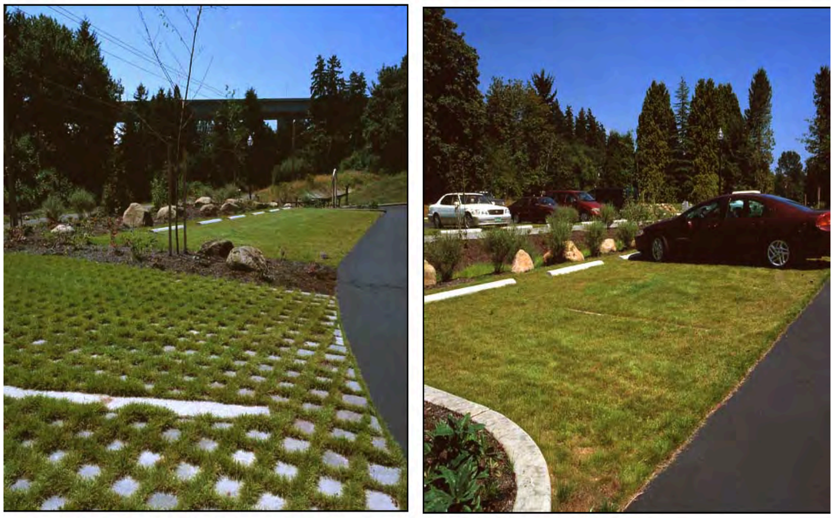

Figure 4-11: Turf Block and Paver Mat (Source, Georgia Stormwater Handbook)

BEST USES
- Parking areas
- Common areas
- Lawn/landscape buffers
- Pathways

ADVANTAGES
- Flow attenuation
- Removes fine particulates
- Reduces need for treatment

LIMITATIONS
- Periodic cleaning required
- Weeds
- Lightly-trafficked areas only
- Higher installation costs

Turf block and permeable joint pavers are used for areas with light vehicle loading, such as automobile parking areas, and areas with little to no vehicle traffic, such as fire access lanes, and walkways. The terms turf block and permeable joint pavers describe systems comprised of a load-bearing, durable surface together with a pervious soil that temporarily stores water, with overflow conveyed to an outlet. The turf block surface is constructed of impermeable blocks separated by spaces and joints, filled with soil. The soil can be planted with turf through which water drains. Permeable joint pavers are impermeable tiles or rock plates with permeable joints to allow runoff to percolate to subsurface layers. Both permeable joint pavers and turf block can help reduce the size of treatment measures by either infiltration or temporary storage of stormwater runoff. Where subgrade soil permeability is low, an underdrain system connected to the storm drain system may be needed. Areas of turf block may be considered "self-treating areas," and may drain directly to the storm drain system if they do not receive runoff from impervious surfaces and if allowed by the local municipality. It may be possible to satisfy requirements for treating stormwater by installing a stormwater treatment measure, such as an infiltration trench, under an area of turf block or permeable joint pavers.

Design and Sizing Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and the layers' required operational life. To provide satisfactory performance, the following criteria shall be considered:

- The subgrade shall be able to sustain traffic loading without excessive deformation.
- The turf block or permeable joint pavers shall give sufficient load-bearing to provide an adequate support for loading.
- The paver materials should not crack or suffer excessive breakage under traffic.

- Both turf block and pavers require a single size grading to give open voids. Materials choice is therefore a compromise considering stiffness, permeability and storage capacity.
- The uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.
- The sub-base shall be sized for strength and durability of the aggregate particles when saturated and subjected to wetting and drying. Crushed rock on geogrid fabric matrix is a typical example of turf block and pavers' sub-base. Other examples of sub-base are uncompacted soil with a sand bed to support the turf block or paver. The sub-base should be reviewed by the manufacturer of turf blocks or pavers.
- Runoff coefficients for turf blocks and permeable joint pavers are presented in Table 5-3 in Chapter 5. Because of sub-base compaction in the crushed rock example, the runoff rates can be higher than for landscaping. Because of the higher infiltration rates and localized storm water storage compared to an impervious surface, the size of downstream stormwater treatment measures can be reduced.

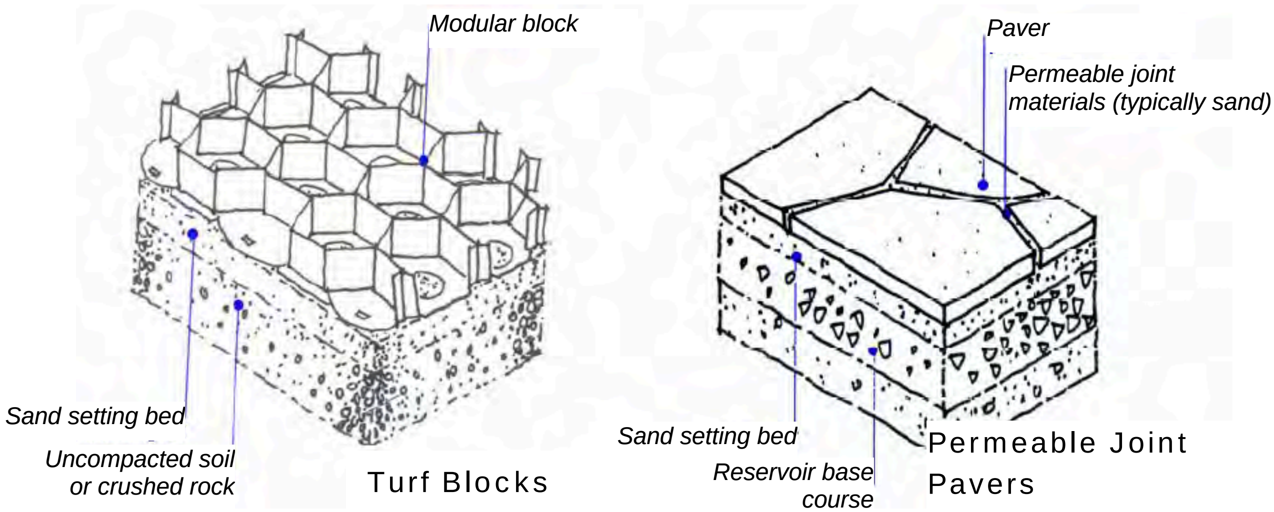

Figure 4-12: Surface and Side Views of Turf Block and Permeable Joint Pavers (Source, BASMAA. Start at the Source. 1999)

Maintenance

Standards for ongoing maintenance and upkeep:

- Keep landscaped areas well maintained.
- The surface of the unplanted turf block and permeable joint pavers shall be vacuum cleaned (if joints are tight, i.e., no sand filling) using commercially available sweeping machines at the following times:
  - End of winter (April)
  - Mid-summer (July / August)
  - After autumn leaf-fall (November)
- Planted turf block can be mowed, as needed.
- Inspect outlets yearly, preferably before the wet season. Remove accumulated trash and debris.

- When vacuum cleaning is conducted, inspect turf block and permeable joint pavers for any signs of hydraulic failure.

As needed maintenance:

- If routine cleaning does not restore infiltration rates, then reconstruction of the pervious surface area that is not infiltrating is required.
- The surface area affected by hydraulic failure should be lifted, if possible, for inspection of the internal materials to identify the location and extent of the blockage.
- Surface materials should be lifted and replaced if damaged by brush (or abrasive) cleaning.
- Sub-surface layers may need periodic cleaning and replacing.
- Deposits may need to be disposed of as controlled waste.
- Replace permeable joint materials, as necessary.

Figure 4-13: Permeable Joint Pavers at High Density Housing Project, Berkeley

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Chapter

5

General Technical Guidance for Treatment Measures

The technical guidance in this Chapter applies to all types of stormwater treatment measures.

This chapter contains general technical information regarding stormwater treatment measures for all types of new development and redevelopment projects. It includes the following topics:

- Hydraulic sizing criteria,
- The applicability of various types of manufactured treatment measures,
- Guidance regarding "treatment trains,"
- Infiltration guidelines,
- Using low-flow systems,
- Selecting and maintaining plantings in landscape-based treatment measures,
- Mosquito control requirements, and
- Incorporating treatment with hydromodification management measures.

5.1 Hydraulic Sizing Criteria

The stormwater treatment measures must be sized to treat stormwater runoff from ***relatively small sized storms*** that comprise the vast majority of storms. The intent is to treat most of the stormwater runoff while recognizing that it would be infeasible to size stormwater treatment measures to treat runoff from very large storms that occur every few years. (See Section 5.6 for more information on how stormwater treatment measures that are sized to treat runoff from small, frequent storms can be designed to also handle flows from large, infrequent storms.)

How Much of Project Site Needs Stormwater Treatment?

The NPDES stormwater permit requires that all of a project site receive stormwater treatment. Exceptions to this are landscaped areas that are "self-treating" (including green roofs and areas of turf block) as described in Section 4.1. Other than these "self-treating" landscaped areas that do not receive stormwater runoff from roofs, pavement and other impervious surfaces, ***ALL AREAS FROM A PROJECT SITE*** must receive stormwater treatment.

Flow-Based Versus Volume-Based Treatment Measures

For hydraulic sizing purposes, stormwater treatment measures can be divided generally into two groups: those that are flow-based, and those that are volume-based. The ***flow-based treatment measures*** remove pollutants from a moving stream of stormwater, and the treatment measures are sized based on hourly or peak flow rates. Examples of flow-based treatment measures include vegetated swales, flow through planter boxes, and media filters. The ***volume-based treatment measures*** detain stormwater for periods of between 24 hours and 5 days, so the sizing is based on detaining a large volume of water for treatment and/or infiltration to the ground. Examples of volume-based stormwater treatment measures include extended detention basins, wet ponds, and constructed wetlands. Table 5-1 shows which hydraulic sizing method is appropriate for the commonly used stormwater treatment measures.

Table 5-1
Flow and Volume Based Treatment Measure Designs

Type of Treatment Measure	Sizing Design
Vegetated swale	Flow
Vegetated buffer strip	Flow
Tree well filter	Flow
Media filter	Flow
Flow-through planter box	Flow and Volume
Bioretention area	Flow or Volume (if it relies on infiltration to ground)
Infiltration trench	Volume
Extended detention basin	Volume

Volume-Based Sizing Criteria

The NPDES stormwater permit specifies two alternative methods for hydraulically sizing volume-based stormwater treatment measures. One of the permit-approved methods is based on simplified procedures that are not recommended for use when information is available from continuous hydrologic simulation of runoff using local rainfall records (see “Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87.) Because the results of continuous simulation modeling based on local rainfall are available, the Alameda Countywide Clean Water Program recommends the use of the sizing method ***shown in the text box.***

> ***Volume-Based Sizing Criteria***
> Volume-based treatment measures shall be designed to treat stormwater runoff equal to the volume of annual runoff required to achieve ***80 percent or more capture***, determined in accordance with the methodology set forth in Appendix D of the California Stormwater Best Management Practices Handbook (1993), using local rainfall data.

Please note that ACCWP’s member agencies may also allow project applicants to use an even ***simpler sizing method*** for sizing flow/volume-based treatment measures such as flow-through planters and bioretention areas, in which the area of the treatment measure is designed to be 4 percent of the area that will receive treatment. Appendix C includes an example (Example 2) of sizing flow-through planter boxes using this simplified method. A simplified method for sizing extended detention basins is provided in Chapter 6, under the heading, "Simplified Sizing Methods." When using the simplified methods, be aware that they can result in a ***conservatively large*** treatment measure. If space is at a premium, it may be cost effective to use the 80 percent capture sizing method, described below.

The ***80 percent capture method*** should be used when sizing extended detention basins. The 80 percent runoff value is determined by the Storage, Treatment, Overflow, Runoff Model (STORM), which uses continuous simulation to convert rainfall to runoff based on local rainfall data. STORM was developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers. (See http://www.hec.usace.army.mil/publications/ComputerProgramDocumentation/CPD-7.pdf).

Figure 5-1: Extended Detention Basin, San Jose (example of a volume-based treatment measure)

The method for sizing volume-based stormwater treatment measures is described in the California Stormwater Quality Association's 2003 Stormwater Best Management Practice Handbook New Development and Redevelopment available at www.cabmphandbooks.com. The method used to size volume-based treatment measures in this guidance involves the following steps:.

1. Determine the ***mean annual precipitation*** for the project site using the Mean Annual Precipitation Map of Alameda County (Appendix E). Use the Oakland Airport unit basin storage volume values from Table 5-2 if the project location's mean annual precipitation is 16.4 inches or greater and the San Jose values if it is less than 16.4 inches.

Table 5-2
Unit Basin Storage Volumes in Inches for 80 Percent Capture Using 48-Hour Drawdowns

		Composite Runoff Coefficient for Area Tributary to the Volume-Based Treatment Measure			
Location	**Mean Annual Precipitation inches**	**0.25**	**0.50**	**0.75**	**1.00**
Oakland Airport	18.35	0.17 inches	0.34	0.50	0.67
San Jose	14.4	0.14	0.28	0.42	0.56
Source: CASQA 2003 .					

2. Determine the ***drainage area*** that will flow to the volume-based treatment measure. This includes all areas that will contribute runoff to the stormwater treatment measure, including pervious areas, impervious areas, and off-site areas, regardless of whether they are directly or indirectly connected to the stormwater treatment measure. Any self-treating areas (described in Section 4.1) that discharge to the storm drain system without directing flows to the stormwater treatment measure are not included in the treatment measure drainage area.

3. Determine the ***composite runoff coefficient*** for the area at the project location that is tributary to the volume-based treatment system. The runoff coefficients for stormwater treatment are lower than for flood control. Runoff coefficient "C" factors from BASMAA include the estimated values shown in Table 5-3 for use in sizing stormwater treatment measures. These "C" factors are only appropriate for stormwater treatment designs that are based on ***small, frequent storms.*** "C" factors such as those in the Alameda County Hydrology and Hydraulics Manual must be used for flood control sizing. The composite runoff coefficient is calculated as a weighted average. Multiply the area of each type of surface tributary to a stormwater treatment measure by the respective runoff coefficient. Add the results and divide by the total area that drains to a stormwater treatment measure.

A ***runoff coefficient*** is ratio of the runoff rate to rainfall and it is dimensionless. For example, a runoff coefficient of 0.70 means that seventy percent of the rainfall that falls on this type of surface will flow off as runoff.

Table 5-3
Estimated Runoff Coefficients for Various Surfaces
During Small Storms[1]

Type of Surface	Runoff Coefficients "C" factor
Concrete	0.80
Roofs	0.75
Asphalt	0.70
Pervious concrete	0.65
Pervious asphalt	0.55
Natural stone (without grout)	0.25
Turf block	0.15
Brick (without grout)	0.13
Unit pavers on sand	0.10
Crushed aggregate	0.10
Grass and landscaping	0.10

Source: BASMAA 2003

The runoff coefficients in Table 5-3 are for use only in stormwater treatment designs based on ***small, frequent storms***. Flood control sizing must be based on coefficients such as those in the Alameda County Hydrology and Hydraulics Manual.

[1] CDM for BASMAA. 2003. Using Site Design Techniques to Meet Development Standards for Stormwater Quality (www.cleanwaterprogram.org/uploads/UsingSatS.pdf) except for roofs, which is based on American Society of Civil Engineers. 1992. Design and Construction of Sanitary and Storm sewers, Manual of Engineering Practice No. 77.

4. Use the composite runoff coefficient to interpolate a ***unit basin storage volume value*** for composite runoff coefficients that are different from the four (0.25, 0.50. 0.75, and 1.00) listed in Table 5-4. For example using the Oakland Airport values, if the composite runoff coefficient was calculated to be 0.55, the unit basin storage volume would be 0.37 inches. The 0.55 composite runoff coefficient is one-fifth of the way between the table's 0.5 and 0.75 composite runoff coefficient values.

Table 5-4
Unit Basin Storage Volumes in Inches for 80 Percent Capture Using 48-Hour Drawdowns

		Composite Runoff Coefficient for Area Tributary to the Volume-Based Treatment Measure			
Location	**Mean Annual Precipitation inches**	**0.25**	**0.50**	**0.75**	**1.00**
Oakland Airport	18.35	0.17 inches	0.34	0.50	0.67
San Jose	14.4	0.14	0.28	0.42	0.56

Source: CASQA 2003 .

5. In order to account for the difference between ***mean annual precipitation of the project site*** and the two rainfall locations shown, adjust the unit basin storage volume value by multiplying the unit basin storage volume value by the following factor:

$$\frac{\text{(project location mean annual precipitation)}}{\text{(18.35 or 14.4, as appropriate)}}$$

6. Calculate the ***required capture volume*** by multiplying the drainage area from step 2 by the adjusted unit basin storage volume value. Due to the mixed units that result, such as acre-inches, it is recommended that the resulting volume be converted to cubic feet for use during design.

The other critical issue for the design of volume-based stormwater treatment measures that temporarily pond water is the ***drawdown time***. The outlet structure's orifices should be designed to draw down the stormwater flow being treated within 48 hours.

Flow-Based Sizing Criteria

The NPDES stormwater permit specifies three alternative methods for hydraulically sizing flow-based stormwater treatment control measures, such as vegetated swales, flow through planter boxes, and media filters. The percentile rainfall intensity method is based on ranking the hourly depth of rainfall from storms over a long period, and determining the 85th percentile hourly rainfall depth and multiplying this value by two. In the Bay Area this value is generally around 0.2 inches/hour. The permit also allows the use of 0.2 inches/hour as one of the three alternative methods regardless of the results from calculating values from local rainfall depths.

> The Alameda Countywide Clean Water Program recommends the use of a ***rainfall of 0.2 inches/hour*** to design flow-based treatment systems.

Because two of the permit allowed methods yield similar results and the third method is difficult to apply, and not as well supported by technical studies, the Alameda Countywide Clean Water Program recommends the use of a ***rainfall of 0.2 inches/hour*** to design flow-based treatment systems.

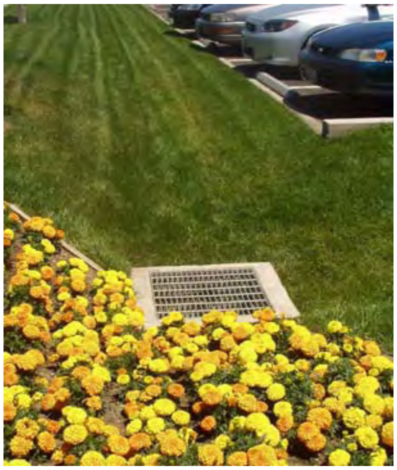

Figure 5-2: Vegetated Swale, Union City (example of a flow-based treatment measure)

The amount of flow that the stormwater treatment measure must be sized to treat is calculated using the rational method:

$$Q = CiA$$

Where

Q = flow in ft^3/second

i = rainfall intensity in inches/hour

C = composite runoff coefficient (unitless – see Table 5.3)

A = drainage area in acres

To calculate the required treatment flow, simply multiply the ***drainage area*** that contributes flow to the treatment measure by the ***composite runoff coefficient*** by 0.2 inches/hour of rainfall intensity. The drainage area and composite runoff coefficient are determined by following steps 1 through 3 described above under the Volume-Based Sizing Criteria. Appendix C includes an example (example 1) of sizing vegetated swales and bioretention areas using this sizing method.

As with volume-based treatment measures, ACCWP's member agencies may allow project applicants to use ***simplified sizing methods*** for some flow-based treatment measures. This is described in Chapter 6, under the heading, "Simplified Sizing Methods."

5.2 Applicability of Inlet Filters, Oil/Water Separators, and Hydrodynamic Separators

One way to categorize the various types of stormwater treatment measures is whether they are ***landscape-based or non-landscape-based***. Generally landscape-based treatment measures are non-proprietary while non-landscape-based treatment measures are proprietary. Some examples of landscape-based, non-proprietary treatment measures include vegetated swales, bioretention areas, extended detention basins, and flow-through planter boxes. These contrast with the manufactured, proprietary treatment measures that tend to be installed below ground and operate using proprietary filtering media, hydrodynamic separation, or sedimentation and screening.

> ACCWP's member agencies encourage the use of ***landscape-based*** treatment measures.

ACCWP's member agencies encourage the use of ***landscape-based*** treatment measures. Underground, non-landscape-based treatment measures typically require frequent maintenance to function properly, and experience has shown that because these systems tend to be "out of sight, out of mind," they often do not receive adequate maintenance. Where underground vaults are allowed, they must be sealed against mosquito access and must also include suitable access doors and hatches to allow for frequent inspections and maintenance. But even when maintained properly, many underground vault systems lack the detention time required to remove ***pollutants associated with fine particles.***[2] The following types of underground systems have been shown to have particular difficulty meeting the NPDES stormwater permit standard of removing pollutants to the maximum extent practicable (MEP):

- Inlet Filters (also called manufactured drain inserts),
- Oil/Water Separators (also called water quality inlets), and
- Hydrodynamic Separators.

In August 2004 the Water Board's Executive Officer wrote a letter stating that a project relying on inlet filters or oil/water separators as the sole treatment measure would be ***unlikely to meet the maximum extent practicable*** (MEP) standard."[3] The letter does note, however, that oil/water separators may be acceptable as part of a "treatment train," or series of stormwater treatment measures at sites with high concentrations of oil and grease, and that inlet filters may be appropriate as part of a treatment train in areas where trash is a concern.

The Executive Officer's August 2004 letter also cautions that most new development projects need stormwater treatment measures "that address the broad spectrum of urban runoff pollutants, from trash to fine particulates and soluble pollutants, are needed." The Contra Costa Clean Water Program has established a policy that hydrodynamic separators, when used as a sole method of stormwater treatment, do not meet the MEP standard for stormwater treatment effectiveness.[4] The policy was based, in part, on a literature review that found that hydrodynamic separators were substantially less effective than various landscape-based treatment measures for removing pollutants that are associated with very fine particles, but that they could be used to remove trash and coarse sediment from stormwater upstream of other treatment measures.

ACCWP has not developed a countywide policy on hydrodynamic separators. Some of ACCWP's member agencies may require an applicant to demonstrate that landscape-based treatment measures and/or media filters are infeasible or impracticable before approving the use of stand-alone hydrodynamic separators. Check with the municipal staff for local requirements. The August 2004 letter is included in Appendix F, along with additional information regarding inlet filters, oil/water separators and hydrodynamic separators.

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[2] Contra Costa County Stormwater Quality Requirements for Development Applications. Stormwater C.3 Guidebook, 3rd Draft, January 2005.

[3] Letter from Bruce H. Wolfe, Executive Officer of the San Francisco Bay Regional Water Quality Control Board to the Bay Area Stormwater Management Agencies Association (BASMAA), dated August 5, 2004, http://www.cleanwaterprogram.org/uploads/RWQCB_letter_re_inlet_filters_etc.pdf.

[4] Contra Costa Clean Water Program, November 16, 2005. Policy on the Use of Hydrodynamic Separators to Achieve Compliance with NPDES Provision C.3. http://www.cccleanwater.org/construction/Publications/HydrodynamicSeparatorsPolicy_11-16-05.pdf.

5.3 Using Manufactured Treatment Measures

In cases where a municipality approves the use of one or more manufactured treatment measures in a development project, the project applicant is responsible for following the manufacturer's instructions for construction and maintenance, and for installing the unit(s) in a manner that facilitates proper functioning. When installed and maintained properly, manufactured media filters (see Section 6.4) may have adequate pollutant removal levels for sediment and pollutants associated with sediment. Media filters typically include two chambers: the first chamber allows coarse solids to settle, and the second filters the stormwater through the proprietary media. When installed and maintained properly, hydrodynamic separators may be effective in removing trash and coarse sediment, but not dissolved pollutants, and they may be installed upstream of other treatment measures.

The ***applicant is responsible*** for ensuring that the manufactured treatment measures used in the project are sized in accordance with the NPDES stormwater permit hydraulic sizing criteria to treat the amount of runoff that will flow to these treatment measures.e

Planning permit submittals should include a description of the product(s) proposed for use, along with preliminary sizing calculations, and conceptual plans showing the proposed locations of treatment measures on the site. ***Building permit submittals*** should include detailed sizing calculations, construction-level drawings, and a copy of the manufacturer's instructions for construction and maintenance. Maintenance plans for manufactured treatment measures must be based on the manufacturer's maintenance instructions.

Listed below are some issues project engineers have encountered when selecting and incorporating manufactured stormwater treatment measures into development projects:[5]

- ***Consider hydraulic depth.*** Different types of manufactured treatment measures have different head losses. Your options may be limited if the site has limited hydraulic depth or other constraints.
- ***Allow for necessary field changes.*** In the planning permit application submittal, request approval to use more than one manufactured treatment measure product in the project. Format the design, details, and specifications to identify the approved, alternative manufactured treatment measures, and include these documents in the building permit application submittal. Giving the contractor options to work with will help avoid delays to your project.
- ***Allow design flexibility.*** Some manufactured treatment measures have the same invert elevation in and out, while some require a change in elevation between the invert and outlet. If possible, provide for a design that allows for a change in invert elevations.
- ***Include sufficient information.*** Contract documents should include enough design information so that the contractor can evaluate and demonstrate that the treatment measure meets the design objectives.

[5] Decker, Thomas R., "Specifying and Permitting Alternative MTDs", in the January/February 2006 edition of the journal Stormwater. http://www.stormh2o.com/sw_0601_guest_editorial.html.

- ***Avoid approval problems.*** If applicable, clarify in the design and construction documents that the contractor will be responsible for obtaining approval from the local jurisdiction for any changes that violate the approved permit plans or conditions.

5.4 Using Treatment Trains

> ***What Is A Treatment Train?***
> A treatment train is a multiple treatment system that uses two or more stormwater treatment measures in series. Examples include: a settling basin/sand [or media] filter combination, a settling basin/infiltration trench combination, and an extended detention zone on a wet pond.

Stormwater can be directed to flow through a series of different types of stormwater treatment measures that are each designed to treat different broad categories of stormwater pollutants. These groupings of stormwater treatment measures have been called "stormwater treatment trains" or a "multiple treatment system." The definition of treatment train given in Fact Sheet TC-60 of the CASQA Handbook is shown in the text box. The use of a ***series of treatment measures*** is most effective where each treatment measure optimizes the removal of a particular type of pollutant, such as coarse solids and debris, pollutants associated with fine solids, and dissolved pollutants. Stormwater treatment measures operate by using physical processes, such as sedimentation and filtration, to remove solids suspended in stormwater runoff. The removal of dissolved pollutants requires chemical adsorption or biological uptake. Each of the stormwater treatment measures in a treatment train should be sized using the Provision C.3 numeric sizing criteria.

The ***simplest version*** of the treatment train concept consists of pretreatment prior to the stormwater reaching the main treatment system. For example, bioretention areas commonly use vegetated buffer strips to pretreat stormwater to settle out sediment prior to the stormwater being treated by a bioretention area. This type of pretreatment helps to prevent sediment from clogging the bioretention area, which maximizes its life. Another example of a coupled ***pretreatment and treatment system*** is used in extended detention basins that have a small, sediment forebay where most of the larger sediment settles and can be easily removed. Or, in areas where oil and grease are a concern, an oil/water separator may be used before stormwater is treated in a vegetated swale.


Figure 5-3: Tule Pond, Fremont

The combining of ***three or more*** stormwater treatment measures in series is often limited in practice because of the expense and additional space required. Some prototypes exist, such as the Tule Pond at Tyson Lagoon in Fremont. This stormwater treatment system was constructed in 1998 by the Alameda County Flood Control and Water Conservation District. It includes a wet pond where most of the sediment in the incoming stormwater settles. The wet pond also includes log booms to trap floating debris. From the wet pond the water flows into two other treatment ponds that are shallower in depth and where finer sediments and their associated pollutants settle and dissolved pollutants are removed by aquatic vegetation. The entire system also allows infiltration of the stormwater into the underlying soils.

5.5 Infiltration Guidelines

Infiltration can be a very cost-effective method to manage stormwater – if the conditions on your site allow. A wide-range of site-design measures and stormwater treatment measures can be used to increase stormwater infiltration and can be categorized as follows:

- ***Site design measures*** -- such as clustering development or otherwise laying out the site to reduce impervious area, routing drainage from building roofs to landscaped areas, and using pervious pavement.
- ***Indirect infiltration*** methods, which allow stormwater runoff to percolate ***into surface soils***. Runoff may reach groundwater indirectly, or it may be underdrained into subsurface pipes. Examples of indirect infiltration methods include bioretention areas and vegetated swales.
- ***Direct infiltration*** methods*,* which are designed to ***bypass surface soils*** and transmit runoff directly to groundwater. These types of devices must be located and designed to limit the potential for stormwater pollutants to reach groundwater. Examples of direct infiltration methods include infiltration trenches and dry wells.

The local jurisdiction may require a geotechnical review for your project. When selecting site design and stormwater treatment measures that promote on-site infiltration, be sure to ***follow the geotechnical engineer's recommendations*** based on soil boring data, drainage pattern, and the current requirements for stormwater treatment. The geotechnical engineer's input will be critical to prevent damage from underground water to surrounding properties, public improvements, slope banks, and even mudslides from accumulated below-ground water.

Appendix G provides guidelines to help you determine whether your project site is suitable for using site design and/or stormwater treatment measures that increase stormwater infiltration and include regulatory requirements that apply to direct infiltration methods, as well as practical tips for the design and construction.

5.6 Technical Guidance for Low-Flow Systems

Although stormwater treatment measures are sized to remove pollutants from flows resulting from frequent, small storms, projects must be designed to handle flows for stormwater treatment and drainage from large infrequent flows to ***prevent flooding***. The integration of flood control and stormwater treatment may be accomplished in one of two ways, which are described below.

One option is to have the flows that are larger than those required by the hydraulic sizing criteria (given in Section 5.1) handled ***within the stormwater treatment measure.*** This includes making sure that landscape-based treatment measures do not re-suspend and flush out pollutants that have been accumulating during small storms, and that landscape-based stormwater treatment measures do not erode during flows that will be experienced during larger storms. Most vegetated swales, vegetated filter strips, and extended detention basins are designed to handle flood flows, although they would not be providing much treatment during these flows. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards to accommodate flood flows associated with larger storms.

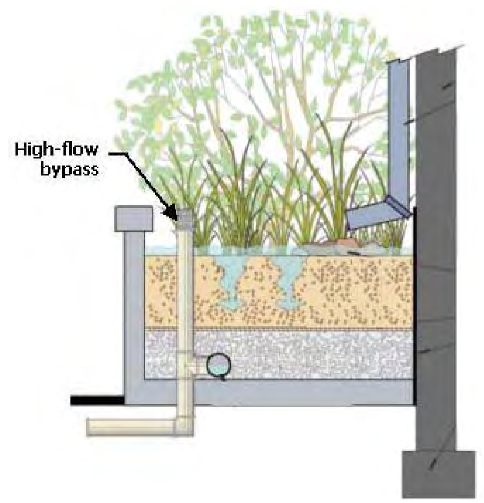


Figure 5-4: Flow-through planter with high-flow bypass (Source: City of Portland, 2004)

The other option is to ***bypass the high flows*** around the stormwater treatment measure so that they flow to a storm drainage system designed to handle the high flows. Bioretention areas, flow-through planter boxes, and other treatment systems that rely on filtration or infiltration must have overflow systems that allow flood flows larger than the increment of flow that can be treated to bypass the stormwater treatment measure. These filtration-based systems have to include an alternative flow path for high flows, otherwise stormwater would back up and flood the project area. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards for high-flow bypasses.

5.7 Selecting and Maintaining Plantings in Landscape-Based Treatment Measures

Selecting the appropriate plants and using sustainable, horticulturally sound landscape installation and maintenance practices are essential components of a successful landscape-based stormwater treatment measure.

Plant Selection Guidance

Plant selection must consider the type of development and location, uses on the site and an appropriate design aesthetic. Ideally, a Landscape Architect will be involved as an active member of the design team ***early in the site design phase*** to review proposed stormwater measures and coordinate development of an integrated solution that responds to all of the various site goals and constraints. In some cases, one professional will design a stormwater control, while another designs the rest of the landscaping. In these situations it is critical for the professionals to work together very early in the process to integrate their designs.

Appendix B provides user-friendly guidance in selecting planting appropriate to the landscape-based stormwater treatment measures included in Chapter 6 and the site design measures in Chapter 4.

Bay Friendly Landscaping

Bay-friendly landscaping is a whole systems approach to the ***design, construction and maintenance*** of the landscape in order to support the integrity of the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly landscaping practices from the initial plant selection through the long-term maintenance of the site. Appendix B summarizes Bay Friendly Landscaping Practices that may be implemented to benefit water quality of the Bay and its tributaries, based on the Bay-Friendly Landscaping Guidelines prepared by Stopwaste.Org (available at www.bayfriendly.org).

Integrated Pest Management

Integrated pest management (IPM) is a holistic approach to mitigating insects, plant diseases, weeds, and other pests. Projects that require a landscaping plan as part of a development project application are encouraged to use IPM, as indicated in each agency's source control measures list. ***Avoiding pesticides and quick release synthetic fertilizers*** is particularly important when maintaining stormwater treatment measures to protect water quality.

IPM encourages the use of many strategies for first preventing, and then controlling, but not eliminating, pests. It places a priority on fostering a healthy environment in which plants have the strength to resist diseases and insect infestations, and out-compete weeds. Using IPM requires an understanding of the life cycles of pests and beneficial organisms, as well as regular monitoring of their populations. When pest problems are identified, IPM considers all viable solutions and uses a combination of strategies to control pests, rather than relying on pesticides alone. The least toxic pesticides are used only as a last resort. More information on IPM is included in Appendix B.

Wetland Regulations and Treatment Measures

The Water Board's "Policy on the Use of Constructed Wetlands for Urban Runoff Pollution Control" (Resolution No. 94-102) recognizes that stormwater treatment wetlands that are constructed and operated pursuant to Resolution 94-102 and are constructed outside a creek or other receiving water are stormwater treatment systems, and, as such, are not waters of the United States subject to Sections 401 and 404 of the federal Clean Water Act.

5.8 Mosquito Control

Some types of stormwater treatment measures are designed to include standing water, and even treatment measures that are designed to eliminate standing water between storms have the potential to ***retain standing water*** if they are not properly designed, constructed and maintained.

To reduce the potential for stormwater treatment measures to lead to mosquito problems, the ACCWP developed a Vector Control Plan, which describes the need to include physical access for mosquito control staff to monitor and treat mosquitoes, and includes guidance for designing and maintaining stormwater treatment measures to control mosquitoes. The Alameda County Mosquito Abatement District (ACMAD) staff has identified a ***five-day maximum*** allowable water retention time, based on actual incubation periods of mosquito species in this area. With the exception of certain stormwater treatment measures designed to hold permanent water (e.g., CDS units and wet ponds), all treatment measures should drain completely within five days to effectively suppress vector production. *Please note that the design of stormwater treatment measures* ***does not require*** *that water be standing for five days. During five days after a rain event, standing water is allowable but not required for the stormwater treatment measure to function effectively.*

Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** from ACCWP's Vector Control Plan, which are included in Appendix H.

Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** from ACCWP's Vector Control Plan, which are included in Appendix H.

5.9 Incorporating Treatment with Hydromodification Management

In addition to the requirement to treat stormwater runoff to remove pollutants, the NPDES stormwater permit also requires that stormwater runoff be detained and released in a way that ***prevents increased creek channel erosion*** and siltation. These restrictions require that the amount of stormwater flow and the duration of the flow be limited to match what occurred prior to the currently proposed development or re-development. These hydromodification management (HM) requirements apply to projects that create one acre or more of impervious surface in most areas of Alameda County. The requirements do not apply to projects that drain directly to the bay or tidal channels nor to projects where stormwater flows into channel segments that have been hardened on three sides and/or are culverted continuously downstream to their outfall in a tidal area. Chapter 7 gives more detail on these requirements.

The ACCWP has prepared a Hydromodification Management Plan (HMP), which is currently being reviewed by Water Board staff. The HMP requirements will become effective after the Water Board's approval, which is expected in late 2006. To help implement the HMP, ACCWP is in the process of developing a Bay Area Hydrology Model (BAHM) with assistance from the municipal stormwater programs in Santa Clara and San Mateo Counties. The BAHM will be available for project applicants to use to ***automatically size stormwater detention measures*** such as detention vaults, tanks, basins and ponds for Flow Duration Control of post-project runoff; it will also check these facilities for performance as volume-based stormwater treatment measures, to meet the permit requirements for both stormwater treatment and hydromodification management. The BAHM is expected to be available for use in Fall 2006, along with additional ACCWP guidance on coordinating design requirements for hydromodification management with treatment and flood control considerations.

Chapter

6

Technical Guidance for Specific Treatment Measures

Technical guidance is provided for stormwater treatment measures commonly used in Alameda County.

Technical guidance is provided for the stormwater treatment measures listed in Table 6-1.

Table 6-1
Stormwater Measures for which Technical Guidance is Provided

Treatment Measures	Section
Vegetated swale	6.1
Vegetated buffer strip	6.2
Tree well filter	6.3
Media filter	6.4
Flow-through planter box	6.5
Bioretention area	6.6
Infiltration trench	6.7
Extended detention basin	6.8

Simplified Sizing Methods

Some simplified sizing methods are offered to help evaluate, during the planning phase, whether sufficient land has been allocated for stormwater treatment. Please note that the following methods are not meant to take the place of design calculations for site-specific conditions.

- A ***vegetated swale*** requires a treatment area equal to 4 percent of the impervious surface area from which stormwater runoff will be treated.

- A ***bioretention area*** or ***flow-through planter*** requires 4 percent of the impervious area (1,750 square feet of bioretention area per impervious acre).
- An ***extended detention basin*** has a minimum drainage area of 5 acres. Allow a 1-inch diameter outlet orifice for a 5-acre drainage area. Allow a 1-acre basin, 3.5-feet deep, for a 100-acre drainage area.

The technical guidance in this chapter is provided to assist you in preparing permit application submittals for your project. The municipalities will require you to prepare more specific drawings taking into consideration the conditions on the project site, project materials, plumbing connections, etc., when you submit your permit application. This technical guidance was developed using best engineering judgment and based on a review of various regional documents concerning treatment measures. Guidance from Water Board staff was incorporated where available. ACCWP looks forward to working with Water Board staff in the future to continue to improve our technical guidance.

6.1 Vegetated Swales

Best uses

- Within parking areas
- Adjacent to roadways
- Landscape buffers
- A landscape design element

Advantages

- Can enhance aesthetics
- Potentially inexpensive treatment measure
- Reduced footprint
- Low maintenance

Limitations

- A single swale cannot treat areas greater than 10 acres
- Requires a thick vegetative cover
- Impractical for steep slopes
- Not effective when flow velocity is high
- Not appropriate for industrial activity

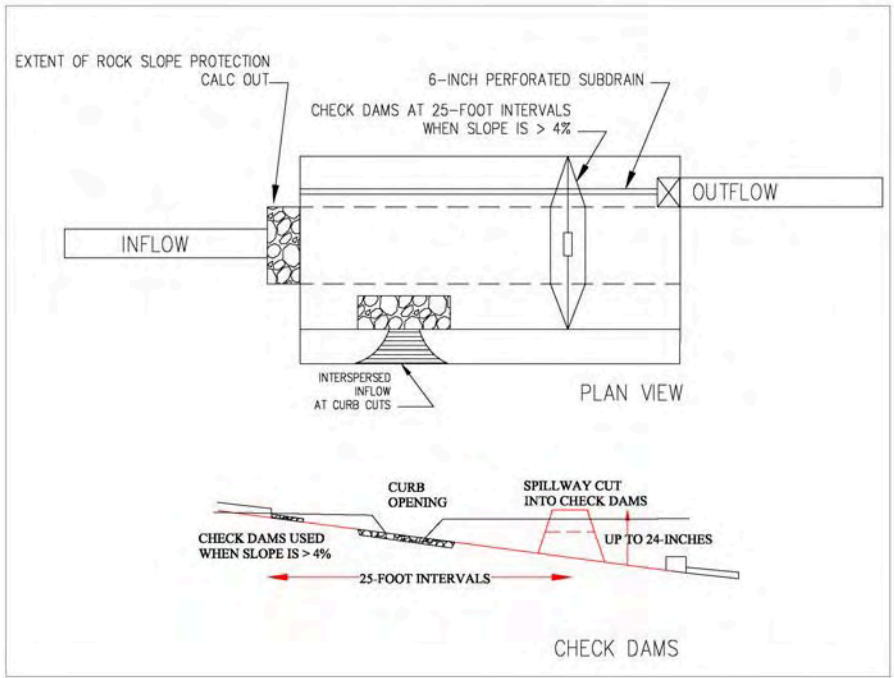
Vegetated swales are open, shallow channels with thick vegetation covering the side slopes and bottom that collect and slowly convey runoff to downstream discharge points. They are designed to treat runoff through sedimentation filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm drain systems.

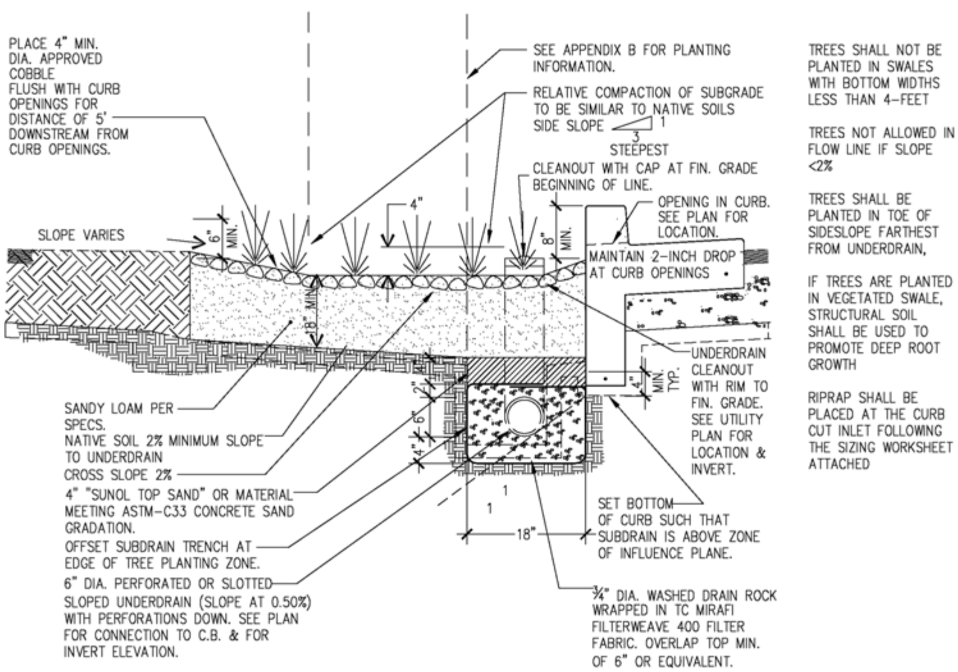
Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- A simplified sizing approach may be used, in which the swale is sized to have a treatment area equal to 4% of the impervious surface area of the site. Alternatively, the swale should meet the treatment standards described below based on maximum flow depth, flow velocity as controlled by maximum slope, and minimum residence time.
- The treatment water depth shall not exceed ⅔ (two-thirds) the height of the grass or 4 inches, which ever is less, at the design treatment flow rate. Water depth can be assumed to be 2 inches for frequently mowed grass.

- The treatment width of the swale should be determined using Manning's Equation with a value of 0.25 for Manning's "n". The analysis methods for developing flow rates are presented in Section 5.1.
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, may be easier to mow than designs with sharp breaks in slope.





- The longest flow path for the swale shall have a minimum retention time of 12 minutes for conditions when the treatment flows enter the vegetated swale uniformly along the swale length. The longest flow path for the swale shall have a minimum retention time of 8 minutes if 90 percent or more of the treatment flow enters the swale at the upstream end.
- Vegetated swales shall have a maximum treatment width of 10 feet. Parallel swales may be used if calculations show greater width is needed.

STORM DRAIN SYSTEM SIZING

- If the 10- or 100-year storm event flow velocity is greater than 4 feet per second, a permanent geofabric liner shall be used that is rated for the calculated flow velocity.
- For flows greater than the 10-year event, the Manning's Roughness coefficient shall be based on recommendations from Section 2.3 of the Alameda County Flood Control and Water Conservation District, Hydrology and Hydraulics Criteria Summary. The swale shall convey the 10-year storm event with flows contained within the swale. Adjacent to streets, the 100-year storm event shall be conveyed with flows below the top of curb elevation. (Include flow in the gutter in the calculation.)
- If the groundwater table is less than 10 feet deep, an impermeable fabric layer shall be placed below the drain rock to insure against infiltration into perforated underdrain from groundwater.

CONSTRUCTION

- Longitudinal swale slopes should be between 0.5% and 4%, or as specified by the municipality. The overall slope may be up to 8%, slopes between 4 and 8% require check dams up to 24-inches high and at least 25 feet apart to achieve no more than a 4% flow line slope between dams.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- The bed of the Swale flow area shall slope at least 2% from toe of side slope to center of swale. Side slopes shall be no steeper than a 3 to 1 slope.
- A minimum separation of 2-feet will be maintained near a joint trench.

VEGETATION

- See Appendix B for guidance to select a palette of diverse, low-growing plants.
- If vegetation is not established by October 1st, a 1-year biodegradable loose weave geofabric shall be placed on swale surface. If vegetation is not established by October 15th of the year, sod shall be placed over loose soils.
- If trees must be planted in the swale, planting shall occur on side slopes of swale to avoid impeding flows.

INTERFACE WITH PAVED AREAS

- Flow may enter the vegetated swale:
    - As overland flow from landscaping (no special requirements)
    - As overland flow from pavement (cutoff wall required)
    - Through a curb opening
    - Through a curb drain

  - With drop structure through a stepped manhole

SOIL CONSIDERATIONS

- No underdrain is needed where native soils are Hydrologic Soil Group A or B
- The perforated underdrain trench shall be backfilled with ¾" drain rock with a 2-inch bed underneath and 6-inch cover. (Caltrans Standard Section 68-1.025 permeable material Class 2) This rock layer shall be separated from the swale using a geofabric covered by a filter layer of sand or fine rock.
- Swale's planting soil shall have a minimum percolation rate of 5 inches/hour and a maximum percolation rate of 10 inches/hour. If native soils do not meet this percolation requirement, an admixture shall be mixed into planting soil to allow for a 5 inch/hour percolation rate. In-situ testing shall be conducted to verify that the material meets the percolation requirements.
- No bark mulch shall be placed in the vegetated swale.
- If import soil is used, it shall have the following properties for sandy loam. A typical soil mix comprises 50% construction sand, 20-30% topsoil with less than 5% maximum clay content and 20-30% organic leaf compost.

MAINTENANCE

- A Maintenance Agreement shall be provided.
- The Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where 6-inch high grasses are used, the grass height shall be at least 3 inches after mowing. Where mowed grasses are shown, the grass height shall be mowed when the height exceeds 3 inches.
- Remove obstructions and trash from vegetated swale.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Vegetated swales shall be inspected and maintained monthly to review:
  - Obstructions and trash.
  - Ponded flow is drained within five days after a rainfall event.
  - Condition of grasses.
  - If ponding is observed, grading will be required to restore positive drainage.
  - If significant sedimentation occurs blocking flows in the swale, sedimentation shall be removed and swale shall be replanted.

6.2 Vegetated Buffer Strip

Source: www.cabmphandbooks.com

Best Uses

- Roadside shoulders
- Landscape buffer

Advantages

- Minimal maintenance
- Reliable
- Aesthetic appeal
- Adjustable to suit site

Limitations

- No large drainage areas
- Thick cover necessary
- Large size requirements
- Minimal detention provided

Vegetated buffer strips (grassed buffer strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Vegetated buffer strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Vegetated buffer strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, vegetated buffer strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure.

Design and Sizing Guidelines

- Maximum width of the tributary impervious drainage area to be treated (in the direction of flow towards the buffer) shall be 60 feet.
- Strip shall be sized as long as the site will reasonably allow, but at least 15 feet in direction of flow.
- Slopes should not exceed 15%.
- A subdrain system shall be used if the vegetated buffer strip's slope is 0.5% or less.
- If runoff is piped or channeled to the strip, a level spreader must be installed to create sheet flow.
- Length should be the same as the tributary area length.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred. See planting guidance in Appendix B.
- Planting soil will be to a minimum depth to at least 6 inches. Native soil may be used as a planting soil if approved by the landscape architect.
- Strip shall be free of gullies or rills.

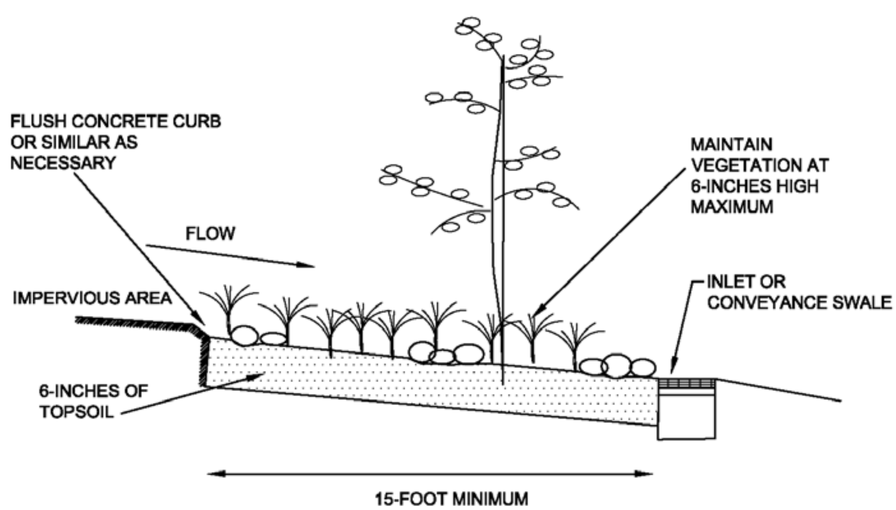
MAINTENANCE

A maintenance agreement shall be provided with the vegetated buffer strip.

- The maintenance agreement shall state the parties' responsibility for maintenance and upkeep.
- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where 6-inch high grasses are used, the grass height shall be at least 3 inches after mowing.
- Remove obstructions and trash from vegetated buffer strip.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

Vegetated buffer strips shall be inspected and maintained monthly to review:

- Obstructions and trash.
- Ponded flow is drained within five days after a rainfall event.
- Condition of grasses or other vegetation.
- If ponding is observed, grading will be required to restore positive drainage.



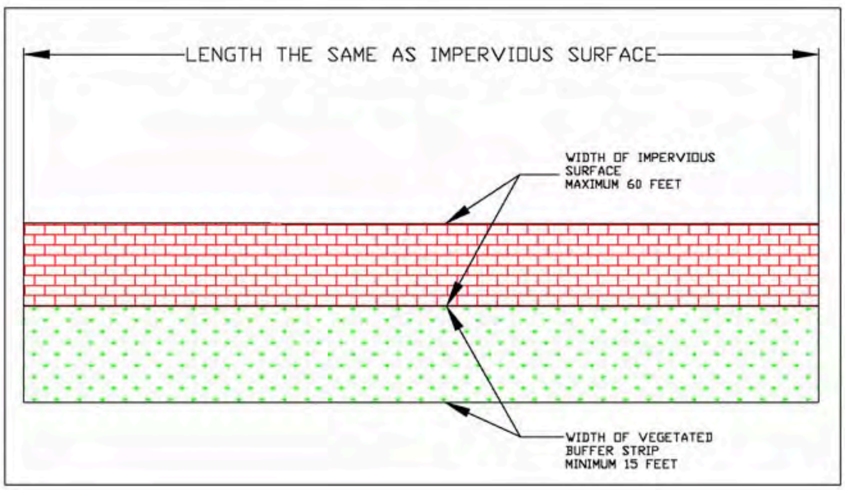
PLANTING SOIL WILL BE OF A MINIMUM DEPTH OF AT LEAST 6 INCHES. NATIVE SOIL MAY BE USED AS A PLANTING SOIL IF APPROVED BY THE LANDSCAPE ARCHITECT.

15% MAXIMUM SLOPE, 2% MINIMUM SLOPE, 0.5% MINIMUM SLOPE WITH UNDERDRAIN, 15 FOOT MINIMUM WIDTH

LONGITUDINAL LENGTH = LONGITUDINAL LENGTH OF CONTRIBUTING AREA

STRIP SHALL BE FREE OF GULLIES OR RILLS.

Profile View, Vegetated Buffer Strip



Plan View, Vegetated Buffer Strip

Alameda Countywide
Clean Water Program

6.3 Tree Well Filter

Best Uses
- Limited space
- Parallel to roadways

Advantages
- Aesthetic
- Small surface land use
- Blends with the landscape

Limitations
- Can clog without maintenance
- High installation cost
- Surface planting soils require replacement twice a year

Source: www.filterra.com The use of this photo is for general information only and is not an endorsement of this or any other proprietary stormwater treatment device.

Tree filters consist of one or multiple chambered pre-cast concrete boxes or hoops with a small tree or shrub planted in a filter bed filled with engineered media or other absorptive filtering media. As stormwater flows into the chamber, large particles settle out in the mulch layer, and then finer particles and other pollutants are removed as stormwater flows through the filtering media. Underground, physical, chemical and biological processes work to remove pollutants from urban stormwater runoff. Stormwater flows through a specially designed filter media mixture that has a high rate of infiltration. The mixture immobilizes some pollutants, which may be decomposed, volatilized and incorporated into the biomass of the tree filter system's micro/macro fauna and flora. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged. Tree filters are similar in concept to bioretention areas in function and applications, with the major distinction that a tree filter has been optimized for high volume/flow treatment, therefore the ratio of impervious area to treatment area is less. A tree filter takes up little space and may be used on highly developed sites such as landscaped areas, green space, parking lots and streetscapes. A tree filter is adaptable and may be used for developments, in all soil conditions to meet stormwater filtration needs.

Design and Sizing Guidelines
- Flows in excess of the treatment flow rate shall bypass the tree filter to a downstream inlet structure or other appropriate outfall.
- A tree filter shall be reviewed by the manufacturer before installation.
- Manufacturers such as Filterra will size the tree filter to the impervious surface of a site. The manufacturer shall certify the ratio of impervious area to treatment area for the project. For example, Filterra states that a tree filter of 6 x 6-feet can treat 0.25 acres of impervious surface.

- Tree filters are available in multi-sized pre-cast concrete drop in boxes, Sizes range from 4 x 6-feet up to 6 x 12-feet boxes.
- Tree filters cannot be placed in sump condition, therefore tree filters shall have flow directed along a flow line of curb and gutter or other lateral structure. Do not direct flows directly to a tree filter.
- Filter media in tree filter shall be specialized for expected site pollutant loads.

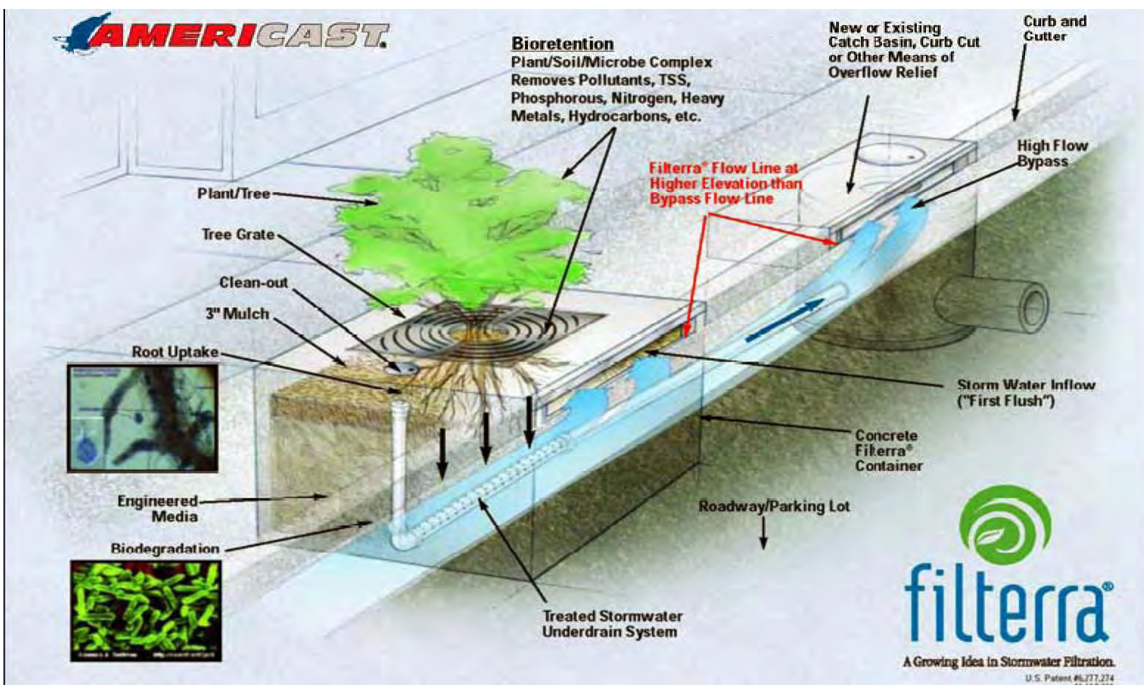
MAINTENANCE AGREEMENT

A maintenance agreement shall be provided.

- The maintenance agreement shall state the parties' responsibility for maintenance and upkeep.
- Installation and maintenance can be simple. A flexible, single-unit design is manufactured for drop-in-place construction. Maintenance can be contracted out, sometimes with the manufacturer.
- A tree filter shall be inspected weekly, with trash and debris being removed. Routine and inexpensive landscape care is required.
- The surface soil of the tree filter must be replaced twice a year to maintain treatment quality of stormwater. Replacement media can be purchased from manufacturers of the tree filter.

MAINTENANCE STANDARDS

- Maintenance activities and frequencies are specific to each product. Semiannual maintenance is typical. Maintenance shall be performed per guidance of specifications.
- Manufactured tree filters, like the Filterra filter, can require a maintenance agreement.



Cut Away View, Source: www.stormwaterinc.com The use of this photo is for general information only, and is not an endorsement of this or any other proprietary stormwater treatment device.

Non Proprietary Tree Filter with Overflow Bypass, Source: www.unh.edu/erg/cstev

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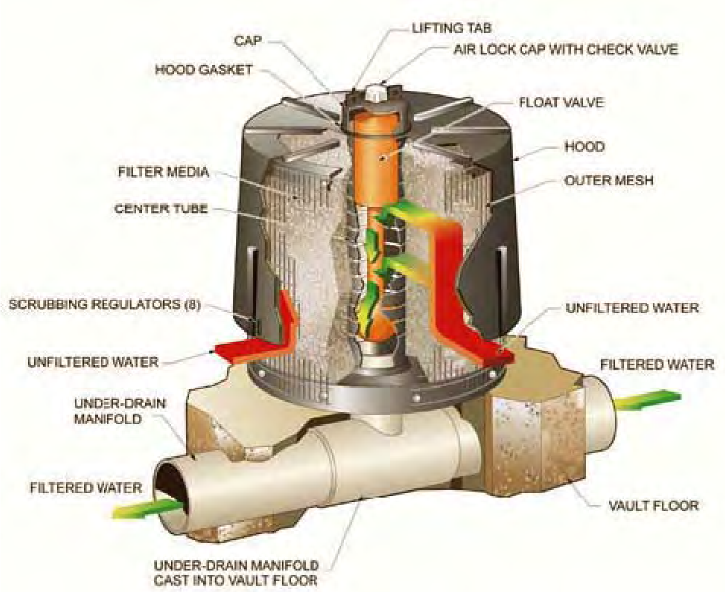
6.4 Media Filter



Best Uses

- Limited space
- Underground
- Used following a separation unit, such as swirl concentrator

Advantages

- Less area required
- Customized media
- Customized sizing

Limitations

- No removal of trash without pre-treatment
- High installation and maintenance costs.

System C Filter Cartridge, Typically Used as Part of Array. Source: CONTECH Stormwater Solutions, affiliated with CONTECH Construction Products, Inc. (Note: The proprietary mediea filters shown are for general information only and are not endorsed by ACCWP. An equivalent filter may be used.)

Stormwater media filters are usually two-chambered, including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. There are currently three types of manufactured stormwater media filter systems. Two are similar in that they use cartridges of a standard size (filter types B and C, seen above). The cartridges are placed in vaults; the number of cartridges are a function of the design flow rate. The water flows laterally (horizontally) into the cartridge to a centerwell, then downward to an underdrain system. The third product (type A) is a flatbed filter, similar in appearance to sand filters.

Design and Sizing Guidelines

There are currently three types of stormwater filter systems:

Filter System A:

- This system is similar in appearance to a slow-rate sand filter.
- The media is cellulose material treated to enhance its ability to remove hydrocarbons and other organic compounds. The media depth is 12 inches.
- Operates at a very high rate, at peak flows. Normal operating rates are much lower assuming that the stormwater covers the entire bed at flows less than the peak rate.
- System uses a swirl concentrator for pretreatment.
- As the media is intended to remove sediments (with attached pollutants) and organic compounds, it would not be expected to remove dissolved pollutants such as nutrients and metals unless they are complexed with the organic compounds that are removed.

Filter System B:

- Uses a simple vertical filter consisting of 3-inch diameter, 30-inch high slotted plastic pipe wrapped with fabric.
- The standard fabric has nominal openings of 10 microns. The stormwater flows into the vertical filter pipes and out through an underdrain system. Several units are placed vertically at 1-foot intervals to give the desired capacity.
- The filter bay has a typical emptying time of 12 to 24 hours.
- In a cartridge filter the media is fabric, therefore the system may not remove dissolved pollutants. It does remove pollutants attached to the sediment that is removed.

Filter System C:

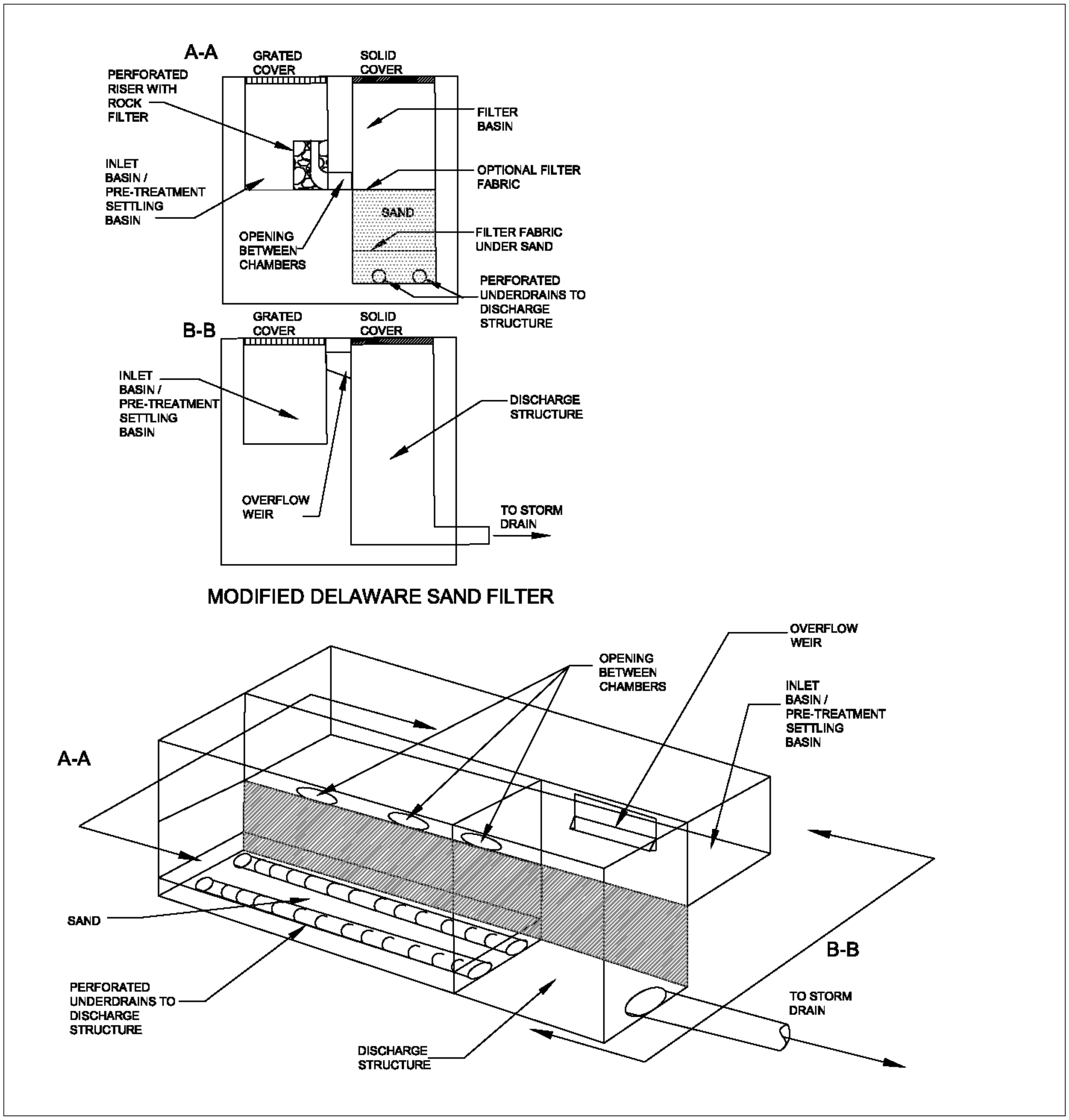
- The system uses vertical cartridges in which stormwater enters radially to a center well within the filter unit, flowing downward to an underdrain system.
- Flow is controlled by a passive float valve system, which prevents water from passing through the cartridge until the water level in the vault rises to the top of the cartridge.
- Full use of the entire filter surface area and the volume of the cartridge is assured by a passive siphon mechanism as the water surface recedes below the top of the cartridge.
- A balance between hydrostatic forces assures a more or less equal flow potential across the vertical face of the filter surface. The filter surface receives suspended solids evenly in this system.
- Absent the float valve and siphon systems, the amount of water treated over time per unit area in a vertical filter is not constant, decreasing with the filter height; furthermore, a filter would clog unevenly.
- Restriction of the flow using orifices ensures consistent hydraulic conductivity of the cartridge as a whole by allowing the orifice, rather than the media, whose hydraulic conductivity decreases over time, to control flow.
- Manufacturers offer several media types used singly or in combination (dual- or multi-media). Total media thickness is about 7 inches. Some media, such as fabric and perlite, remove only suspended solids (with attached pollutants). Media that also remove dissolved pollutants include compost, zeolite, and iron-infused polymer. Pretreatment occurs in an upstream unit and/or the vault within which the cartridges are located. Water quality volume or flow rate (depending on the particular product) is determined by local governments or sized so that 85% of the annual runoff volume is treated.

All 3 types of media filter shall have a pretreatment system in place such as a swirl concentrator.

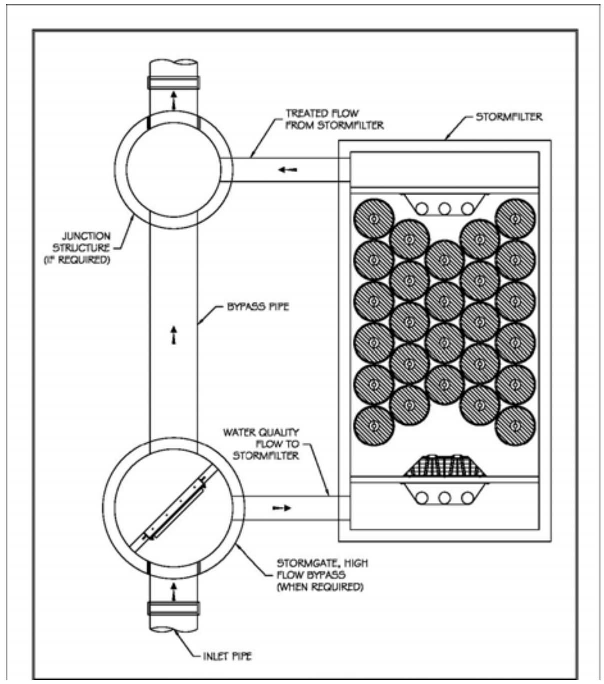
MAINTENANCE

- A maintenance agreement shall be provided.
- The maintenance agreement shall state the parties' responsibility for maintenance and upkeep.
- Maintenance activities and frequencies are specific to each product. Annual maintenance is typical.
- Manufactured filters, like cartridge filters, require more frequent maintenance than most standard treatment systems, typically annually for most sites.

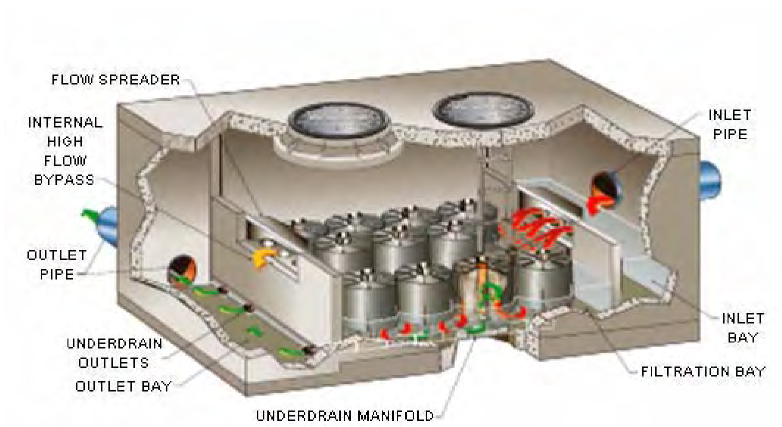
Cut Away Profile Views, System A Filter



Modified Delaware Media Filter



Profile View, Typical System C Filter Array. Source: CONTECH Stormwater Solutions, affiliated with CONTECH Construction Products, Inc. (Note: The proprietary mediea filters shown are for general information only and are not endorsed by ACCWP.



Plan View, Typical System C Filter Array. Source: CONTECH Stormwater Solutions. (Note: The proprietary media filters shown are for general information only and are not endorsed by ACCWP.

6.5 Flow-Through Planter

Source: City of Portland 2004 Stormwater Manual

Best uses

- Treating roof runoff
- Next to buildings
- Dense urban areas
- Locations where infiltration is not desired

Advantages

- Can be adjacent to structures
- Multi-use
- Versatile
- May be any shape
- Low maintenance

Limitations

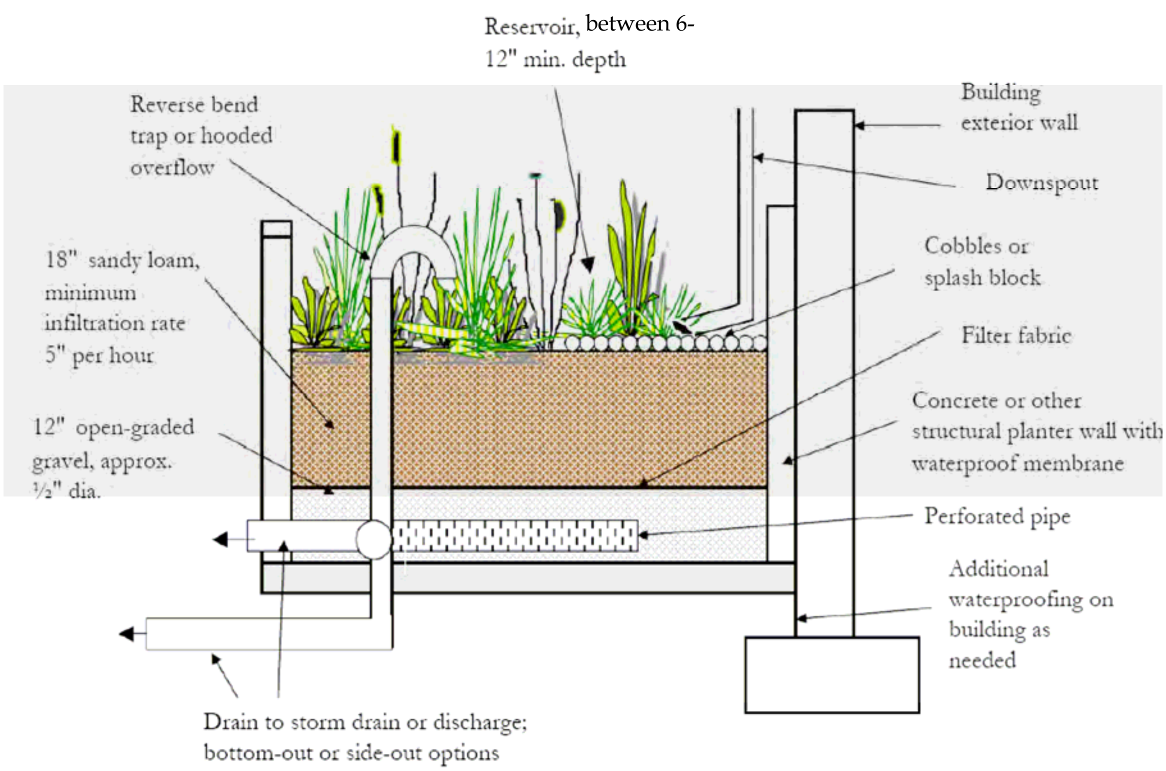
- Requires underdrain
- Requires sufficient head
- Careful selection of plants
- Requires level installation
- Requires irrigation

Flow-through planters are designed to treat and detain runoff without allowing seepage into the underlying soil. They can be used next to buildings and other locations where soil moisture is a potential concern. Flow-through planters typically receive runoff via downspouts leading from the roofs of adjacent buildings. However, flow-through planters can also be set level with the ground and receive sheet flow. Pollutants are removed as the runoff passes through the soil layer and is collected in an underlying layer of gravel or drain rock. A perforated pipe underdrain must be directed to a storm drain or other discharge point. An overflow inlet conveys flows that exceed the capacity of the planter.

Design and Sizing Guidelines

- Infiltration planters shall be designed with a 4% sizing factor (surface area of planter/surface area of tributary impervious area). A loamy sand with a minimum infiltration rate of 5"/hour is required. The ratio is for planning review and is from 0.2 inches of rainfall per hour inflow versus 5 "/hour infiltration rate.
- Plantings should be selected for viability in a well-drained soil. Irrigation is required to maintain plant viability.
- Planting surface shall be level.
- Install an overflow weir adequate to meet municipal drainage requirements.
- Between 6 and 12 inches of storage shall be between planting surface and crest of overflow weir.

- 18-inch thick loamy sand with minimum infiltration rate of 5-10 inches/hour. Similar to bioretention 6 inches of planting soil will be placed at the surface for plant growth. Plant in two stages to ensure plants are viable for biotic uptake.
- 12-inch thick layer of ½ inch pea gravel or crushed rock.
- Perforated pipe underdrain with cleanouts and connection to storm drain or discharge point.
- Adequate fall from underdrain to storm drain or discharge point.
- Waterproofing as required to protect building foundations or for the groundwater table.
- Splash blocks or cobbles at downspouts and inlet pipes.
- Provide adequate irrigation to keep vegetation viable.
- Can be used adjacent to building and within set back area.
- Can be used above or below grade.
- Install filter fabric between soil and gravel underdrain and around perforated pipe.
- Size overflow trap for building code design storm, set trap below top of planter box.
- Planter wall set against building should be higher to avoid overflow against building.
- Sizing calculation is area of impervious surface multiplied by 0.04 sizing factor will equal the footprint of the flow-through planter.



Side View. Adapted from the City of Portland 2004 Stormwater Manual

Maintenance

- Maintain vegetation and irrigation system; inspect periodically and after storms to ensure structural integrity and that planter has not clogged.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

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6.6 Bioretention Area

Source: California BMP Handbook (CASQA, 2003)

Bioretention areas function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through the buffer strip and is subsequently distributed evenly along a ponding area. Percolation of stored water in the bioretention area's planting soil will enter the underdrain, so that the bioretention area empties over two days.

Best uses

- Any type of development
- Drainage area up to 2 acres
- Landscape design element

Advantages

- Detains low flows
- Landscape feature
- Low maintenance
- Reliable once established

Limitations

- Not appropriate for
  - Slopes greater than 5%
  - High water tables
  - Where soil is unstable
- Requires irrigation
- Susceptible to clogging – especially if installed prior to construction site soil stabilization.

Design and Sizing Guidelines

- The bioretention area shall be sized to 4% of the impervious surfaces on the project site. The ratio is for planning review and is from 0.2 inches of rainfall per hour inflow versus 5 inches/hour infiltration rate.
- Bioretention area's planting soil shall have a minimum percolation rate of 5 inches/hour and a maximum percolation rate of 10 inches/hour. If native soils do not meet this percolation requirement, an admixture shall be mixed into planting soil to allow for a 5-inch/hour percolation rate. In-situ testing shall be conducted to verify that the material meets the percolation requirements.
- The bioretention area shall be sized to either:
  - Percolate the design treatment flow using a rate of 5 inches per hour. No additional allowance is provided for storage or for infiltration rates in excess of 5 inches per hour; or,
  - Store the 24-hour treatment volume, with a reduction of 1 inch per hour infiltration throughout the 24-hour time period.
- Bioretention areas shall have a vegetation layer with a 3-inch layer of non-pine mulch or grasses provided in areas between plantings. Shrubs and small trees shall be placed to

anchor the bioretention area cover. Irrigation shall be provided to maintain plant life in the bioretention area.

- Where there is a positive surface overflow, bioretention areas shall have freeboard of at least 0.2 feet to the lowest structural member versus the 100-year storm water level in the bioretention area.
- Where the bioretention area is in a sump that depends on outflow through a catch basin, the bioretention area shall have a freeboard of at least 0.5 feet to the lowest building finished floor elevation (including garage and excluding crawl space) for conditions with the outlet 50 percent clogged. Where the freeboard cannot be provided, emergency pumps may be allowed on a case-by-case basis.
- Beneath the planting soil, a layer of sand/ loam, up to 2.5' deep, stores treated runoff before it seeps into native soil or underdrain.
- Surface ponding depths should vary, with a maximum depth of 12 inches.
- Plant species should be suitable to well-drained soil and occasional inundation. See planting guidance in Appendix B.
- The inlet to the overflow catch basin shall be at least 6-inches above the low point of the bioretention planting area.
  - The bioretention area shall have a minimum surface slope of 1 percent to local low points.
  - Only areas at least 2 inches below the overflow catch basin elevation shall be considered in the surface area of the bioretention basin.
- An underdrain system and liner shall be provided for the bioretention area except when percolation tests show that the native percolation rate is greater than 5 inches per hour and the depth to groundwater is greater than 10 feet from the surface of the bioretention area.
- One tree shall be provided per 50 square feet of planting area. If larger trees are selected, plant them at the periphery of bioretention area.
- A liner of concrete or impermeable fabric shall be used to limit groundwater contamination of a high water table.

Design Checklist for Bioretention

- Set back from structures 10' or as required by structural or geotechnical engineer.
- Surface area of planter shall be at least 4% of tributary impervious area.
- Tributary impervious area does not exceed 2 acres.
- Tributary area shall not contain a significant source of soil erosion, such as high velocity flows or high slopes.
- 50-foot minimum setback from, and no connection to, any on-site septic system or leach field.
- The surface area of the bioretention area shall be less than 5%. Sloped areas immediately adjacent to the bioretention area are less than 20% - but greater than 0.5% for pavement and greater than 1% for vegetated areas.
- Side slopes do not exceed 2:1; downstream slope for overflow shall not exceed 3:1.
- Inlets are protected with rock s, cobbles or splash blocks. Curb cuts have 12" minimum width.
- Overflow inlet can safely convey design flood flows to a downstream storm drain or discharge point.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

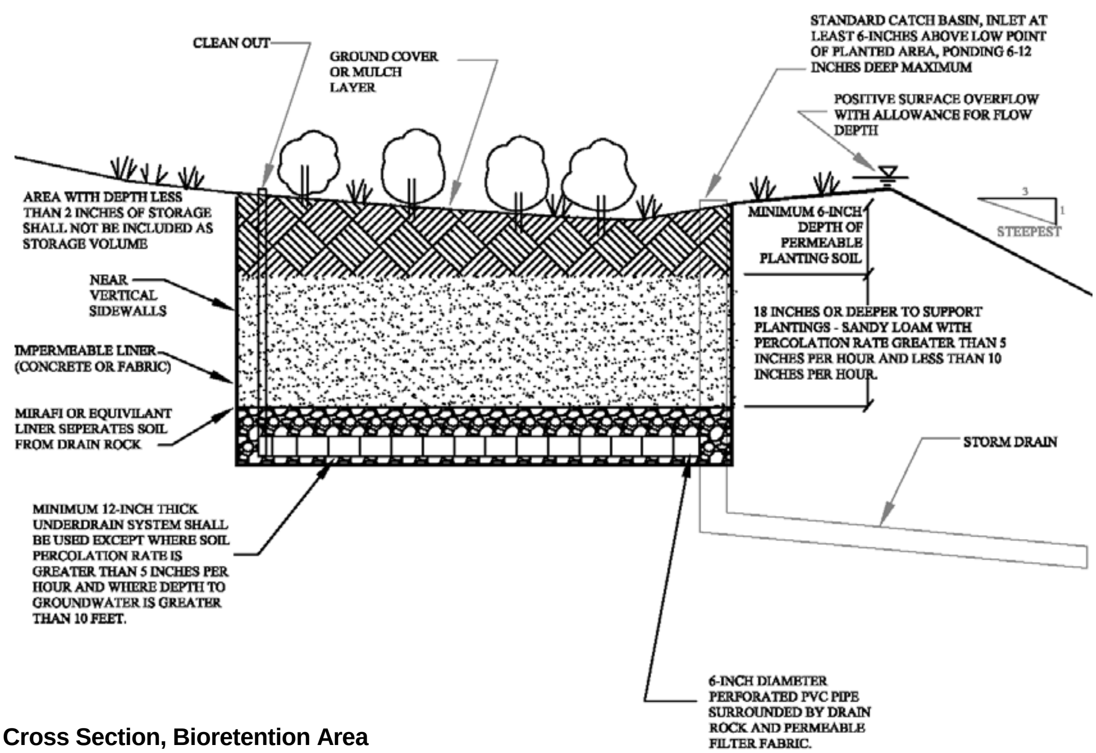
- Filter fabric between soil and gravel layers.
- Underdrain has a clean-out consisting of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 6 inches and a watertight cap fit flush with the ground.
- When excavating, avoid spreading fines of the soils on bottom and side slopes.
- Minimum compaction of native soils. Protect the area from construction site runoff.

Soil Considerations

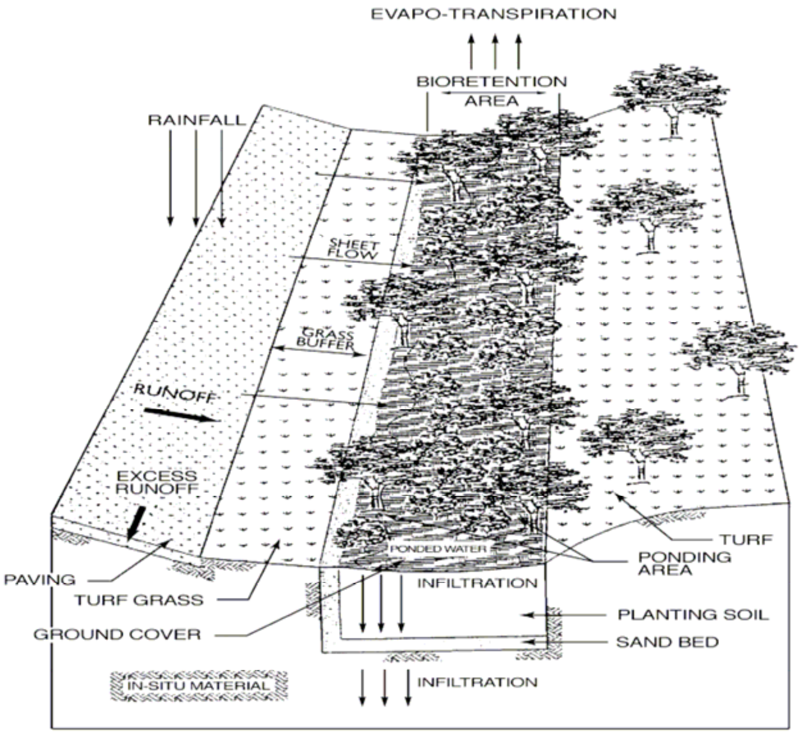
- If import soil is used, it shall have the following properties for loamy sand. A typical soil mix comprises 85% construction sand, 10% topsoil with less than 5% maximum clay content and 5% organic leaf compost. A 6-inch layer of planting soil will be placed above loamy sand soil to allow for plant growth.

MAINTENANCE

- Bioretention areas shall be inspected monthly for:
  - Obstructions and trash.
  - Ponded water. If ponded water is observed, the surface soils shall be removed and replaced with sand.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Soils and plantings must be maintained, including routine pruning, replenishment of mulch, and weeding.
- Erosion at inflow points must be repaired.



Cross Section, Bioretention Area



Source: PGDER, 1993

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6.7 Infiltration Trench

Source: CASQA, 2003

Best Uses

- Limited space
- Adjacent to roadways
- Landscape buffers
- A landscape design element

Advantages

- Increases groundwater recharge
- Removes suspended solids
- Used with other BMPs
- No surface outfalls
- Aesthetic and unobtrusive

Limitations

- Fails with no maintenance
- Stable soils must be used
- No high water tables
- No type C and D soils
- No steep slopes

An infiltration trench is a long, narrow, excavated trench backfilled with a stone aggregate, and lined with a filter fabric. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench, which can clog and render the trench ineffective. Infiltration practices, such as infiltration trenches, remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from stormwater runoff. The infiltration trench treats the design volume of runoff either underground or at grade. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils. Infiltration trenches also provide groundwater recharge and preserve base flow in nearby streams.

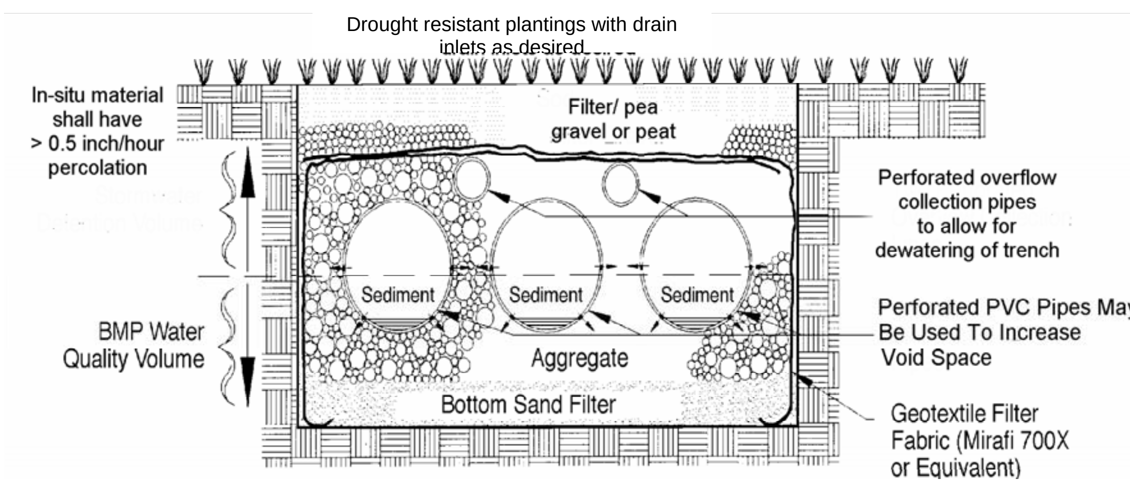
Design and Sizing Guidelines

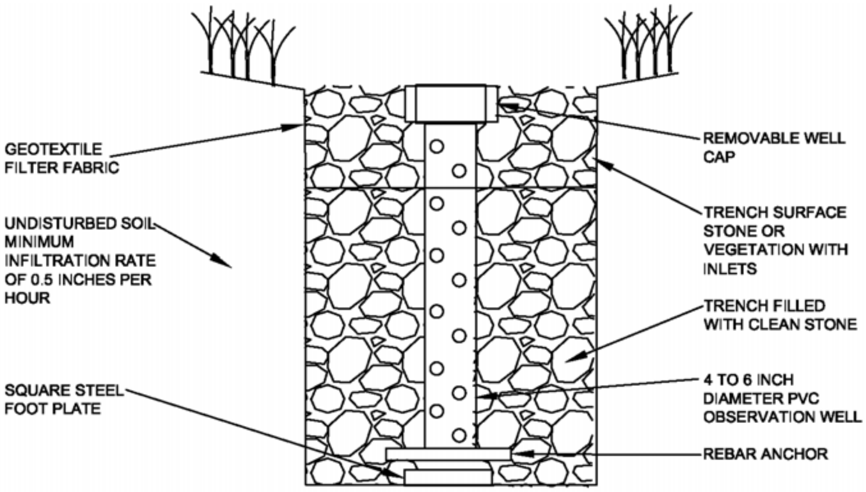
- The infiltration trench shall be sized to store the full 48-hour water quality volume.
- In-situ / undisturbed soils shall have a low silt and clay content and have percolation rates greater than 0.5 inches per hour. Acceptable soil texture classes include sand, loamy sand, sandy loam and loam. These soils are within the A or B hydrologic group. Soils in the C or D hydrologic groups shall be avoided. In-situ testing is required to confirm percolation rate of trench site.
- There shall be at least 10 feet below the trench to the water table to prevent potential ground water problems. Trenches shall also be located at least 100 feet upgradient from water supply wells. A set back of 100 feet from building foundations is recommended unless shorter is approved by geotechnical engineer and local standards.
- When the drainage area exceeds 5 acres, other treatment measures shall be considered.
- The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. Runoff from unstabilized areas shall be diverted away from the trench into a construction period sedimentation control BMP until vegetation is established.

- Infiltration trenches work best when the upgradient drainage area slope is less than 5 percent. The downgradient slope shall be no greater than 20 percent to minimize slope failure and seepage.
- The trench surface may consist of stone or vegetation with inlets to evenly distribute the runoff entering the trench. Runoff can be captured by depressing the trench surface or by placing a berm at the down gradient side of the trench. The basic infiltration trench design utilizes stone aggregate in the top of the trench to promote filtration; however, this design can be modified by substituting pea gravel for stone aggregate in the top 1-foot of the trench. Typically, there is about 35 to 40% void space within the rock.
- Use trench rock that is 1.5 to 2.5 inches in diameter or pea gravel to improve sediment filtering and maximize the pollutant removal in the top 1 foot of the trench.
- Infiltration trenches can also be modified by adding a layer of organic material (peat) or loam to the trench subsoil. This modification enhances the removal of metals and nutrients through adsorption. The modified trenches are then covered with a permeable geotextile membrane overlain with topsoil and grass or stones.
- A vegetated buffer strip at least 5-feet wide, swale or detention basin shall be established adjacent to the infiltration trench to capture large sediment particles in the runoff. If a buffer strip or swale is used, installation should occur immediately after trench construction using sod instead of hydroseeding. The buffer strip shall be graded with a slope between 0.5 and 15 percent so that runoff enters the trench as sheet flow. The vegetated swale or detention basin shall be sized according to Sections 6.1 and 6.8 respectively.
- If runoff is piped or channeled to the trench, a level spreader shall be installed to create sheet flow.
- Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Place permeable filter fabric around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric shall overlap each side of the trench in order to cover the top of the stone aggregate layer. The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate. Filter fabric that is placed 1 foot below the trench surface will maximize pollutant removal within the top layer of the trench and decrease the pollutant loading to the trench bottom, reducing frequency of maintenance.
- The required trench volume can be determined by several methods. One method calculates the removed volume based on capture of the treatment event, which is defined in Table 5-1 in Chapter 5. Trench depths are usually between 3 and 8 feet, with a depth of 8 feet most commonly used.
- A site-specific trench depth can be calculated based on the soil infiltration rate, aggregate void space, and the trench storage time. The stone aggregate used in the trench is normally 1.5 to 2.5 inches in diameter, which provides a void space of 35 to 40 percent. A minimum drainage time of 6 hours shall be provided to ensure satisfactory pollutant removal in the infiltration trench. Trenches may be designed to provide temporary storage of storm water.
- The infiltration trench shall drain within 5 days to avoid vector generation.
- An observation well is recommended to monitor water levels in the trench. The well can be 4 to 6-inch diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench.

MAINTENANCE

- A maintenance agreement shall be provided.
- The maintenance agreement shall state the parties' responsibility for maintenance and upkeep.
- Routine inspection and maintenance shall be designed into the life performance of the facility. Maintenance shall be performed as indicated by these routine inspections. The principal maintenance objective is to prevent clogging, which may lead to trench failure.
- Infiltration trenches shall be inspected after large storm events and any accumulated debris or material removed. A more thorough inspection of the trench shall be conducted annually. Annual inspection shall include monitoring of the observation well to confirm that the trench is draining within the specified time.
- Trenches with filter fabric shall be inspected for sediment deposits by removing a small section of the top layer.
- If inspection indicates that the trench is partially or completely clogged, it shall be restored to its design condition.
- Trash, grass clippings and other debris shall be removed from the trench perimeter and be disposed properly. Trees and other large vegetation adjacent to the trench shall also be removed to prevent damage to the trench.





Observation Well Detail: Infiltration Trench

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6.8 Extended Detention Basin

Source: California BMP Handbook (CASQA, 2003)

Best uses

- Detain low flows
- Can be expanded to detain peak flows
- Sedimentation of suspended solids
- Sites larger than 5 acres

Advantages

- Easy to operate
- Inexpensive to construct
- Treatment of particulates
- Low maintenance

Limitations

- Storage area available
- Moderate pollutant removal

Extended detention ponds (a.k.a. dry ponds, dry extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a permanent pool. They can also be used to provide flood control by including additional flood detention storage above the treatment storage area.

Design and Sizing Guidelines

- Extended detention basins shall be sized to capture the required water quality volume over a 48-hour period. At least 10 percent additional storage shall be provided to account for storage lost to deposited sediment.
- The outlet shall be sized with a drawdown time of 48 hours for the design water quality volume. The outlet shall have two orifices at the same elevation sized using the following equation:

$$a = (7x10^{-5}) * A * (H\text{-}Ho)^{.5} \; / \; CT$$

Where:

a = area of each orifice in square feet
A = surface area of constructed wetlands at mid-treatment storage elevation (square feet)
H = elevation of basin when filled by water treatment volume (feet)
Ho = final elevation of basin when empty (bottom of lowest orifice) (feet)
C = orifice coefficient (0.6 typical for drilled orifice)
T = drawdown time of full basin (hours)
(Caltrans Method, Appendix B, Stormwater Quality Handbook, September 2002)

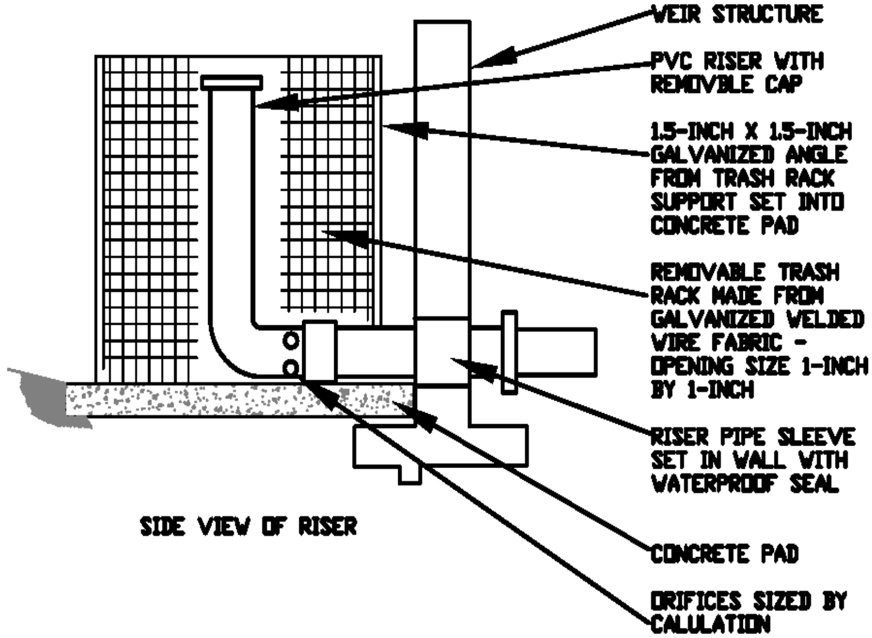
- The orifices shall each be a minimum diameter of 1 inch. Extended detention basins are not practical for small drainage areas because the minimum orifice diameter cannot be met. Each orifice shall be protected from clogging using a screen with a minimum surface area of 50 times the surface area of the openings to a height of at least 6 times the diameter. The screen shall protect the orifice openings from runoff on all exposed sides.
- Extended detention basin shall have no greater than 3:1 side slopes.
- The optimal basin depth is between 2 and 5 feet.
- If planting of the extended detention basin is not completed by October 1st, a 1-year biodegradable loose weave geofabric shall be installed on exposed side slopes to anchor soils. If vegetation is not established by October 15th, sod or an equivalent measure shall be placed where disturbed soils are present.
- A safety bench shall be added to the perimeter of the basin wall for maintenance when basin is full.
- Piping into the extended detention basin shall have erosion protection. The inlet pipe shall have at least 1 foot of clearance to the pond bottom. As a minimum, a forebay with a 6-inch thick layer of Caltrans Section 72, Class 2 rock slope protection shall be placed at and below the inlet to the extent necessary for erosion protection. For each outlet, documentation shall be provided regarding adequacy of outlet protection, and a larger stone size may be necessary depending on the slope and the diameter of the outfall.
- Extended detention basin shall empty within five days of the end of a 6-hour, 100-year storm event to avoid vector generation.
- Irrigation of the extended detention basin is recommended, depending on the requirements of the specified vegetation.
- A 12-foot wide maintenance ramp leading to the bottom of the basin and a 12-foot wide perimeter access road shall be provided. If not paved, the ramp shall have a maximum slope of 5 percent. If paved, the ramp may slope 12 percent.
- The extended detention basin shall have a length to width ratio of at least 1.5:1.
- If the groundwater level is within 10 feet of the ground surface, a liner shall be provided.
- A fixed vertical sediment depth marker shall be installed in the sedimentation forebay. The depth marker shall have a marking showing the depth where sediment removal is required. The marking shall be at a depth where the remaining storage equals the design water quality volume.
- The detention basin is a volume-based treatment measure and requires detention time to be effective. The basin shall not empty more than 50% of its treatment volume in less than 24 hours to ensure treatment of runoff.
- A Maintenance Agreement shall be provided as required by the municipality. The Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep and allow access by mosquito abatement personnel.

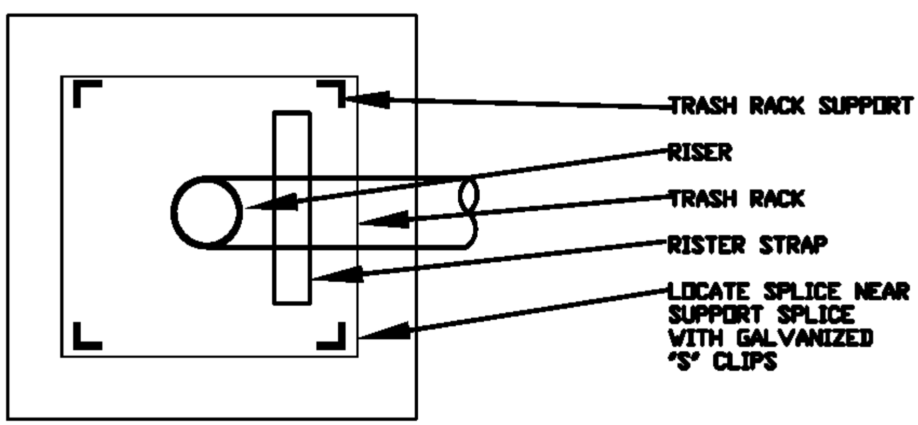
MAINTENANCE

The maintenance plan shall include the following provisions:

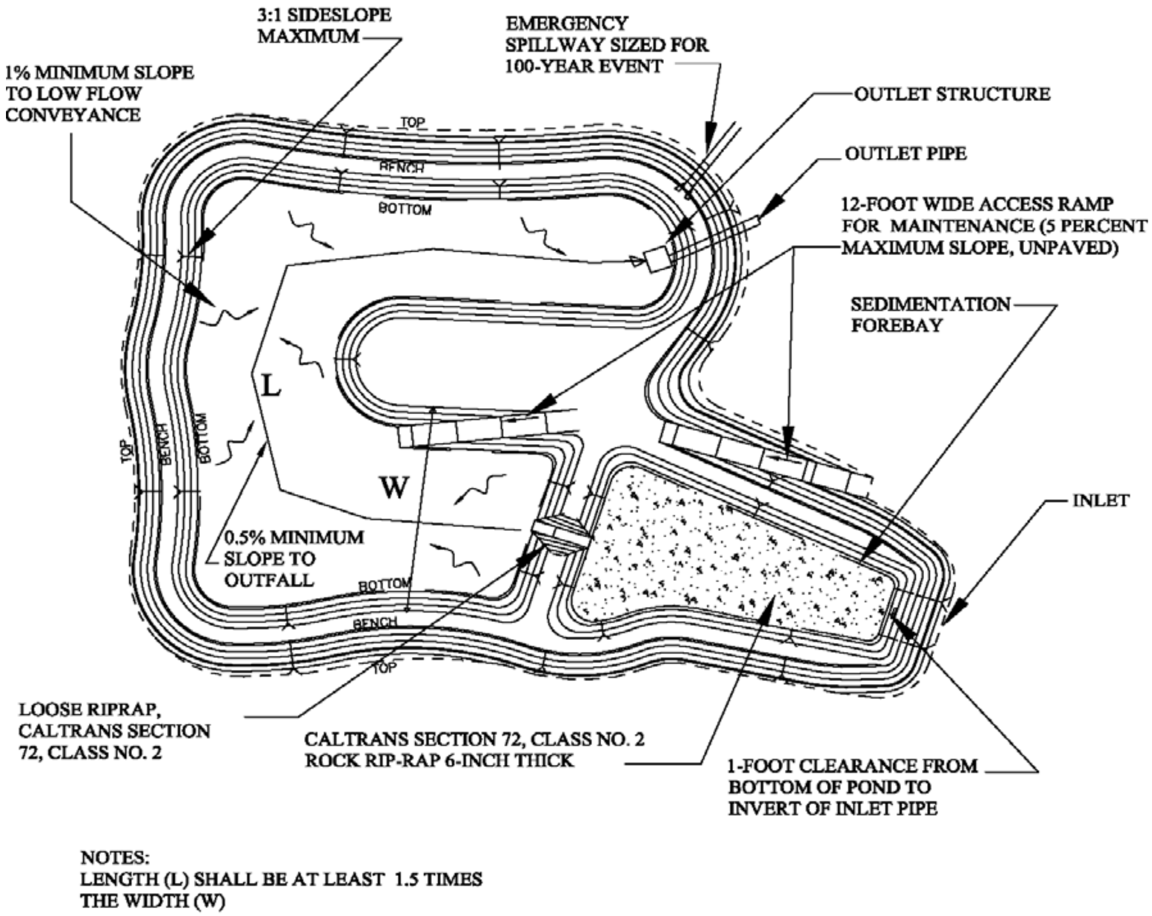
- Vegetation shall be harvested annually during the summer.
- The structural integrity of the outlet and berms shall be inspected semiannually.
- Accumulated trash and debris shall be removed from the extended detention basin at the middle and end of the wet season. (January and April).
- Remove sediment from the forebay when the sediment level reaches the level shown on the fixed vertical sediment marker.

- Pesticides and fertilizers shall not be used in the extended detention basin.





Top View of Riser
(Square Design)



Plan View, Typical Extended Detention Basin

Chapter

7

Hydromodification Management Measures

This Chapter summarizes the requirements for reducing erosive flows from development projects.

7.1 Summary of HM Requirements

Changes in the timing and volume of runoff from a site are known as “hydrograph modification” or “hydromodification”. When a site is developed, much of the rainwater can no longer infiltrate into the soils, so it flows offsite at ***faster rates and greater volumes***. As a result, erosive levels of flow occur more frequently and for longer periods of time in creeks and channels downstream of the project. Hydrograph modification is illustrated in Figure 7-1, which shows the stormwater peak discharges after rainstorms in an urban watershed (the red, or dark, line) and a less developed (the yellow, or light, line). The axes indicate the volume of water discharged, and the time over which it is discharged.

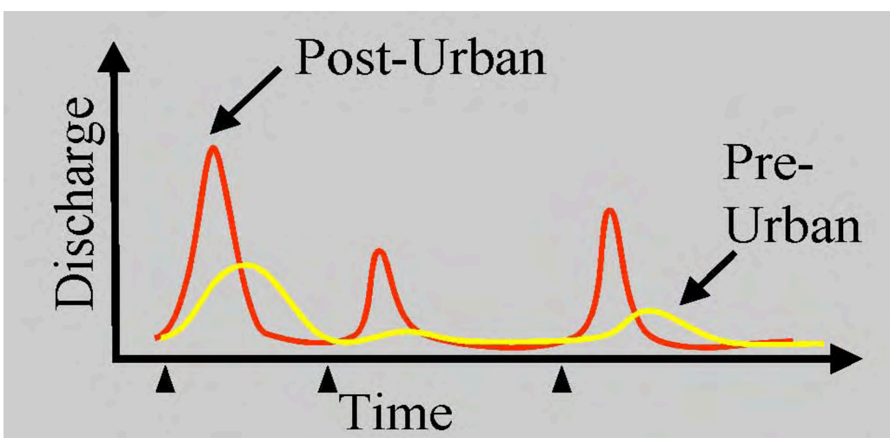


Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

In watersheds with large amounts of impervious surface, the larger volumes, faster rates and extended durations of discharge often cause natural creeks or earthen channels to erode, as the channel enlarges in response to the increased flows. Problems from this additional erosion often include property damage, degradation of stream habitat and loss of water quality, and have not been addressed by traditional detention designs. Figures 7-2 and 7-3 illustrate the effect of increasing urbanization on stormwater volumes.

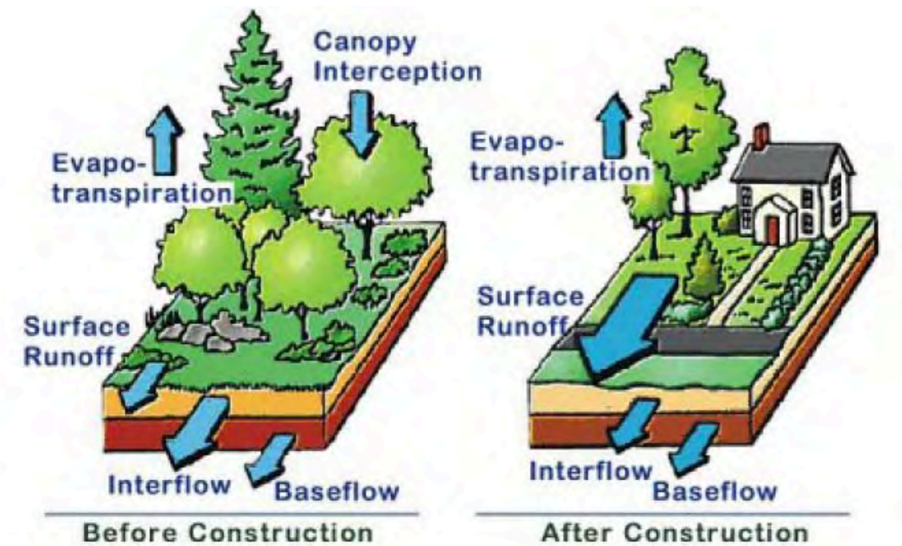


Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

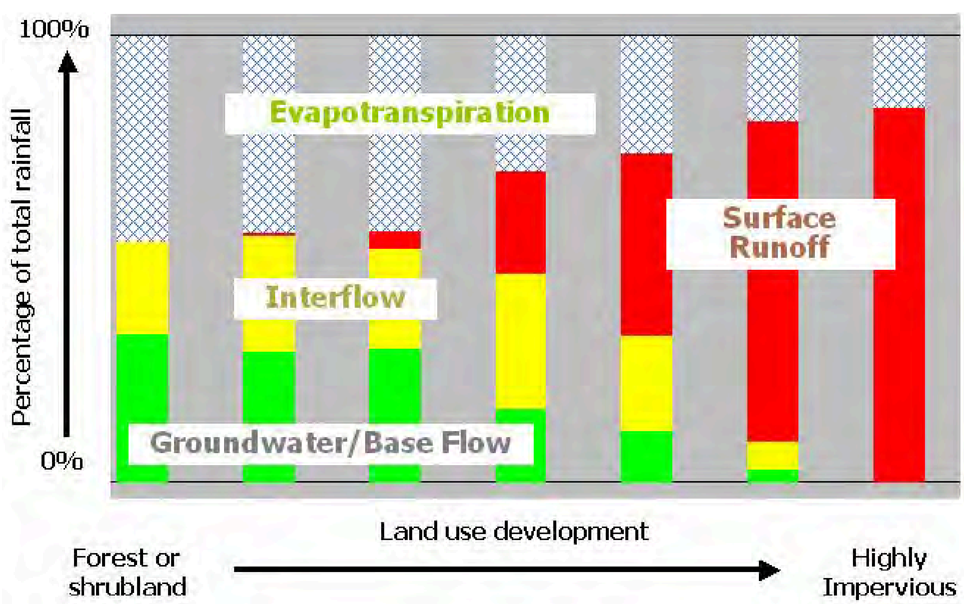


Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek Solutions.)

The Water Board required ACCWP to prepare a ***Hydrograph Modification Management Plan (HMP)*** in order to reduce erosive flows that result from increasing impervious surfaces in the watersheds of natural creeks. The HMP includes a simple (default) map-based approach for determining which parts of the drainage network are susceptible to hydromodification impacts. Projects that meet certain criteria, and from which runoff passes through the susceptible areas, will be required to incorporate one or more hydromodification management (HM) measures in the design in order to reduce erosive flows from a wide range of runoff conditions. ***Flow Duration Control*** for frequent, small runoff events (with average occurrence ranging from less than two-years to approximately ten-years), is especially critical. The HMP also describes procedures for assessing the potential impacts of development-related hydrograph changes in a specific section of a watercourse.

> Flow Duration Control looks at the full range of flows in a simulated long-term history, and is ***not directly comparable*** to approaches based on one or a few synthetic "design storms".

Before it can be implemented, ACCWP's HMP must be approved by the Water Board. Full implementation of the HMP will be required upon approval. You can view the latest HMP on ACCWPs website, by checking links at http://www.cleanwaterprogram.org/businesses_developers.htm. Please note that details of the HMP are ***subject to change*** in the process of gaining approval by the Water Board. Although implementation of the HMP is not yet required, the Water Board has encouraged early implementation based on the version submitted by ACCWP.

7.2 Determining Applicability

Unless it is listed as exempt in Table 7-1, your project will be required to comply with the HMP if it meets the following applicability criteria:

- The project creates one acre or more of new impervious surface.
- The project is located in a susceptible area, as shown on the default susceptibility map.

Appendix J shows a schematic view of a portion of the draft hydromodification susceptibility map. The final version of this map will be available for download from the ACCWP website in an interactive format that enables zooming to a closer view of the project vicinity with local streets. Note that project sites draining to earthen flood control channels are not automatically exempt from HMP requirements.

Table 7-1
Projects Exempt from HMP Requirements

1	The construction of a single-family residence that is not part of a larger plan of development
2	A redevelopment project that does not increase the amount of impervious surface and the time of concentration of stormwater runoff
3	A transit type of development within ¼ to ½ mile of a transit station and/or intermodal facility
4	A project within a "Redevelopment Project Area" that redevelops an existing brownfield site or creates housing units affordable to persons of low or moderate income.

Please note that projects located in susceptible areas should include hydrologic source control measures for HM if they are likely to cause hydrograph changes, ***even if they do not meet the other applicability criteria.***

7.3 Hydromodification Management (HM) Measures

Hydromodification management (HM) measures can be grouped into three types:

- ***Site planning and hydrologic source control measures*** which are generally distributed throughout a project site. These types of measures minimize hydrological changes caused by development beginning with the point where rainfall initially meets the ground. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention, many of which also serve as pollution source controls.
- ***On-site structural HM measures*** that manage excess runoff from the site after hydrologic source control measures are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes from stormwater collected in pipes and channels before the runoff is discharged to a natural channel that could suffer adverse effects. Examples include extended detention basins, wet ponds and constructed wetlands. Please note that there is a difference between the design approach for sizing measures remove pollutants from stormwater and the approach for designing HM measures to prevent an increase in the potential for creek bank erosion. The treatment of stormwater pollutants targets capture of 80% of average runoff volume, which means that treatment measures will be bypassed every one to two years. Structural HM measures must be sized to control the statistical duration of a wide range of flow levels under simulated runoff conditions. Depending on pre-project and post project conditions, the required detention volume is ***likely to be greater*** than the capture volume required for treatment

> Structural HM measures must be sized to control the flow and duration of stormwater runoff according to a ***Flow Duration Control*** standard, which is often greater than size requirements for volume-based treatment.

- ***In-stream or restorative measures*** that modify susceptible watercourses to withstand projected increases in runoff flows and durations without increasing erosion or other impacts to beneficial uses. In-stream measures are more complicated to use than the hydrologic source control and end-of-pipe measures, and are best suited for creeks or channels that have ***already received impacts*** from previous development and have only localized channel instability. Examples include biostabilization techniques using roots of live vegetation roots to stabilize banks and localized structural measures such as rock weirs, boulder clusters or deflectors. These measures will not automatically provide HM protection for channel reaches farther downstream and may require longer planning timelines and cooperation among multiple jurisdictions compared to on-site measures.

7.4 Requirements for Hydromodification Management

For projects subject to HMP requirements, consider HM at every stage of project development and incorporate the step-by-step instructions for C.3 submittals, provided in Chapter 3. The most effective use of land and resources may require combining measures from all three categories described above. In general, the strategy for designing HM measures should :

- ***Start with site design*** to minimize the amount of runoff to be managed (see Plannning Steps 2 & 3 in Chapter 3).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration is limited by site constraints such as slope stability concerns, low-permeability soils or groundwater protection constraints.
- Use ***structural HM measures*** to detain the remaining calculated runoff from the site enough to ***control its release*** in a way that meets the remaining runoff design requirements. This may be accomplished with a measure that also provides volume-based treatment, such as an extended detention basin. For some project locations, off-site options may be available to reduce or eliminate the need for onsite detention.

7.4.1 Flow Duration Control

Flow Duration Control (FDC) differs from traditional "design storm" approaches used to design detention facilities for flood control or water quality treatment. Instead of specifying static holding times for one or a few discrete events, the Flow Duration standard manages runoff discharge over the full range of runoff flow levels predicted through continuous hydrologic simulation modeling, based on a long-term precipitation record. Flow Duration Control requires that the increase in surface runoff resulting from new impervious surfaces be ***retained on-site with gradual discharge*** either to groundwater through infiltration, losses by evapotranspiration, and/or discharge to the downstream watercourse at a level below the critical flow that causes creek channel erosion. ***Critical flow,*** or Qc***,*** is the lower threshold of in-stream flows that contribute to sediment erosion and sediment transport or effective work. The duration of channel flows below Qc may be increased indefinitely without significant contribution to hydromodification impacts.

> The duration of channel flows below the ***"critical flow"*** may be increased indefinitely without significant contribution to hydromodification impacts.

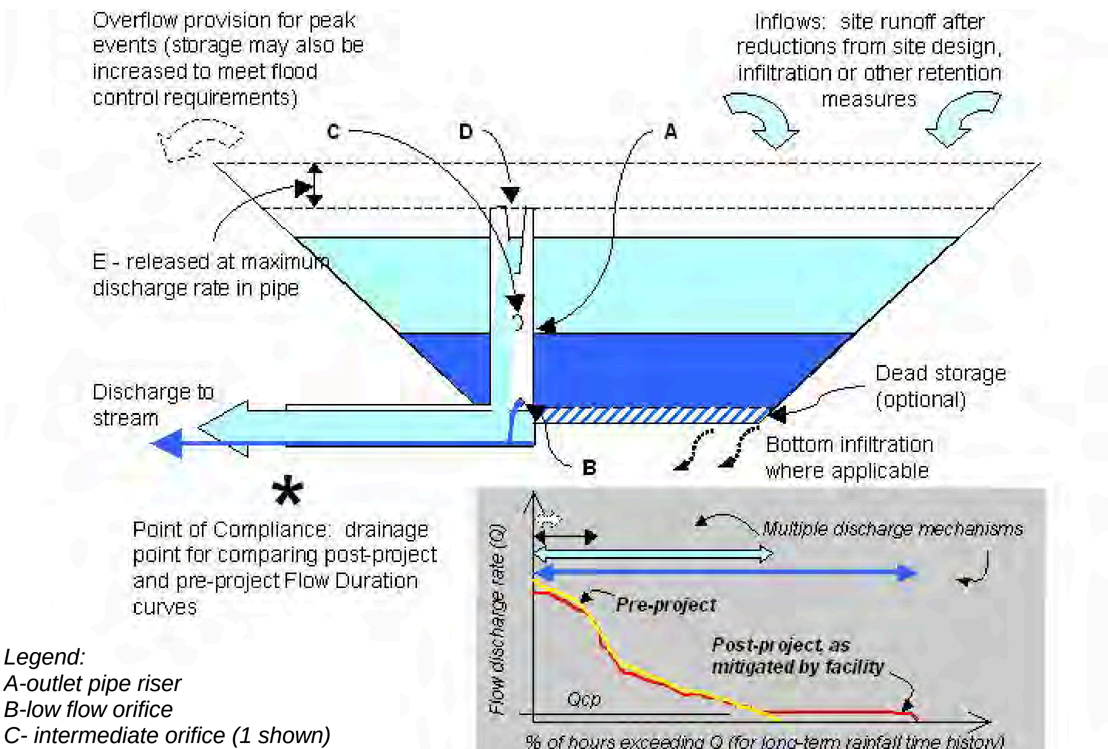
7.4.2 Application of Flow Duration Control to Project Areas

The Flow Duration approach involves a continuous model that applies a time series of at least 20 years of rainfall records to a watershed area or project site to generate a simulated stormwater runoff record based on two sets of inputs, one representing future development and the other representing pre-project conditions. The 20-year precipitation record is the minimum length necessary to capture the range of runoff conditions that are cumulatively responsible for most of the erosion and sediment transport in the watershed, primarily flow levels that would recur at average intervals of 10 years or less in the pre-project condition. The design objective is to preserve the pre-project cumulative frequency distribution of flow durations and sizes under post-project flows. This is done with a combination of site design, infiltration and detention. Typically the post-project increase in surface runoff volume is routed through a ***flow duration control pond*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4).

The flow duration basin, tank or vault is designed conceptually to incorporate multiple pools that are filled with different frequencies and discharge at different rates. The low-flow pool is the bottom level designed to capture and retain small to moderate size storms, the initial portions of larger storms, and dry weather flows. These flows are discharged through the lowest orifice which allows continuous ***discharge below the critical flow rate*** for a project (Qcp). Successively higher-flow pools store and release higher but less frequent flows through other orifices or graded weir notches to approximate the pre-project runoff durations. In practice the multiple pools are usually integrated into a single detention basin, tank or vault that works as a unit with the specialized outlet structure. Matching the pre-project flow durations is achieved through fine-tuning of the number, heights and dimensions of orifices or weir notches, as well as depth and volume of the basin, tank or vault.

> Flow Duration facilities are subject to ***Operations and Maintenance*** reporting and verification requirements similar to those for numerically sized treatment measures.

As shown in the example chart of Figure 7-4, the post-project flow duration curve (red, or dark line) is reduced by the facility to remain ***at or below the pre-project curve*** (yellow, or light line), except for flows less than Qcp. Minor exceedances are permissible at a limited number of higher flows since at other flow levels the post-project duration is actually less than the pre-project condition.



Legend:
A-outlet pipe riser
B-low flow orifice
C- intermediate orifice (1 shown)
D-weir notch (V-type shown)
E-freeboard above riser (typically 1 foot)

Figure 7-4: Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume.

If feasible, ***combining flow duration and water quality treatment*** into a single facility reduces the overall land requirements for stormwater management. ***Adequate maintenance*** of the low-flow orifice or notch is critical to proper performance. The outlet may be in a protective enclosure to reduce risk of clogging. Please note that Flow Duration facilities are subject to Operations and Maintenance verification requirements similar to those for numerically sized treatment measures.

7.4.3 Bay Area Hydrology Model (BAHM)

To facilitate the simulation modeling aspect of FDC for project proponents and their engineers, ACCWP is working with the Santa Clara and San Mateo Counties' stormwater programs to develop a Bay Area Hydrology Model ***software package*** that is adapted from Version 3 of the Western Washington Hydrology Model (WWHM) developed by Clear Creek Solutions for the State of Washington Department of Ecology (WDOE). The WWHM was specifically developed to help engineers design facilities to meet a Flow Duration Control standard for development projects.

The BAHM will be provided for downloading from the Internet along with county-specific data, and it will include:

- Databases to automatically assign default ***rainfall conditions*** for a project location selected within the County boundary.
- A user interface for developing a ***schematic drainage model*** of the project site, with forms for entering areas of land use or impervious surface for multiple sub-basins.
- Continuous simulation modeling of ***pre-project and post-project runoff*** from the site using actual long-term rainfall records appropriately scaled for the project location.
- A design module for sizing a ***FDC detention facility*** and designing the discharge structure to meet the Flow Duration standard for matching post-project and pre-project duration-frequency curves. Pre-project and post-project runoff are compared at a "point of compliance" selected by the designer, usually near the point where runoff leaves the project area.
- Options to check facility sizing for ***volume-based treatment***, and incorporate runoff reductions attributable to some common hydrologic source control measures.
- Standardized output ***report files*** that can be saved in Word format, and include all information about data inputs, model runs, facility design, and summary of the hydrological statistics showing the compliance of post-project flow duration curves with the Flow Duration standard. Project input and output data can also be saved in Excel and other formats for other uses.

The BAHM currently exists in a beta test version for Alameda County and final release is scheduled for Fall 2006.

7.5 Area-Specific HM Provisions

Individual municipalities may have special policies or ordinances for creek protection applicable in all or part of their jurisdictions. ***Contact the municipal staff from your jurisdiction*** to identify any special local provisions that may encourage or affect specific forms of HM implementation. Examples of area-specific HM provisions can include:

> Individual municipalities may have special policies or ordinances for ***creek protection*** applicable in all or part of their jurisdictions.

- Watershed-based land-use planning measures, such as creek buffers, which may be incorporated in local General Plans, zoning codes or watercourse ordinances.
- Special permitting provisions for project design and review of projects on streamside properties.
- Specific plans for regional HM measures or in-stream restoration projects.
- Any Equivalent Limitation Protocols that may be proposed, in accordance with Provision C.3.f.vii of the municipal stormwater permit, as alternatives to the default HM requirements in specific jurisdictions or watersheds.

Chapter

8

Operation and Maintenance

This Chapter summarizes the operation and maintenance requirements for stormwater treatment and structural hydromodification management measures.

8.1 Summary of O&M Requirements

Maintenance is essential for assuring that stormwater treatment and structural hydromodification management (HM) measures continue to function effectively and do not cause flooding, provide habitat for mosquitoes, or otherwise become a nuisance. The maintenance requirements described in this chapter apply to stormwater treatment measures and structural HM measures included in your project. The operation and maintenance (O&M) process can be organized into five phases, as described below:

- Determining ownership and maintenance responsibility,
- Identifying maintenance requirements when selecting treatment measures,
- Preparing the maintenance plan and other documentation,
- Executing a maintenance agreement or other maintenance assurance, and
- Ongoing inspections and maintenance.

O&M requirements for treatment also will ***apply to HM measures*** where and when they are implemented (including early implementation).

8.1.1. Responsibility for Maintenance

The responsibility for the maintenance of stormwater treatment and structural HM measures ***belongs to the project applicant and/or property owner*** unless other specific arrangements have been made. Ownership and maintenance responsibility for stormwater treatment measures and structural HM measures should be considered at the earliest stages of project planning, typically at the pre-application meeting with municipal staff. The municipal stormwater permit also requires that the project applicant provide a signed statement accepting responsibility for maintenance until this responsibility is legally transferred, as well as ensuring access to municipal, Water Board, and Alameda County Mosquito Abatement District or Vector Control District staff.

8.1.2 Considerations When Selecting Treatment Measures

CONSIDER OPERATION AND MAINTENANCE

When determining which types of treatment measures to incorporate into project plans, be mindful of how maintenance intensive they are. Study the operation manual for any manufactured, proprietary system. Treatment measures must be maintained so that they continue to treat stormwater runoff effectively ***throughout the life of the project*** and do not provide habitat for mosquito breeding. Adequate funds must be allocated to support long-term site maintenance. Manufactured, proprietary systems tend to clog easily and therefore require frequent maintenance to ensure that they operate as intended and do not hold standing water. A properly designed and established grassy swale, by contrast, may require little maintenance beyond periodic mowing.

The party responsible for maintenance will also be required to ***dispose of accumulated residuals properly.*** Residuals are defined as trash, oil and grease, filter media and fine sediments that are collected from treatment measures that may or may not be contaminated. At present, research generally indicates that residuals are not hazardous wastes and as such, after dewatering, property owners can generally disposed of residuals in the same way they would dispose of any uncontaminated soil.

The USEPA Fact Sheet titled Storm Water O&M Fact Sheet: Handling and Disposal of Residuals (www.epa.gov/npdes/pubs/handdisp.pdf) provides useful information to help property owners dispose of residuals properly. The fact sheet describes the properties of stormwater residuals, O&M requirements for specific types of treatment measures, key elements for a residual handling and disposal program, and specific information on residual disposal from case studies. Two landfills in Alameda County accept sediment ("soil"), contaminated or otherwise:

- Altamont Landfill and Resource Recovery, 1040 Altamont Pass Road, Livermore, (510) 430-8509
- Vasco Road Sanitary Landfill, 4001 N. Vasco Road, Livermore, (661) 257-3655.

Alternatively, property owners may choose to contract with the treatment device manufacturer to maintain their treatment measures. Services typically provided include inspection, maintenance, handling and disposal of all residuals.

> Except for treatment measures designed to hold permanent pools of standing water, treatment measures should ***drain completely within five days*** to suppress mosquito production.

CONTROL MOSQUITOES

When selecting and installing stormwater treatment devices, you will need to consider the various environmental, construction, and local factors that may influence mosquito breeding. With the exception of certain treatment measures designed to hold permanent pools of standing water, ***treatment measures should drain completely within five days*** to effectively suppress mosquito production. ACCWP has prepared a Vector Control Plan that includes mosquito control design guidance and maintenance guidance for treatment measures, which focus on mosquito control. This guidance is included in Appendix H.

CONSIDER ACCESS

The maintenance agreement for your project will need to guarantee access permission for local municipality staff, the Alameda County Mosquito Abatement District and Water Board staff to enter the property to verify that maintenance is being conducted in accordance with the maintenance plan, throughout the life of the project. Make sure stormwater treatment and structural HM measures are ***readily accessible to the inspectors***, and contact municipal staff to determine whether easements will be needed. Stormwater treatment and structural HM measures must also be accessible to equipment needed to maintain them. Maintenance needs vary by the type of treatment measure that is used. Review the maintenance requirements described in Section 8.2 to identify the accessibility needs for maintenance equipment. By nature, it is more difficult to provide adequate access for below-ground treatment measures than above-ground treatment measures.

8.1.3 Documentation Required with Permit Application

As part of the building permit application, project applicants typically need to prepare and submit the documents listed below. ***Check with the local jurisdiction*** for exact requirements.

- A legible conceptual plan of the site, clearly showing the locations of stormwater treatment measures. Letter-sized plans are preferred; legal-sized plans may be accepted.
- Detailed maintenance plan for stormwater treatment and structural HM measures, including inspection checklists, as appropriate.
- A standard treatment measure O&M report form, to be attached to a maintenance agreement, or other maintenance assurance.

Please note that requirements may vary from one jurisdiction to another. Ask the staff from the local municipality if there are any additional requirements. Appendix I includes templates to assist project applicants in preparing their standard treatment measure O&M report form and maintenance plan. Guidance on preparing these documents is provided in Section 8.2.

8.1.4 Maintenance Agreement or Other Maintenance Assurance

Where a property owner is responsible for maintenance, the property owner is required to enter into a maintenance agreement with the municipality to ensure long-term maintenance of treatment and structural HM measures. The agreement will be ***recorded against the property*** to run with the title of the land. Contact your local jurisdiction to obtain a copy of its standard maintenance agreement. The maintenance agreements require property owners to conduct maintenance inspections of all stormwater treatment measures, and – depending on the municipality – may require the annual submittal of a Standard Treatment Operation and Maintenance Inspection Report form.

For residential properties where the stormwater treatment measures are located within a common area that will be maintained by a homeowner's association, language regarding the responsibility for maintenance must be included in the project's conditions, covenants and restrictions (CC&Rs). Printed educational materials regarding on-site stormwater controls are typically required to be included with the first, and any subsequent, deed transfer. The educational materials typically include the following information:

- Explain the post-construction stormwater controls requirements;
- Provide information on what stormwater controls are present;
- Describe the need for maintenance;
- Explain how necessary maintenance can be performed; and
- For the initial deed transfer, describe the assistance that the project applicant can provide.

If stormwater treatment measures are proposed to be located in a public area for transfer to the municipality, these treatment measures must meet the design guidelines specified in Chapter 6 and shall remain the property owner's responsibility for maintenance until the treatment measures are accepted for transfer.

8.1.5 Ongoing Inspections and Maintenance

After the maintenance agreement is executed, or the municipality approves other maintenance assurance such as CC&Rs, the party responsible for maintenance begins to implement the maintenance plan. Inspection reports are submitted to the municipality as required by the maintenance agreement, or other maintenance assurance.

> The municipality, Water Board and Alameda County Mosquito Abatement District staff may conduct ***O&M verification inspections*** to make sure that treatment measures are maintained.

The municipality, Water Board and Alameda County Mosquito Abatement District may conduct ***operation and maintenance verification inspections*** to make sure that stormwater treatment measures are being maintained. In the event adequate maintenance is not conducted, the municipality will take necessary steps to restore the treatment measures to good working order. The property owner will be responsible for reimbursing the municipality for expenditures associated with restoring the treatment measures to good working order.

8.2 Preparing Maintenance-Related Documents

This section provides instructions for preparing the following documents that will typically be required as parts of the building permit application, if your project includes stormwater treatment measures and/or structural hydromodification management (HM) measures:

- A standard treatment measure O&M report form
- A maintenance plan, including a schedule of maintenance activities.

8.2.1 Standard Treatment Measure O&M Report Form

The municipality may require the property owner, or other responsible party, to submit an annual report summarizing the maintenance and inspections of treatment measures included in the project. To standardize and simplify the reporting process, the property owner submits a "Standard Treatment Measure O&M Report Form" with the building permit application, and the municipality includes the report form as an Exhibit to the maintenance agreement. After the agreement is executed, the property owner, or other responsible party, uses this form to prepare the annual report, which is typically submitted by December 31 of each calendar year.

When submitting the completed report form each year, the responsible party will typically be required to attach the inspection forms that were completed during that calendar year.

To help you prepare your Standard Treatment Measure O&M Report Form, a template is included in Appendix I. ***Check with the local jurisdiction*** for an electronic version of the template.

When using the template to prepare your report form, please insert project-specific information where you find highlighted prompts such as the following:

[[== insert name of property owner/responsible party ==]]

8.2.2 Maintenance Plan

The maintenance plan must be sufficiently detailed to demonstrate to the municipality that stormwater treatment measures and/or structural HM measures will receive ***adequate inspections and maintenance*** to continue functioning as designed over the life of the project. A maintenance plan typically includes the following elements:

- Contact information for the property owner or other responsible party.
- Project address and, if required, the Assessors Parcel Number and directions to the site.
- Identification of the number, type and location of all stormwater treatment/structural HM measures on the site.
- A list of specific, routine maintenance tasks that will be conducted, and the intervals at which they are conducted. (For example, "Inspect treatment measure once a month, using the attached checklist.")
- An inspection checklist, specific to the treatment/HM measure(s) included in your project, that indicates the items that will be reviewed during regular maintenance inspections. You will typically be required to submit completed inspection forms as part of the annual Stormwater Treatment Measure O&M Report, as described in Section 8.2.1.

The following materials are available to help you prepare your maintenance plan:

- A maintenance plan template is included in Appendix I. ***Check with the local jurisdiction*** for an electronic version of the template.
- A list of common maintenance concerns for the stormwater treatment measures for which technical guidance is provided in Chapter 6.

When preparing your Maintenance Plan, it is recommended that you use the ***treatment measure-specific maintenance information*** presented in this Section (Section 8.2).

When using the template to prepare your report form, please insert project-specific information where you find prompts such as the following: [[== insert name of property owner/responsible party ==]]. The template includes sample inspection checklists for vegetated swales and extended detention basins. If your project includes different treatment/HM measures, you will need to customize the inspection checklist. It is recommended that you use the ***treatment measure-specific maintenance information*** presented in the following paragraphs.

VEGETATED SWALES – COMMON MAINTENANCE CONCERNS:

The maintenance objectives for vegetated swales include keeping up the pollutant removal efficiency of the channel by maintaining a dense, healthy vegetated cover. The typical maintenance requirements as follow:

- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where 6-inch high grasses are used, the grass height should be at least 3 inches after mowing.
- Remove obstructions and trash from vegetated swale.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Inspect vegetated swales monthly, as described below:
  - Inspect for and remove obstructions and trash.
  - Confirm that any ponded flow drains within five days after a rainfall. If ponding lasts for more than five days, grading will be required to improve positive drainage.
  - Confirm that vegetation is healthy, dense, and in good condition.
- Inspect vegetated swale twice annually to check for erosion and sediment and debris accumulation. One inspection should occur at the end of the wet season in order to plan and schedule summer maintenance. The other inspection is recommended to occur after periods of heavy runoff.
- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 millimeters (3 inches) at any spot, or if it covers the vegetation.

Figure 8-1: Vegetated Swale in Livermore

VEGETATED BUFFER STRIPS – COMMON MAINTENANCE CONCERNS:

Vegetated buffer strips mainly require vegetation management. Typical maintenance requirements are as follow:

- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where six-inch high grasses are used, the grass height shall be at least three inches after mowing. Where mowed grasses are shown on the plans, the grass shall be mowed when the height exceeds three inches. Dispose of grass clippings properly.
- Remove obstructions and trash from the vegetated buffer strip.
- Conduct monthly inspections as follows:
  - Inspect vegetated buffer strip for and remove obstructions and trash,
  - Confirm that any ponded flow drains within five days after a rainfall event. If ponding is observed for longer than five days, grading is required to improve positive drainage.
  - Confirm that grasses are in good condition.
  - Identify and correct any erosion problems.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

Figure 8-2: Vegetated Buffer Strip (Source: California Stormwater Quality Association, 2003)

TREE WELL FILTERS – COMMON MAINTENANCE CONCERNS:

Some manufacturers require a maintenance agreement, under which the manufacturer conducts the maintenance. The following maintenance requirements are typical:

- Conduct a biannual (twice yearly) evaluation of the health of trees and any ground cover. Remove any dead, dying, or missing vegetation.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed as needed to keep the tree well filter neat and orderly in appearance. Clean up fallen leaves or debris.
- Before the wet season begins, check that the media is at the appropriate depth. Remove any accumulations of sediment, litter, and debris. Confirm that the tree well filter is not clogging and will drain per design specifications. Till or replace the media as necessary.
- Inspect tree well filter periodically, and after storms, to ensure that it has not clogged.
- Periodically inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Repair or replace any damaged or disconnected piping.

Figure 8-3: Non-proprietary tree well filter (Source: University of New Hampshire)

MEDIA FILTERS – COMMON MAINTENANCE CONCERNS:

Clogging is the primary maintenance concern for media filters, although mosquito control is also an issue. Typical maintenance requirements are as follows:

- During the wet season, inspect periodically for standing water, sediment, trash and debris, and to identify potential problems.
- Remove accumulated trash and debris in the sedimentation basin, from the riser pipe, and the filter bed during routine inspections.
- Inspect the media filter once during the wet season after a large rain event to determine whether the facility is draining completely within five days.
- If the facility drain time exceeds five days, remove the top 50 millimeters (2 inches) of sand and dispose of sediment. Restore media depth to 450 millimeters (18 inches) when overall media depth drops to 300 millimeters (12 inches).

FLOW-THROUGH PLANTERS – COMMON MAINTENANCE CONCERNS:

Maintenance objectives include maintaining healthy vegetation at an appropriate size; avoiding clogging; and ensuring the structural integrity of the planter and the proper functioning of inlets, outlets, and the high-flow bypass.

- Conduct a biannual (twice yearly) evaluation of the health of the vegetation and remove and replace any dead or dying plants.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed as needed to keep the flow-through planter neat and orderly in appearance. Prune or remove any overgrown plants or shrubs that may interfere with planter operation. Clean up fallen leaves or debris.
- Before the wet season begins, check that the soil is at the appropriate depth to allow water to temporarily pond above the soil surface and is sufficient to effectively filter stormwater. Remove any accumulations of sediment, litter, and debris. Till or replace soil (specify sandy loam), as necessary. Confirm that soil is not clogging and that the planter will drain within 3-4 hours after a storm event. Inspect and, if needed, replenish mulch.
- Inspect planter box periodically, and after storms, to ensure structural integrity of the box and that the planter has not clogged.
- Periodically inspect downspouts from rooftops or sheet flow from paving to ensure that flow to the planter is unimpeded. Remove any debris and repair any damaged pipes. Check splash blocks or rocks and repair, replace or replenish as necessary.
- Periodically inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Repair or replace any damaged or disconnected piping.

Figure 8-4: Flow through planter (Source: City of Portland, 2004)

BIORETENTION AREAS – COMMON MAINTENANCE CONCERNS:

The primary maintenance requirement for bioretention areas is the regular inspection and repair or replacement of the treatment measure's components. Generally, the level of effort is similar to the routine, periodic maintenance of any landscaped area.

- Conduct monthly inspections as follows:
  - Inspect bioretention area for obstructions and trash.
  - Inspect bioretention area for ponded water. If ponded water does not drain within five days, remove surface soils and replace with sand. If mosquito larvae are observed, contact the Alameda County Mosquito Abatement District at 510/783-7744. (In Albany, contact the Alameda County Vector Control District, at 510/567-6800.)
  - Inspect inlets for channels, exposure of soils, or other evidence of erosion. Clear any obstructions and remove any accumulation of sediment.
- Conduct a biannual (twice yearly) evaluation of the health of any plants, and remove any dead or diseased vegetation.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible, and replace any dead plants.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed, as needed, to keep the bioretention area neat and orderly in appearance.
- Inspect and, if needed, replace mulch before the wet season begins. Mulch should be replaced when erosion is evident or when the bioretention area begins to look unattractive. The entire area may need mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas.

Figure 8-5: Bioretention Area (Source: California Stormwater Quality Association, 2003)

INFILTRATION TRENCHES – COMMON MAINTENANCE CONCERNS:

The primary maintenance objective is to prevent clogging, which may lead to trench failure. Typical inspection and maintenance tasks are as follows:

- Inspect infiltration trench after large storm events and remove any accumulated debris or material.
- Check the observation well 2 to 3 days after storms to confirm drainage.
- Repair any erosion at inflow or overflow structures.
- Conduct thorough inspection annually, including monitoring of the observation well to confirm that the trench is draining within the specified time.
- Trenches with filter fabric should be inspected annually for sediment deposits by removing a small section of the top layer.
- If inspection indicates that the trench is partially or completely clogged, it shall be restored to its design condition.
- Mow and trim vegetation around the trench as needed to maintain a neat and orderly appearance.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Routinely remove trash, grass clippings and other debris from the trench perimeter and dispose of these materials properly. Trees or other large vegetation should be prevented from growing adjacent to the trench to prevent damage to the trench.

Figure 8-6: Infiltration Trench (Source: California Stormwater Quality Association)

EXTENDED DETENTION BASINS – COMMON MAINTENANCE CONCERNS:

Primary maintenance activities include vegetation management and sediment removal, although mosquito control is a concern in extended detention basins that are designed to include pools of standing water. The typical maintenance requirements include:

- Harvest vegetation annually, during the summer.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and mosquito control reasons.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Conduct a biannual (twice yearly) evaluation of the health of the vegetation and remove and replace any dead or dying plants.
- Conduct semiannual inspection as follows
  - Inspect the outlet, embankments, dikes, berms, and side slopes for structural integrity and signs of erosion.
  - Examine outlets and overflow structures and remove any debris plugging the outlets. Identify and minimize any sources of sediment and debris. Check rocks or other erosion control and replace, if necessary.
  - Check inlets to make sure piping is intact and not plugged. Remove accumulated sediment and debris near the inlet.
  - Inspect for standing water and correct any problems that prevent the extended detention basin from draining as designed.
  - If mosquito larvae are observed, contact the Alameda County Mosquito Abatement District at 510/783-7744. (In Albany, contact the Alameda County Vector Control District, at 510/567-6800.)
  - Check for slope stability and the presence of rodent burrows. Fill in any holes detected in the side slopes.
  - Inspect for and remove any trash and debris.
  - Confirm that any fences around the facility are secure.
  - Check for sediment accumulation.
- Remove sediment from the forebay when the sediment level reaches the level shown on the fixed vertical sediment marker.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume.
- Remove accumulated trash and debris from the extended detention basin at the middle and end of the wet season (January and April), or as needed.

Figure 8-7: Extended Detention Basin, Palo Alto

Chapter

9

Alternative Compliance

This Chapter describes the ACCWP's draft Alternative Compliance Model Program.

9.1 What Is Alternative Compliance?

Provision C.3.g of the municipal stormwater permit allows municipalities to grant "alternative compliance" to eligible new development or redevelopment projects in lieu of requiring on-site stormwater treatment measures. In most cases, projects that receive alternative compliance must demonstrate that onsite stormwater treatment is impracticable or infeasible and either provide for off-site treatment of an equivalent surface area, or provide other equivalent water quality benefit, such as stream restoration. Projects may, however, be allowed to contribute to a regional or watershed-based solution without demonstrating impracticability or infeasibility.

9.2 ACCWP's Draft Model Alternative Compliance Program

The municipal stormwater permit allows the creation of a model alternative compliance program for individual municipalities to implement upon its approval from the Water Board. Municipalities are not required to implement the Model Program, but may choose to do so. ACCWP has prepared a Model Alternative Compliance Program, which has not yet been approved by the Water Board. Accordingly, the ***information presented in this chapter is subject to change.*** Municipalities have the option to grant interim alternative compliance on a case-by-case basis until the model program is approved and adopted by the local jurisdiction. Please check with the local municipality for its specific requirements.

Municipalities are ***not required*** to implement ACCWP's Model Alternative Compliance Program, but may choose to do so.

9.2.1 Categories of Alternative Compliance

ACCWP's Model Alternative Compliance Program includes four categories of alternative compliance, described below.

REGIONAL OR WATERSHED-BASED SOLUTION

A regional or watershed-based solution is a post-construction stormwater treatment measure that ***treats the stormwater from more than one property*** within a designated geographical area ("service area"). If a municipality approves a request to use a regional or watershed-based solution, the project applicant contributes an agreed-upon dollar amount to fund the development project's share of the regional or watershed-based solution. Regional or watershed-based solutions are typically required to:

> To obtain a category of alternative compliance other than a regional or watershed-based solution, you will need to demonstrate that on-site stormwater treatment is ***impracticable or infeasible*** for your project.

- Discharge into the same receiving water as the development or redevelopment project,
- Have sufficient capacity to treat the runoff from the project,
- Be constructed within an appropriate timeframe (generally within five calendar years of the completion of the development project).

OFFSITE EQUIVALENT TREATMENT PROJECT

An offsite equivalent treatment project provides off-site treatment for a surface area, pollutant loading or volume of storm water runoff equivalent to that of the proposed new development or redevelopment project for which alternative compliance is sought. Examples of acceptable equivalent treatment projects include the installation of hydraulically-sized stormwater treatment measures in a nearby parking lot or other development where hydraulically-sized treatment measures were not previously installed, or the construction of hydraulically-sized swales along a public road. In addition to the typical requirements for regional or watershed-based solutions, you must ***demonstrate that it is impracticable*** to install treatment measures onsite in order to use an offsite equivalent treatment project.

OFFSITE EQUIVALENT WATER QUALITY BENEFIT PROJECT

An offsite equivalent water quality benefit project provides water quality benefit (other than treatment) roughly equivalent to the water quality benefit that would have resulted from onsite stormwater treatment. Examples of water quality benefit projects include stream restoration or other activities that limit or ***mitigate impacts from excessive erosion*** or sedimentation. Enhancements of existing mitigation projects that meet the qualifying criteria are acceptable. In addition to the typical requirements for regional or watershed-based solutions, you must demonstrate that it is impracticable to install treatment measures onsite in order to use an equivalent water quality benefit project.

EXEMPTIONS

Exemptions are only available for three types of redevelopment projects: ***affordable housing*** projects, ***brownfield*** projects and ***transit village*** type developments. In order for your redevelopment project to qualify for an exemption, under which no onsite or offsite stormwater treatment is required, you must demonstrate that onsite stormwater treatment is impracticable and the cost of offsite equivalent treatment would unduly burden your project.

9.2.2 Impracticablity

To obtain a category of alternative compliance other than a regional or watershed-based solution, you will need to demonstrate that on-site stormwater treatment is ***impracticable or infeasible*** for your project. The Model Alternative Compliance Program gives three conditions under which compliance with the numeric sizing standards in the municipal stormwater permit may be found impracticable or infeasible. (Only one condition needs to be present.) The conditions are:

- ***Soil conditions*** – Geotechnical constraints may prevent installation of treatment controls. This includes projects in an area where infiltration is not permitted and other means of meeting hydraulic sizing requirements are impracticable for cost or regulatory reasons;
- ***Cost*** – Projected cost of the required treatment measure (cost of labor and materials for the treatment measure) would exceed two percent (2%) of Total Project Cost; or
- ***Lack of adequate space*** – Lack of adequate space may be considered as a basis of impracticability to apply post-construction treatment measures, but before making a finding based on inadequate space, municipalities should carefully consider treatment measures that require little space, do not require landscaping, are located underground, or are lined and include sub-drains.

9.2.3 Obtaining Alternative Compliance

After the Model Program has been approved by the Water Board, municipalities that choose to adopt it will require applicants to provide supporting information to demonstrate that all of the qualifying criteria for the requested category of alternative compliance are met. ***Please check with the local jurisdiction*** to learn whether an alternative compliance program has been adopted and obtain information on the procedures for requesting alternative compliance.

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Appendix

A

Index of Internet Links

Internet links included in the handbook are listed below, in the order in which they appear in the applicable chapter or appendix.

Chapter 1 Links

http://cleanwaterprogram.org - home page of the Alameda Countywide Clean Water Program.

http://www.swrcb.ca.gov/stormwtr/construction.html - The State Water Resources Control Board's Construction Stormwater Program's web page, with information about obtaining coverage under the statewide General Permit for construction activity.

Chapter 2 Links

http://cfpub.epa.gov/npdes/faqs.cfm?program_id=6 - USEPA's list of Stormwater Frequently Asked Questions.

http://www.waterboards.ca.gov/sanfranciscobay/basinplan.htm - The San Francisco Bay Basin Plan (San Francisco Bay Regional Water Quality Control Board, 2004)

www.cleanwaterprogram.org/ACCWP_NPDESOrderR2-2003-0021.pdf, - The full text of the Alameda Countywide Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) Permit.

Chapter 3 Links

www.cleanwaterprogram.org/uploads/ACCWP_Site_Design_Guidebook_final.pdf. ACCWP's Guidebook of Post-Construction BMP Examples, which includes photographs and descriptions of site design measures and stormwater treatment measures in Alameda County.

http://soils.usda.gov/technical/handbook - National Soil Survey Handbook, Part 618.35 (USDA, 2006), which includes a description of the four hydrologic soil groups.

www.basmaa.org - Home page for the Bay Area Stormwater Management Agencies Association (BASMAA). When BASMAA completes its web-based treatment measure sizing tool, the tool may be accessed from this site.

http://www.cleanwaterprogram.org/businesses_developers.htm - The Developers/Builders page of the Alameda Countywide Clean Water Program (ACCWP). This site includes a wide range of stormwater information for developers/builders. When the Bay Area Hydrology Model is completed, it may be accessed from this site.

Chapter 4 Internet Links

http://www.hec.usace.army.mil/publications/ComputerProgramDocumentation/CPD-7.pdf). The users manual for Army Corps of Engineers' Storage, Treatment, Overflow, Runoff Model (STORM), which uses continuous simulation to convert rainfall to runoff based on local rainfall data.

www.concreteparking.org - Website sponsored by the National Ready Mixed Concrete Association, which includes information on pervious concrete.

www.greenroofs.com - The international green roof industry's resource and online information portal.

Chapter 5 Links

www.cabmphandbooks.com - The California Best Management Practice (BMP) Handbooks page of the California Stormwater Quality Association. The New Development BMP Handbook may be downloaded from this site.

http://cleanwaterprogram.org/uploads/UsingSatS.pdf - Using Site Design Techniques to Meet Development Standards for Stormwater Quality (BASMAA, 2003).

http://www.epa.gov/owm/mtb/hydro.pdf - USEPA Hydrodynamic Separator Fact Sheet.

http://www.cccleanwater.org/construction/Publications/HydrodynamicSeparatorsPolicy_11-16-05.pdf - Contra Costa County's policy regarding hydrodynamic separators.

http://www.stormh2o.com/sw_0601_guest_editorial.html - "Specifying and Permitting Alternative MTDs," by Thomas R. Decker, in the January/February 2006 edition of Stormwater magazine.

www.bayfriendly.org - The Bay-Friendly Landscaping page sponsored by Stopwaste.org, the Alameda County Waste Management Authority and the Alameda County Source Reduction and Recycling Board operating as one public agency. A free copy of the Bay-Friendly Landscaping Guidelines may be ordered or downloaded from this site.

Chapter 6 Links

www.cabmphandbooks.com - The California Stormwater Quality Association's statewide BMP Handbooks.

www.unh.edu/erg/cstev - The University of New Hampshire Environmental Research Group's Stormwater Center. Includes information on non-proprietary tree well filters.

Chapter 7 Links

http://www.cleanwaterprogram.org/uploads/ACCWP_HMP_PartA_5-15-05.pdf - Final Draft of Part A (General Provisions for Hydromdification Management) of ACCWP's Hydromodification Management Plan (HMP).

Chapter 8 Links

www.epa.gov/npdes/pubs/handdisp.pdf - USEPA Fact Sheet, "Storm Water O&M Fact Sheet: Handling and Disposal of Residuals."

Chapter 9 Links

None.

Appendix B Links

www.birc.org - Home page of the Bio-Integral Resource Center, which provides up-to-date resources and information on Integrated Pest Management (IPM).

www.ipm.ucdavis.edu - The University of California Online Statewide Integrated Pest Management Program, which provides up-to-date resources and information on IPM.

www.ourwaterourworld.org - A website that offers fact sheets and information on alternative pest control strategies to assist consumers in managing home and garden pests in a way that helps protect water quality.

Appendix C (Example Scenarios) Links

None

Appendix D (Local Requirements) Links

None

Appendix E (Mean Annual Precipitation Map) Links

None

Appendix F (Inlet Filters, Etc.) Links

http://www.cleanwaterprogram.org/uploads/RWQCB_letter_re_inlet_filters_etc.pdf - Letter from Executive Officer of the San Francisco Bay Water Board to BASMAA (August 5, 2004).

http://www.epa.gov/owm/mtb/hydro.pdf - USEPA, Hydrodynamic Separators Fact Sheet, 1999.

http://www.cccleanwater.org/construction/publications/hydrodynamicseparatorpolicy_11-16-05.pdf - Contra Costa Clean Water Program's. Policy on the Use of Hydrodynamic Separators to Achieve Compliance with NPDES Provision C.3 (November 16, 2005).

Appendix G (Infiltration Guidelines) Links

http://www.epa.gov/region09/water/groundwater/uic-classv.html - Instructions for submitting information for stormwater treatment measures that meet the USEPA's definition of Class V underground injection wells.

Appendix H (Mosquito Control) Links

http://www.mosquitoes.org/ - The Alameda County Mosquito Abatement District.

http://www.acvcsd.org/ - The Alameda County Vector Control District.

Appendix I (Maintenance Templates)

None

Appendix J (Draft HM Susceptibility Map)

http://www.cleanwaterprogram.org/uploads/ACCWP_HMP_PartA_5-15-05.pdf - Final Draft of Part A (General Provisions for Hydromdification Management) of ACCWP's Hydromodification Management Plan (HMP).

Appendix

B

Plant List and Planting Guidance for Landscape-Based Stormwater Measures

Table of Contents

B.1 Introduction

The purpose of this appendix is to provide guidance on the planting techniques and selection of appropriate plant materials for the stormwater measures described in this handbook.

The plant lists described in this appendix are not prescriptive, but should serve as a guide. In selecting plant materials, it is important to consider factors that influence plant establishment and success, such as microclimate, type of soil, water availability, proximity to saltwater and exposure to sun. Numerous resources are available to assist in selecting appropriate plant species in Alameda County, including Sunset's *Western Garden Book* and the East Bay Municipal Utility District's *Plants and Landscapes for Summer-Dry Climates of the San Francisco Bay Region.*

In addition, the function of the individual stormwater measure should be carefully considered when selecting plant materials. Factors to be considered include inundation period, expected flow of water, and access and maintenance requirements.

> The plant lists described in this appendix are not prescriptive, but should ***serve as a guide.*** In selecting plant materials, it is important to consider factors that influence plant establishment and success, such as microclimate, type of soil, water availability, proximity to saltwater and exposure to sun.

B.2 General Recommendations

- **Avoid the use of invasive species.** In selecting plants for stormwater measures, the use of invasive species should be avoided. A complete list of invasive plants can be found at www.cal-ipc.org, the California Invasive Plant Council's Invasive Plant Inventory.
- **Minimize or eliminate the use of irrigated turf.** Effort should be made to minimize the use of irrigated turf, which has higher maintenance requirements and greater potential for polluted runoff.

B.3 Plants for Stormwater Measures

Plants play an important role in the function of landscape-based stormwater treatment measures:

- Infiltration and evapotranspiration. Plants aid in the reduction of stormwater runoff by both increasing infiltration, and by returning water to the atmosphere through evapotranspiration.
- Sedimentation. Some stormwater treatment measures, such as vegetated swales and vegetated buffer strips, are designed to remove coarse solids through sedimentation that is aided by dense, low-growing vegetation.
- Pollutant trapping. Vegetation helps to prevent the resuspension of pollutants associated with sediment particles. It is essential that pollutants removed during small storms are not remobilized during large storms.
- Phytoremediation. Plants for stormwater treatment measures are important for their role in phytoremediation, the uptake of nutrients and the ability to neutralize pollutants.
- Soil stabilization. As in any landscaped area, established plantings help control soil erosion. This is important both to keep sediment out of stormwater and to retain the surface soils, which help to remove pollutants from infiltrated runoff.
- Aesthetic benefits. Plants within or adjacent to stormwater facilities provide an aesthetic benefit.

Plants suitable for use in stormwater treatment measures are organized according to the following categories:

- **Emergent** refers to those species which occur on saturated soils or on soils covered with water for most of the growing season. The foliage of emergent aquatics is partly or entirely borne above the water surface.
- **Grasses** refer to those species that are monocotyledonous plants with slender-leaved herbage found in the in the Family Poaceae.
- **Herbaceous** refers to those species with soft upper growth rather than woody growth. Some species will die back to the roots at the end of the growing season and grow again at the start of the next season. Annuals, biennials and perennials may be herbaceous.
- **Shrub** is a horticultural distinction that refers to those species of woody plants which are distinguished from trees by their multiple stems and lower height. A large number of plants can be either shrubs or trees, depending on the growing conditions they experience.
- **Tree** refers to those species of woody plants with one main trunk and a rather distinct and elevated head.

Plants suitable for use in stormwater treatment measures are listed in two ways. First, a comprehensive list of all recommended plant species is provided in Table B-1, which lists the plants in alphabetical order by Latin name, in the categories described above. The columns in Table B-1 indicate stormwater treatment measures for which each plant species may be suitable. Following Table B-1 are brief descriptions of the stormwater measures for which technical guidance is included in this handbook, including the suitable plantings from Table B-1.

Table B-1 Plant List for Stormwater Measures

		Green Roof - extensive	Green Roof - intensive	Turf Block Pavers	Vegetated Buffer Strip	Vegetated Swale	Tree Well Filters	Flow-Through Planters	Bioretention Area	Infiltration Trench	Extended Detention Basin
Emergent Species											
Carex barbarae	Santa Barbara sedge								✓		
Carex densa	dense sedge								✓		✓
Carex obnupta	slough sedge							✓	✓		✓
Eleocharis macrostachya	creeping spikerush								✓		✓
Hydrocotyle spp.	pennywort								✓		✓
Juncus balitcus [1]	baltic rush								✓		✓
Juncus bufonius	toad rush								✓		✓
Juncus effusus [1]	Pacific rush								✓		✓
Juncus leseurii	common rush								✓		✓
Juncus mexicanus	Mexican rush								✓		✓
Juncus patens	blue rush				✓			✓	✓		✓
Juncus xiphioides	iris-leaved rush								✓		✓
Phragmites spp.	common reeds										✓
Scirpus americanus [1]	three square								✓		
Scirpus californicus [1]	california bulrush										✓
Typha angustifolia	narrowleaf cattail										✓
Typha latifolia	cattail										✓
Grass Species											
Agrostis exarata	spike bentgrass			✓							✓
Alopecurus aequalis	shortawn foxtail										✓
Alopecurus saccatus	Pacific foxtail										✓
Bromus carinatus	California brome				✓	✓			✓	✓	
Danthonia californica	California oatgrass										✓
Deschampsia cespitosa [1]	tufted hairgrass				✓	✓			✓	✓	
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass				✓	✓			✓	✓	
Deschampsia danthonioides	annual hairgrass					✓				✓	
Distichlis spicata	salt grass				✓				✓	✓	✓
Eleocharis palustris	creeping spikerush					✓			✓	✓	
Elymus glaucus	blue wild rye				✓	✓			✓		✓
Elytrigia intermedia	intermediate wheat grass	✓	✓	✓	✓	✓					
Festuca arundinacea[1]	tall fescue	✓	✓	✓	✓	✓				✓	
Festuca californica	California fescue							✓	✓		
Festuca idahoensis	Idaho fescue	✓	✓	✓	✓	✓		✓			
Festuca rubra[1]	red fescue			✓	✓	✓		✓			
Festuca rubra 'molate'	Molate fescue			✓	✓	✓		✓			
Hordeum brachyantherum [1]	meadow barley				✓	✓			✓		✓
Leymus triticoides	creeping wildrye				✓	✓			✓	✓	✓
Linum usitatissimum [1]	flax							✓	✓		

** Denotes riparian species with limited drought tolerance*
[1] Denotes species with phytoremediation capabilities

Table B-1 Plant List for Stormwater Measures

		Green Roof - extensive	Green Roof - intensive	Turf Block Pavers	Vegetated Buffer Strip	Vegetated Swale	Tree Well Filters	Flow-Through Planters	Bioretention Area	Infiltration Trench	Extended Detention Basin
Grass Species cont'd											
Lolium perenne[1]	ryegrass					✓		✓	✓	✓	
Melica californica	California melic				✓	✓					
Muhlenbergia rigens	deergrass				✓	✓		✓	✓	✓	✓
Nasella pulchra	purple needlegrass	✓	✓		✓	✓			✓	✓	
Nassella lepida	Foothill needlegrass	✓	✓		✓	✓				✓	
Panicum coloratum[1]	kleingrass				✓	✓		✓	✓	✓	
Panicum virgatum[1]	switchgrass				✓	✓		✓	✓	✓	
Phalaris californica	California canarygrass				✓	✓			✓	✓	
Pleuropogon californicus	semaphore grass				✓	✓				✓	
Sisyrinchium bellum	blue-eyed grass	✓			✓	✓		✓		✓	
Sisyrinchium douglasii	purple-eyed grass	✓				✓				✓	
Herbaceous Species											
Achillea millefolium[1]	common yarrow	✓	✓		✓	✓		✓	✓		
Anthemis nobilis	chamomile			✓							
Armeria maritima	sea pink	✓	✓								
Carex densa	dense sedge				✓	✓					
Carex obnupta	slough sedge				✓	✓					
Carex pansa	California meadow sedge			✓	✓	✓					
Carex praegracilus	clustered field sedge				✓	✓			✓		
Carex subfusca	rusty sedge				✓	✓			✓		
Carex tumulicola	Berkeley sedge				✓	✓		✓			
Epilobium canum	California fuchsia				✓				✓		
Epilobium densiflorum	dense spike-primrose					✓			✓	✓	
Eriogonum fasciculatum	flattop buckwheat				✓				✓		
Eschscholzia californica	California poppy	✓	✓		✓				✓		
Fragaria chiloensis	beach strawberries	✓	✓					✓			
Layia platyglossa	tidy tips	✓	✓		✓						
Lotus scoparius	deerweed	✓	✓		✓				✓		
Lupinus bicolor	miniature lupine	✓	✓		✓				✓		
Medicago sativa[1]	alfalfa					✓		✓			
Mimulus aurantiacus	common monkeyflower				✓	✓		✓	✓		
Mimulus cardinalis	scarlet monkeyflower				✓	✓		✓	✓		
Prunella vulgaris	self heal	✓	✓								
Sedum spp.	stonecrop	✓	✓								
Sempervivum spp.	hen and chicks	✓	✓								
Solidago spp.[1]	goldenrod	✓	✓		✓	✓					
Thymus pseudolanuginosus	woolly thyme	✓	✓	✓							
Vigna unguiculata[1]	cowpea				✓	✓					

** Denotes riparian species with limited drought tolerance*
[1] Denotes species with phytoremediation capabilities

Table B-1 Plant List for Stormwater Measures

		Green Roof - extensive	Green Roof - intensive	Turf Block Pavers	Vegetated Buffer Strip	Vegetated Swale	Tree Well Filters	Flow-Through Planters	Bioretention Area	Infiltration Trench	Extended Detention Basin
Shrub Species											
Adenostema fasciculatum	chamise				✓						
Arctostaphylos densiflora 'McMinn'	manzanita 'McMinn'		✓		✓		✓	✓	✓		
Arctostaphylos manzanita	common manzanita		✓		✓		✓	✓			
Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'		✓		✓			✓	✓		
Baccharis pilularis 'Twin Peaks'	coyote brush prostrate				✓		✓	✓	✓		
Baccharis salicifolia	mulefat				✓						
Berberis aquifolium	barberry				✓		✓	✓			
Ceanothus hearstiorum	ceanothus		✓								
Ceanothus spp.	ceanothus				✓		✓		✓		
Cephalanthus occidentalis	buttonbush						✓		✓		
Cercocarpus betuloides	mountain mahogany				✓						
Cistus spp.	rockrose				✓			✓			
Cornus sericea	western dogwood				✓		✓	✓			
Cornus stolonifera	redosier dogwood				✓		✓	✓			
Garrya elliptica	coast silk tassle				✓			✓			
Heteromeles arbutifolia	toyon		✓		✓		✓		✓		
Lavandula spp.	lavender		✓					✓			
Lavatera spp.	tree mallow							✓			
Lepechina calycina	pitcher sage				✓						
Lupinus albifrons	bush lupine				✓						
Mahonia repens	creeping Oregon grape		✓		✓			✓	✓		
Myrica californica	wax myrtle		✓		✓				✓		
Philadelphus coronarius¹	sweet mock orange		✓		✓		✓	✓	✓		
Physocarpus capitatus	Pacific ninebark		✓		✓		✓		✓		
Pittosporum tobira	mock orange				✓			✓			
Rhamnus Californica	coffeeberry		✓					✓	✓		
Ribes malvaceum	chaparral currant				✓						
Rosa californica	California wild rose				✓				✓		
Rubus ursinus	California blackberry				✓				✓		
Salvia brandegii	black sage				✓						
Salvia melifera	black sage				✓						
Sambucus mexicana	elderberry				✓				✓		
Symphoricarpos albus	snowberry				✓		✓	✓	✓		

** Denotes riparian species with limited drought tolerance*
¹ Denotes species with phytoremediation capabilities

Table B-1 Plant List for Stormwater Measures

		Green Roof - extensive	Green Roof - intensive	Turf Block Pavers	Vegetated Buffer Strip	Vegetated Swale	Tree Well Filters	Flow-Through Planters	Bioretention Area	Infiltration Trench	Extended Detention Basin
Tree Species											
Acer macrophyllum*	big leaf maple				✓				✓		
Acer negundo*	box elder								✓		
Aesculus californica	buckeye				✓						
Alnus rhombifolia *	white alder		✓						✓		
Alnus rubra*	red alder		✓		✓				✓		
Betula nigra	river birch				✓				✓		
Celtis occidentalis	common hackberry		✓		✓				✓		
Cercidium floridum	Blue Palo Verde						✓				
Cercis occidentalis	redbud		✓		✓		✓	✓			
Chionanthus retusus	Chinese fringe tree						✓	✓			
Fraxinus latifolia	Oregon ash		✓					✓	✓		
Geijera parviflora	Australian willow						✓	✓			
Lagerstroemia spp.	crepe myrtle						✓	✓			
Morus alba (fruitless var.)[1]	white mulberry				✓				✓		
Platanus racemosa*	sycamore								✓		
Populus fremontii* [1]	Fremont's cottonwood								✓		
Quercus agrifolia	California live oak				✓				✓		
Quercus lobata	valley oak				✓				✓		
Quercus palustris	pin oak				✓						
Salix laevigata[1]	red willow				✓				✓		
Salix lasiolepis[1]	arroyo willow				✓				✓		
Salix lucida ssp. lasiandra [1]	shining willow				✓				✓		

** Denotes riparian species with limited drought tolerance*
[1] Denotes species with phytoremediation capabilities

A brief paragraph describing each stormwater measure is provided below, including the key factors that should influence planting techniques and plant selection, and a list of suitable plantings from Table B-1. The suitable plantings are reiterated in this manner for the landscape designer's convenience in preparing landscape plans for each type of stormwater measure.

Green roof

A green roof is intended to capture precipitation and roof runoff. Green roofs utilize a lightweight, porous planting substrate as a medium for plant growth. The depth and composition of this substrate is extremely important in determining types of plants that will be successful as part of a green roof system. Intensive green roofs, which can have up to 48" of substrate, can support a wider variety of plant types. The list below is only a sample of plants that could be suitable for an intensive green roof. Extensive green roofs, which have a depth of 3" to 7" of planting medium, are suitable for a limited number of grass and herbaceous species. These roofs generally require little maintenance and should be designed to succeed with minimal irrigation.

In addition to the species listed below, pre-vegetated mats can be utilized on extensive green roofs. Information can be found at the following website: www.hfmgv.org/rouge/livingroof.asp

EXTENSIVE GREEN ROOF

GRASS SPECIES

Elytrigia intermedia	intermediate wheat grass
Festuca arumdinacea	tall fescue
Festuca idahoensis	Idaho fescue
Nasella pulchra	purple needlegrass
Nassella lepida	Foothill needlegrass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Armeria maritima	sea pink
Eschscholzia californica	California poppy
Fragaria chiloensis	beach strawberries
Layia platyglossa	tidy tips
Lotus scoparius	deerweed
Lupinus bicolor	miniature lupine
Prunella vulgaris	self heal
Sedum sp.	stonecrop
Sempervivum sp.	hen and chicks
Sisyrinchium bellum	blue-eyed grass
Solidago spp	goldenrod
Thymus pseudolanuginosus	woolly thyme

INTENSIVE GREEN ROOF

GRASS SPECIES

Elytrigia intermedia	intermediate wheat grass
Festuca arumdinacea	tall fescue
Festuca idahoensis	Idaho fescue
Nasella pulchra	purple needlegrass
Nassella lepida	Foothill needlegrass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Armeria maritima	sea pink
Eschscholzia californica	California poppy
Fragaria chiloensis	beach strawberries
Layia platyglossa	tidy tips
Lotus scoparius	deerweed
Lupinus bicolor	miniature lupine
Prunella vulgaris	self heal
Sedum sp.	stonecrop
Sempervivum sp.	hen and chicks
Sisyrinchium bellum	blue-eyed grass
Solidago spp	goldenrod
Thymus pseudolanuginosus	woolly thyme

SHRUB SPECIES *(MINIMUM 12"* substrate depth *)*

Arctostaphylos manzanita prostrate	common manzanita
Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'
Ceanothus hearstiorum	ceanothus
Heteromeles arbutifolia	toyon
Lavandula spp.	lavender
Mahonia repens	creeping Oregon grape
Myrica californica	wax myrtle
Philadelphus coronarius	sweet mock orange
Physocarpus capitatus	Pacific ninebark
Rhamnus Californica	coffeeberry

TREE SPECIES[+] (minimum 36" substrate depth)

Alnus rhombifolia *	white alder
Alnus rubra *	red alder
Celtis occidentalis	common hackberry
Cercis occidentalis	western redbud
Fraxinus latifolia	Oregon ash

* Denotes riparian species with limited drought tolerance

+ Note: These species have been selected among trees suitable for stormwater. A large number of tree species are suitable for intensive green roofs, and will depend on the type and depth of soil mix, microclimate and available space.

Pervious paving – Turf Block Pavers

Some pervious paving systems can be planted with grass or herbaceous species in order to assist with erosion prevention as well as promote infiltration and pollutant uptake. Plant species should be tolerant of compaction, have the ability to neutralize contaminants, and should not interfere with maintenance and use of the paved surface. Most plant species cannot tolerate frequent vehicular compaction. Therefore, turf block pavers are best suited for areas requiring infrequent access, such as emergency vehicle access routes. Paver manufacturer should be consulted regarding recommended and acceptable plant species.

GRASS SPECIES

Agrostis exarata	spike bentgrass
Elytrigia intermedia	intermediate wheat grass
Festuca arumdinacea	tall fescue
Festuca idahoensis	Idaho fescue
Festuca rubra	red fescue
Festuca rubra 'Molate'	Molate fescue

HERBACEOUS SPECIES

Anthemis nobilis*	chamomile
Carex pansa	California meadow sedge
Thymus pseudolanuginosus*	woolly thyme

* Denotes species that cannot tolerate vehicular compaction

Vegetated Swale

Plants in a vegetated swale slow water movement, which assists with the sedimentation of coarse solids and increases infiltration through a layer of topsoil. Therefore, a vegetated swale should be planted with the intent of slowing water flow, retaining pollutants associated with solids that settle out, and stabilizing the topsoil. Species can include grass and herbaceous species. All plants should be tolerant of extended periods of dry conditions. However, species tolerant to periodic inundation should be concentrated within the center of the swale where the soil would be saturated for a greater duration.

GRASS SPECIES

Bromus carinatus	California brome
Deschampsia cespitosa	tufted hairgrass
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass
Deschampsia danthonioides	annual hairgrass
Eleocharis palustris	creeping spikerush
Elymus glaucus	blue wild rye
Elytrigia intermedia	intermediate wheat grass
Festuca arundinacea	tall fescue

Festuca idahoensis	Idaho fescue
Festuca rubra	red fescue
Festuca rubra ‘Molate’	Molate fescue
Hordeum brachyantherum	meadow barley
Leymus triticoides	creeping wildrye
Lolium perenne	ryegrass
Melica californica	California melic
Muhlenbergia rigens	deergrass
Nasella pulchra	purple needlegrass
Nassella lepida	Foothill needlegrass
Panicum coloratum	kleingrass
Panicum vigatum	switchgrass
Phalaris californica	California canarygrass
Pleuropogon californicus	semaphore grass
Sisyrinchium bellum	blue-eyed grass
Sisyrinchium douglasii	purple-eyed grass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Carex densa	dense sedge
Carex obnupta	slough sedge
Carex pansa	California meadow sedge
Carex praegracilus	clustered field sedge
Carex subfusca	rusty sedge
Carex tumulicola	Berkeley sedge
Epilobium densiflorum	dense spike-primrose
Medicago sativa	alfalfa
Mimulus aurantiacus	common monkeyflower
Mimulus cardinalis	scarlet monkeyflower
Sisyrinchium bellum	blue-eyed grass
Solidago spp.	goldenrod
Vigna unguiculata	cowpea

Vegetated buffer strips

Vegetated buffer strips should be designed to function and appear as natural vegetated areas adjacent to development. They treat surface runoff from adjacent impervious areas so a variety of trees, shrubs, and grass and herbaceous species should be included in order to maximize water and nutrient uptake, as well as to retain sediment.

EMERGENT/GRASS SPECIES

Juncus patens	blue rush
Bromus carinatus	California brome
Deschampsia cespitosa	tufted hairgrass
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass
Deschampsia danthonioides	annual hairgrass
Eleocharis palustris	creeping spikerush

Elymus glaucus	blue wild rye
Elytrigia intermedia	intermediate wheat grass
Festuca arundinacea	tall fescue
Festuca idahoensis	Idaho fescue
Festuca rubra	red fescue
Festuca rubra 'Molate'	Molate fescue
Hordeum brachyantherum	meadow barley
Leymus triticoides	creeping wildrye
Lolium perenne	ryegrass
Melica californica	California melic
Muhlenbergia rigens	deergrass
Nasella pulchra	purple needlegrass
Nassella lepida	Foothill needlegrass
Panicum coloratum	kleingrass
Panicum vigatum	switchgrass
Phalaris californica	California canarygrass
Pleuropogon californicus	semaphore grass
Sisyrinchium bellum	blue-eyed grass
Sisyrinchium douglasii	purple-eyed grass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Carex densa	dense sedge
Carex obnupta	slough sedge
Carex pansa	California meadow sedge
Carex praegracilus	clustered field sedge
Carex subfusca	rusty sedge
Carex tumulicola	Berkeley sedge
Epilobium canum	California fuchsia
Eriogonum fasciculatum	flattop buckwheat
Eschscholzia californica	California poppy
Layia platyglossa	tidy tips
Lotus scoparius	deerweed
Lupinus bicolor	miniature lupine
Mimulus aurantiacus	common monkeyflower
Mimulus cardinalis	scarlet monkeyflower
Sisyrinchium bellum	blue-eyed grass
Solidago spp.	goldenrod
Vigna unguiculata	cowpea

SHRUB SPECIES

Adenostema fasciculatum	chamise
Arctostaphylos manzanita	common manzanita
Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'
Baccharis pilularis 'Twin Peaks'	coyote brush prostrate
Baccharis salicifolia	mulefat

Berberis aquifolium	barberry
Ceanothus spp.	ceanothus
Cercocarpus betuloides	mountain mahogany
Cistus spp.	rockrose
Cornus sericea	western dogwood
Cornus stolonifera	redosier dogwood
Garrya elliptica	coast silk tassle
Heteromeles arbutifolia	toyon
Lepechina calycina	pitcher sage
Lupinus albifrons	bush lupine
Mahonia repens	creeping Oregon grape
Myrica californica	wax myrtle
Philadelphus coronarius	sweet mock orange
Physocarpus capitatus	Pacific ninebark
Ribes malvaceum	chaparral currant
Rosa californica	California wild rose
Rubus ursinus	California blackberry
Salvia brandegii	black sage
Salvia melifera	black sage
Sambucus mexicana	elderberry
Symphoricarpos albus	snowberry

TREE SPECIES

Acer macrophyllum*	big leaf maple
Aesculus californica	buckeye
Alnus rubra*	red alder
Betula nigra	river birch
Celtis occidentalis	common hackberry
Cercis occidentalis	redbud
Morus alba (fruitless var.)	white mulberry
Quercus agrifolia	California live oak
Quercus lobata	valley oak
Quercus palustris	pin oak
Salix laevigata	red willow
Salix lasiolepis	arroyo willow
Salix lucida ssp. lasiandra	shining willow

* Denotes riparian species with limited drought tolerance

Tree well filter

Trees and shrubs planted in tree well filters should be an appropriate size for the space provided. Because plant roots are confined to the container, it is recommended that small trees and shrubs with shallow, fibrous roots be planted in the tree well filter. Provided that site conditions allow, it may be possible to work with the manufacturer to design a container that would allow for the planting of larger trees or shrubs. Plants for tree well filters should be tolerant of frequent, but temporary periods of inundation as well as adapted to extremely well-drained soils. Species with the ability to neutralize contaminants are preferred.

SHRUB SPECIES

Arctostaphylos manzanita	common manzanita
Berberis aquifolium	barberry
Arctostaphylos densiflora 'McMinn'	manzanita 'McMinn'
Baccharis pilularis 'Twin Peaks'	coyote brush prostrate
Berberis aquifolium	barberry
Cephalanthus occidentalis	buttonbush
Cornus sericea	western dogwood
Cornus stolonifera	redosier dogwood
Ceanothus spp.	ceanothus
Heteromeles arbutifolia	toyon
Philadelphus coronarius	sweet mock orange
Symphoricarpos albus	snowberry

TREE SPECIES

Cercidium floridum	blue palo verde
Cercis occidentalis	redbud
Chionanthus retusus	Chinese fringe tree
Geijera parviflora	Australian willow
Lagerstroemia spp.	crepe myrtle

* Denotes riparian species with limited drought tolerance

Flow-through planter

Plant species for flow-through planters will depend on the size of the planter. Shrubs and trees should be planted in planters only when there is sufficient space. Recommended minimum soil depth for shrubs is 18", and for small trees is 36". Plant species should be adapted to well-drained soils. Irrigation is typically required, but selecting plants adapted to extended dry periods can reduce irrigation requirements.

EMERGENT/GRASS SPECIES

Carex obnupta	slough sedge
Festuca californica	California fescue
Festuca idahoensis	Idaho fescue
Festuca rubra	red fescue
Festuca rubra 'Molate'	Molate fescue
Juncus patens	blue rush
Linum usitatissimum	flax
Lolium perenne	ryegrass
Muhlenbergia rigens	deergrass
Panicum coloratum	kleingrass
Panicum vigatum	switchgrass
Sisyrinchium bellum	blue-eyed grass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Carex tumulicola	Berkeley sedge
Fragaria chiloensis	beach strawberries
Medicago sativa	alfalfa
Mimulus aurantiacus	common monkeyflower
Mimulus cardinalis	scarlet monkeyflower

SHRUB SPECIES

Arctostaphylos manzanita	common manzanita
Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'
Baccharis pilularis 'Twin Peaks'	coyote brush prostrate
Berberis aquifolium	barberry
Cistus spp.	rockrose
Cornus sericea	western dogwood
Cornus stolonifera	redosier dogwood
Garrya elliptica	coast silk tassle
Lavandula spp.	lavender
Lavatera	tree mallow
Mahonia repens	creeping Oregon grape
Philadelphus coronarius	sweet mock orange
Rhamnus Californica	coffeeberry
Symphoricarpos albus	snowberry

TREE SPECIES

Cercis occidentalis	western redbud
Chionanthus retusus	Chinese fringe tree
Fraxinus latifolia	Oregon ash
Geijera parviflora	Australian willow
Lagerstroemia spp.	crepe myrtle

Bioretention Area

Bioretention areas are intended to act as filters with plants. Plants in bioretention areas help with phytoremediation and infiltration. Therefore, nutrient uptake and the ability to neutralize pollutants are priorities for species selection. Plants for these areas should be able to withstand periods of inundation as well as extended periods of drought. Emergent, grass and herbaceous species can be planted in the bioretention area, while shrub and tree species should be concentrated on the outer edges. Grasses can also be planted along the exterior to slow the velocity of flow and allow the sedimentation of coarse solids, which helps minimize clogging of the bioretention area. Supplemental irrigation will be necessary to maintain emergent species during extremely dry conditions.

EMERGENT SPECIES

Carex barbarae	Santa Barbara sedge
Carex densa	dense sedge
Carex obnupta	slough sedge
Eleocharis macrostachya	creeping spikerush
Hordeum brachyantherum	meadow barley
Hydrocotyle spp.	pennywort
Juncus balitcus	baltic rush
Juncus bufonius	toad rush
Juncus effusus	Pacific rush
Juncus leseurii	common rush
Juncus mexicanus	Mexican rush
Juncus patens	blue rush
Juncus xiphioides	iris-leaved rush
Scirpus americanus	three square

GRASS SPECIES

Bromus carinatus	California brome
Deschampsia cespitosa	tufted hairgrass
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass
Distichlis spicata	salt grass
Eleocharis palustris	creeping spikerush
Elymus glaucus	blue wild rye
Festuca californica	California fescue
Hordeum brachyantherum	meadow barley
Leymus triticoides	creeping wildrye
Linum usitatissimum	flax
Lolium perenne	ryegrass
Muhlenbergia rigens	deergrass
Nasella pulchra	purple needlegrass
Panicum coloratum	kleingrass
Panicum virgatum	switchgrass
Phalaris californica	California canarygrass

HERBACEOUS SPECIES

Achillea millefolium	common yarrow
Carex praegracilus	clustered field sedge
Carex subfusca	rusty sedge
Epilobium canum	California fuchsia
Epilobium densiflorum	dense spike-primrose
Eriogonum fasciculatum	flattop buckwheat
Eschscholzia californica	California poppy
Lotus scoparius	deerweed
Lupinus bicolor	miniature lupine
Mimulus aurantiacus	common monkeyflower
Mimulus cardinalis	scarlet monkeyflower
Sisyrinchium bellum	blue-eyed grass

SHRUB SPECIES

Shrubs and trees are recommended to be planted at a rate of 2500 shrubs and trees per hectare (1000 per acre). The shrub-to-tree ratio should be 2:1 to 3:1.[1]

Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'
Baccharis pilularis Twin Peaks'	coyote brush prostrate
Ceanothus spp.	Ceanothus
Cephalanthus occidentalis	buttonbush
Heteromeles arbutifolia	toyon
Mahonia repens	creeping Oregon grape
Myrica californica	wax myrtle
Philadelphus coronarius	sweet mock orange
Physocarpus capitatus	Pacific ninebark
Rhamnus californica	coffeeberry
Rosa californica	California wild rose
Rubus ursinus	California blackberry
Sambucus mexicana	elderberry
Symphoricarpos albus	snowberry

TREE SPECIES

Acer macrophyllum*	big leaf maple
Acer negundo*	box elder
Alnus rhombifolia *	white alder
Alnus rubra*	red alder
Betula nigra	river birch
Celtis occidentalis	common hackberry
Fraxinus latifolia	Oregon ash
Morus alba (fruitless var.)	white mulberry
Platanus racemosa*	sycamore

[1] California Stormwater Quality Association (CASQA).

Populus fremontii*	Fremont's cottonwood
Quercus agrifolia	California live oak
Quercus lobata	valley oak
Salix laevigata	red willow
Salix lasiolepis	arroyo willow
Salix lucida ssp. lasiandra	shining willow

* denotes riparian species with limited drought tolerance

Infiltration Trench

An infiltration trench is an aggregate filled trench that receives and stores stormwater runoff in the void spaces between the aggregate and allows it to infiltrate into the surrounding soil. Vegetated filter strips of grass species on either side of the trench can slow and pre-treat the runoff while the trench can physically remove fine sediment and other suspended solids.

GRASS SPECIES

Bromus carinatus	California brome
Deschampsia cespitosa	tufted hairgrass
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass
Deschampsia danthonioides	annual hairgrass
Distichlis spicata	salt grass
Eleocharis palustris	creeping spikerush
Festuca arundinacea	tall fescue
Leymus triticoides	creeping wildrye
Lolium perenne	ryegrass
Muhlenbergia rigens	deergrass
Nasella pulchra	purple needlegrass
Nassella lepida	Foothill needlegrass
Panicum coloratum	kleingrass
Panicum vigatum	switchgrass
Phalaris californica	California canarygrass
Pleuropogon californicus	semaphore grass
Sisyrinchium bellum	blue-eyed grass
Sisyrinchium douglasii	purple-eyed grass

Extended Detention Basin

Extended detention basins are intended to capture and detain water for much longer periods (up to 72 hours) than bioretention areas. They are designed to drain completely between storms. Plants in extended detention basins increase pollutant removal and assist with soil stabilization, therefore nutrient uptake and the ability to neutralize pollutants are priorities for species selection. Because extended detention basin are intended to capture and move large quantities of water, trees should not be planted in the basins. Shrubs are typically not specified for extended detention basins, but may be included only on the outer perimeter (top of bank) that they do not interfere with detention. Species should be adapted to periodic inundation and saturation and extended periods of dry conditions. Emergent, grass and herbaceous species for extended detention basins should consists of species that are able withstand extended periods of inundation. Supplemental irrigation will be necessary to maintain emergent species during extremely dry conditions.

EMERGENT SPECIES

Carex densa	dense sedge
Carex obnupta	slough sedge
Eleocharis macrostachya	creeping spikerush
Hordeum brachyantherum	meadow barley
Hydrocotyle spp	pennywort
Juncus balitcus	baltic rush
Juncus bufonius	toad rush
Juncus effusus	Pacific rush
Juncus leseurii	common rush
Juncus mexicanus	Mexican rush
Juncus patens	blue rush
Juncus xiphioides	iris-leaved rush
Phragmites spp.	common reeds
Scirpus californicus	california bulrush
Typha angustifolia	narrowleaf cattail
Typha latifolia	cattail

GRASS SPECIES

Agrostis exarata	spike bentgrass
Alopecurus aequalis	shortawn foxtail
Alopecurus saccatus	Pacific foxtail
Danthonia californica	California oatgrass
Distichlis spicata	salt grass
Elymus glaucus	blue wild rye
Hordeum brachyantherum	meadow barley
Leymus triticoides	creeping wildrye
Muhlenbergia rigens	deergrass

B.4 Planting Specifications

Planting plans and specifications must be prepared by a qualified professional and coordinated with other site development details and specifications including earthwork, soil preparation and irrigation (if used). Plans indicating a planting layout, with species composition and density, should be prepared on a site-specific basis. Reference Alameda County's Bay Friendly Landscaping Guidelines prepared by Stopwaste.Org (available at www.bayfriendly.org), which outline principles and practices to minimize waste, protect air and water quality, conserve energy and water, and protect natural ecosystems, including:

- Evaluate site and assess the soil;
- Consider potential for fire;
- Select plants for appropriate size upon maturity, do not over-plant;

- Irrigation, if required, should be designed as a high efficiency, water conserving system; and
- Utilize compost (see the specification in the Bay-Friendly Landscaping Guidelines) and mulch to build healthy soils and increase the water holding capacity of the soil.

Propagation and Planting Methods

The propagation methods for different species will vary, depending upon type of plant and stormwater adaptation. In general, container stock will be utilized most commonly for greenroofs, flow-through planters, tree well filters, vegetated swales and buffer strips and infiltration trenches. Bioretention areas and extended detention basins will generally utilize native plants available as transplants (plugs), pole cuttings and seed mixes.

Container Stock. Planting holes for container stock should be twice as wide and only as deep as the container size. Plant spacing should be determined on a site-specific basis. When planting, the root collar and base of the stem should be 1" above the adjacent soil surface. Soils should be backfilled and tamped down to assure contact with the roots. The planting should be watered-in promptly to promote the settling of soil. If appropriate, container plantings may receive a balanced time-released fertilizer tablet, quantity and placement per manufacturer's recommendation, placed in the planting hole prior to installation of the plant. Planting berms for water retention and mulch shall be used to enhance plant establishment. Trees shall be staked or guyed to provide interim support until established.

Transplants (Plugs). Transplanted plant divisions, referred to here as "plugs", should be planted during the fall dormant period, preferably between October 1 and November 15 after first soaking rain. Plugs should be collected from a suitable collection site in the vicinity of the constructed basins. Plugs are clumps of plant roots, rhizomes or tubers combined with associated soil that can be manually removed, or salvaged with an excavator or backhoe. The maximum recommended size is 1 foot x 1 foot. Whole plants or plant divisions can be utilized. The plugs should be from healthy specimens free of insects, weeds and disease. The plugs should be spaced from 1 foot to 6 feet apart, depending on the size of the plug. Smaller plugs can be planted at the minimum distance to promote faster spreading and cover. Larger plugs from cattail and bulrush species should be planted at 3-foot to 6-foot intervals.

To plant a plug, a hole slightly wider than the diameter of the plug should be prepared and the roots system of the plug placed in the hole. Do not over-excavate the hole depth or the plant will settle below grade. A shovel could be used to create the planting hole. Manual planting with a spade is recommended for wet soils. Power augers can be used for creating holes in dry soils. Alternatively, a trench could be created along the narrow axis of the extended detention basin, and planting material manually placed at specified elevations in relation to the proximity of permanently saturated soils. To plant a plug with an established root system, the base of the stem and top of the root collar should be level with the ground surface. Tubers should be secured to prevent floating. Rhizomes should be placed in the soil with a slight upward angle.

The hole or trench containing the plug(s) should be backfilled with soil and the soil tamped down to assure good soil contact and secure the plug. The vegetative portion of the plant should be cut back to prevent water loss and wilting, and encourage the growth of roots and new shoots. Plugs of wetland plants should be grown in saturated soil. The soil should not be allowed to dry out after planting. Plugs should be planted immediately, when possible. When necessary, plugs can be stored in a cool, moist, shaded location for a maximum of one day. Plants must be thoroughly watered.

Pole Cuttings. Pole cuttings should be collected from the 1-year old wood of dormant trees and have a minimum of 5 viable nodes. The parent material should be healthy and free of diseases. The basal area of the pole cutting should be a minimum of one to two inches in diameter; however, the diameter at the base should not exceed 2 inches. The optimum diameter width of the base is 1 inch. The length of the cutting should be a minimum of 2 feet and should not exceed a maximum of 4 feet in length. Generally, 75 percent of the length of the cutting should be planted beneath the soil surface.

Pole cuttings should be collected no more than 2 days prior to planting. Cuttings should be placed in cool water to promote swelling of the nodes. Water should be kept fresh by aeration and/or by daily replacement. The pole cuttings should be placed in a hole approximately 3 feet deep (as determined by the length of the cutting) and backfilled with native soil, or a rich organic medium mixed with native soil. Soil should be tamped down to remove air pockets and assure soil contact with the cutting.

Seeding. Seeding should be conducted after plugs, container stock and pole cuttings are installed. Hydroseeding or broadcast method shall be utilized as appropriate for the size and accessibility of the area. The soil surface should be scarified prior to seeding. Do not damage previously planted vegetation. The seeds should be planted in fall, ideally in October.

Seeds should be broadcast or hydroseeded over the specified planting area. With broadcast seeding, the seed should be applied with hand-held spreaders to scarified soil. The soil surface should then be raked to cover the seeds with about one-eighth to one-quarter inch of soil to discourage predation, and tamped or rolled to firm soil surface.

Seeds should be planted at the ratios and rates specified by the supplier. The seed should be free of weeds and diseases. The certified germination percentage should be provided by the supplier.

Water Level Management and Irrigation for Plant Establishment

All newly planted material will need careful attention to watering requirements to ensure proper establishment. As mentioned in the introduction, it is important to select plants based on specific site conditions, which will affect the availability of water for plant use. In addition, grouping plants with similar water requirements can help reduce irrigation needs. The specific approach will vary for irrigated and non-irrigated conditions, and for each stormwater application. In most cases, stormwater applications will require a permanent irrigation system which shall be designed to maximize water conservation. Irrigation specifications and design plans shall be provided.

Plants such as shrubs and trees grown in naturalized areas that are not saturated to the surface or inundated shall be irrigated with drip irrigation. The irrigation system shall remain in place for a minimum of three years, and should continue until it is demonstrated that the plantings can survive on annual rainfall and/or groundwater. Seeded areas do not need irrigation in years of normal rainfall. If a period of drought occurs after seeding, supplemental watering may be needed for germination in the first year.

The plants on the bottom and edge of the constructed basins should be allowed to become established for one growing season prior to the onset of significant flooding that will inundate the plantings for extended periods. The types of plants recommended for these locations are rushes, sedges, grasses and herbaceous species. Initially, saturated soils are required for the bioretention areas and extended detention basins during the establishment period of the plantings. After the plants have become established, inundation with a surface depth of 1 cm to 2 cm alternating with short dry periods is recommended for the basins during the first year. Periodic shallow flooding of these basins can slow the growth of non-native weedy terrestrial species in the wetland system; however, the water depth should not be greater than the height of the plants. This initial irrigation regime will prevent plant mortality from dry periods or excessive flooding in the first year, and reduce the growth of non-native weedy species.

Emergent species should be planted in saturated soil so the plants will become established. For emergent species, the water level in the first year should be maintained to allow for soil saturation or shallow inundation around the base of the plants. Significant flooding and inundation of stems and leaves of the plants should be avoided the first year. Tall plugs and plantings can tolerate greater depths of inundation if a significant portion of the stems and leaves of the plantings remain above the water surface.

B.5 Monitoring and Maintenance

General Requirements

All planted areas shall be monitored and maintained as required to ensure proper establishment by a Contractor with a valid California C-27 contractor's license. Frequency of site visits and required maintenance practices will vary depending upon the stormwater measure and plant selection. Maintenance shall include watering, cultivation, weeding and pruning as necessary to maintain optimum growth conditions and, as appropriate to the specific stormwater measure, to keep the planted areas neat and attractive in appearance. In all instances, controlling weeds and unwanted growth with chemical applications is prohibited.

The contractor shall be familiar with the design and function of the specific stormwater measure(s) to ensure that the plantings are maintained appropriately and do not interfere with the efficient runoff drainage and filtration.

Ongoing management of invasive weed species will be required in all applications. Monthly hand weeding will allow the naturalized vegetation to take hold, and will ultimately be less costly than less frequent, and more intensive clearing. Regular application of arbor chip mulch, or other mulch material that will knit together and resist floating with surface runoff, will also help control weed growth.

Erosion Control

Particularly with landscapes that are not fully established, contractors will need to monitor and evaluate potential for erosion and sediment accumulation in the runoff, which will influence irrigation scheduling and as well as determine the need for additional erosion control measures. Soil can be protected from erosion by a number of methods including:

- Keep the soil covered with vegetation to the extent possible;
- Slow water runoff by using compost berms, blanket, socks or tubes along slopes;
- Cover bare soil with a minimum of 2" mulch cover;
- Minimize the use of blowers in planting beds and on turf;
- On slopes use coarse shredded mulch that is not prone to washing into storms drains; and
- Store leaf litter as additional much in planting beds as appropriate.

Irrigation Systems

Where irrigation systems have been installed for temporary or permanent irrigation, the contractor shall maintain the irrigation system for optimum performance, as per manufacturer's specifications. Contractor shall inspect the entire system on an ongoing basis, including cleaning and adjusting all sprinkler and bubbler heads, drip emitters and valves for proper coverage. Contractor shall monitor the irrigation system while operating to identify and correct problems with water runoff or standing water.

Monitor soil moisture within plant root zones using a soil probe or shovel and adjust irrigation schedules accordingly if a soil moisture sensor is not being utilized to signal the irrigation controller. If a Weather-Based Irrigation Controller (WBIC), otherwise known as a "Smart" Controller is not utilized on the project, irrigation shall be scheduled using a water budget approach, basing irrigation frequency on evapotranspiration data (ET) to avoid over-irrigation of plant material. Adjust irrigation frequency within each hydrozone area a minimum of every four weeks to respond to expected adjustments in ET data.

If a standard turf mix is used in lieu of a no-mow variety, implement grasscycling, where appropriate to the stormwater treatment measure. Grass clippings shall not be carried into the drainage structures. Refer to A Landscaper's Guide to Grasscycling available from StopWaste.Org at www.bayfriendly.org .

Bioretention and Extended Detention Basins

In bioretention and extended detention basins, in particular, non-native invasive plant species should be carefully monitored and controlled to reduce competition with the native plantings and to assure the success of the revegetation activities. The establishment of weeds and invasive species in the bottom of the basins can be partially controlled during the establishment period by implementing the watering schedule of initial saturation followed by alternating periods of shallow inundation and dry soil. Manual methods of weed removal should be conducted on the bottom, edge and side of the basins when these areas are not inundated. Areas with hydroseeding on the banks of the basins should be weeded carefully to avoid removal of the native species.

Weeding should be conducted regularly the first two years to prevent the growth, flowering, and seed set of non-native weeds and invasive species. After the first two years, weeding frequency will be determined on a site-specific basis as determined by the type of weeds and seasonal growth cycle of the weed species. In general, weeding once a month will be necessary to avoid more extensive and costly eradication in the future.

Long-term maintenance tasks on the banks of the basins will include continued control of nonnative weeds and invasive plants, and control of erosion. Erosion could include gullies, rills and sheet erosion. Actions to control erosion should include redirecting or dissipating the water source. Recontouring and subsequent mulching and/or reseeding with erosion control species may be required in bare areas. In the event of extensive die-off of the native plant species, the bare areas should be replanted. Where the event that caused plant mortality was not a natural catastrophic occurrence, the site condition that resulted in the die-off should be investigated and remedial action to correct the problem should be undertaken prior to replanting.

B.6 Bay-Friendly Landscaping and Integrated Pest Management

This section provides a summary of Bay-Friendly landscaping and integrated pest management techniques, based on Alameda County's Bay Friendly Landscaping Guidelines prepared by Stopwaste.Org (available at www.bayfriendly.org).

Bay Friendly Landscaping

Bay-Friendly landscaping is a whole systems approach to the design, construction and maintenance of the landscape in order to support the integrity of the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly landscaping practices from the initial plant selection through the long-term maintenance of the site. This section summarizes Bay-Friendly Landscaping practices that may be implemented information that project sponsors need about how these practices canto benefit water quality of the Bay and its tributaries.

Bay-Friendly landscaping is based on 7 principles of sustainable landscaping and features the following practices

- **1. Landscape Locally.** Landscapes designed to be part of the larger ecosystem of the Bay Area can both protect the health, diversity and sustainability of this valuable resource while making the most of the natural processes of a well-functioning ecosystem. By selecting plants appropriate to the climate, exposure, soils, drainage and topography, plantings can be established more successfully with less consumption of resources and intensive maintenance. Landscape designers are also encouraged to use local, well-adapted plant communities as models and to consider the potential for fire when developing the plant palette for a project.
- **2. Less to the Landfill.** Reducing waste –and thus conserving landfill space and fossil fuel for hauling this material to the landfill - starts with not generating it in the first place. Plant trimmings pruning can be reduced by selecting plants that can grow to their natural size is the space allotted them, by avoiding the use of sheared hedges as design elements and not specifying invasive species (see the list in Appendix B). Prune selectively, and avoid excessive plant growth by applying water and fertilizer judiciously..

The second step is to recognize the value of plant debris, and to keep this organic matter on the site, using it as a gardening resource for mulching and composting.

- **3. Nurture the Soil.** Returning organic matter to the soil, in the form of plant debris, is the link between protecting our watershed and protecting our watershed. Healthy soil that is rich in organic matter is full of life and can store water and actively cycle nutrients, regulate and partition water flow, neutralize pollutants, and resist pests. The following practices will encourage a complex soil community of microorganisms, worms, and other beneficial creatures. Base the landscape design on a soil analysis and understanding of soil texture, structure and drainage. The following practices are recommended Dduring construction:
  - Remove and store the topsoil for re-spreading after grading;
  - Limit construction traffic to areas that will not be landscaped;
  - Control soil erosion;
  - Amend the soils with compost before planting; and
  - Specify and maintain an adequate layer of organic mulch, taking into account water flow and designing to avoid the loss of mulch with runoff.

  Maintenance practices to benefit soils and the watershed include allowing grass clippings to remain on the lawn; feeding soils with naturally based products including compost and a water extract of mature compost, instead of synthetic, fast release fertilizers and avoiding pesticides.

- **4. Conserve Water.** Amending the soil with compost and keeping it covered with mulch can increase soil permeability and water-holding capacity, reduce water loss through evaporation and decrease the need for irrigation. Planting appropriate, drought tolerant California natives or Mediterranean plants also reduces water consumption for irrigation, as well as consumption of other resources for mowing, fertilizing, and spraying. Minimize the use of turf grasses that require regular watering and fertilizing to remain green, particularly on slopes or in narrow, irregular hard to water shapes. Arrange plants in “hydrozones” of low, medium or high water demand. Onsite collection systems can allow the use of rainwater, or the reuse of “graywater” – uncontaminated wastewater from sinks, bathtubs, and washing machines. Specify, install and maintain high-efficiency irrigation systems, and train landscaping staff to manage irrigation according to need.

- **5. Conserve Energy.** Conventional landscapes are very fossil fuel consumptive. Selecting plantings that do not require regular mowing or pruning, fertilizing and watering can help reduce this demand and restore our landscapes to those that are more productive than consumptive. Tree plantings can be used to moderate building temperatures, and to shade paved areas and air conditioners. Trees can also intercept significant amounts of rainfall each year and thus help control stormwater runoff. Specify as large a tree as possible but be sure that it will be allowed to grow to its natural shape and size in the allotted space. Outdoor lighting should be designed to use less energy and minimize “light pollution.” Choose and maintain energy-efficient landscaping equipment to conserve fuel. Specifying local products and suppliers reduces the energy needed to transport products and supports local economies.

- **6. Protect Water and Air Quality.** Bay-Friendly landscaping can help protect water quality by increasing on-site infiltration and reducing runoff, reducing pollutants in runoff, and increasing the soil’s ability to remove pollutants from runoff. It can help protect air quality by reducing fossil fuel consumption, recycling plant debris onsite, and planting trees to remove carbon dioxide and absorb air pollutants. Many of the practices described previously, such as minimizing high input decorative lawns, keeping soil covered with mulch and planting trees play a critical role in protecting water and air quality. An additional very important component of Bay-Friendly landscaping is reducing the use of pesticides through integrated pest management, which is described in a separate section, below.

- **7. Create and Protect Wildlife Habitat.** Although we tend to rely on parks and open space to preserve wildlife habitat, developed landscapes can also provide food, water, shelter and nesting sites for birds, butterflies, beneficial insects, and other creatures. This can be accomplished by providing a diverse landscape that includes annuals, biennials and perennials of many different sizes, shapes, colors and textures; by choosing California natives first; providing appropriate water and shelter for wildlife; eliminating the use of pesticides; and planning sites to conserve or restore natural areas and wildlife corridors.

Integrated Pest Management

All creeks in the San Francisco Bay Area exceed water quality toxicity limits, primarily due to the pesticide Diazinon entering urban runoff. Although the residential use of Diazinon is currently being phased out, the use of a group of highly toxic chemicals, called pyrethroids, is increasing. Because all pesticides are toxins, a Iintegrated pest management (IPM) places a priority on avoiding their use. IPM is a holistic approach to mitigating insects, plant diseases, weeds, and other pests. Projects that require a landscaping plan as part of a development project application are required encouraged to use IPM, as indicated in each agency's source control measures list, which is based on ACCWP's Source Control Model (see Appendix D). Avoiding pesticides and quick release synthetic fertilizers are particularly important when maintaining stormwater treatment measures, to protect water quality.

IPM encourages the use of many strategies for first preventing, and then controlling, but not eliminating, pests. It places a priority on fostering a healthy environment in which plants have the strength to resist diseases and insect infestations, and out-compete weeds. Using IPM requires an understanding of the life cycles of pests and beneficial organisms, as well as regular monitoring of their populations. When pest problems are identified, IPM considers all viable solutions and uses a combination of strategies to control pests, rather than relying on pesticides alone. The least toxic pesticides are used only as a last resort. IPM features the following practices:

- **Prevent Pest Problems.** Fostering a healthy soil and selecting appropriate plant communities for the site helps reduce the susceptibility to disease and other pests. Landscape designs should include a diversity of species that are well-suited to the site; specify resistant varieties and native species, including plants that attract beneficial insects; place plants a proper distance from buildings; avoid over-planting; and include compost in the soil specifications. Cultural methods of avoiding pests during construction and maintenance include the following:
  - Selecting plant material that is free from disease and insects;
  - Planting at the right depth;
  - Watering thoroughly but not over-watering;
  - Keeping mulch on the soil surface at all times, keeping it away from root crowns;

  - Using slow release fertilizer, if necessary, and not over-fertilizing;
  - Pruning judiciously;
  - Eliminating noxious weeds before they go to seed or spread;
  - Cleaning equipment after use on infected plants;
  - Inspecting and removing invasive plant parts or seeds from clothing, tools and vehicle before leaving an infected site; and
  - Cleaning up fruit and plant material that is infected with insects or diseases.

- **Watch for and Monitor Problems.** Landscaping firms should provide their staff with the time and resources to learn to identify both pest and beneficial organisms, and train residential clients to monitor and record pest problems. Plants should be checked often for vigor and signs of pests. Clarify which problems are the result of pests and not other environmental problems. Evaluate the results of any treatments, and check regularly with the Bio-Integral Resource Center (www.birc.org) or UC Davis (www.ipm.ucdavis.edu) for up-to-date resources and information.
- **Education is Key.** Many property owners have unrealistic standards of absolute pest control and need to learn how landscapes can tolerate a certain level of pests without resulting in significant, or even noticeable, damage. Landscape professionals should educate their clients and refer them to www.ourwaterourworld.org for fact sheets and information on alternative pest control strategies.
- **Use Physical and Mechanical Controls.** If pests are identified as the source of unacceptable levels of damage, physical barriers or mechanical techniques are the first line of control. This can include the carefully timed and conducted pruning of infested plant material or removal of whole plants, spraying aphids with a strong jet of water, using pheromone or sticky traps to keep ants and other insects away or hand-picking large adult insect pests and larvae as they appear
- **Use Biological Controls.** Living organisms can also be used to keep pest populations under control. The most important biological controls appear naturally and will be abundant in a landscape that is not heavily treated with pesticides. Encourage beneficial insects by planting a wide range of plants that flower throughout the year (a list is provided in the Bay-Friendly Landscaping Guidelines), and introduce natural predators. Buy all biological controls from a reputable source, and do not use pesticides except as a last resort.
- **Least Toxic Pesticides are a Last Resort.** The least toxic and least persistent pesticide is used only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. Pesticides are not used on a calendar basis. When used, their efficiency is maximized by understanding the pest and beneficial life cycles, by careful timing and targeted application.

B.7 Nursery Sources for Native Plants

It is recommended that the native plants used in treatment controls be grown by a qualified nursery. Seed collection should be conducted by a qualified botanist and/or nursery staff. Seed should be collected locally from selected sites to maintain the genetic integrity of the native plant species. The seeds shall be propagated by the nursery for planting during the fall dormant season. The appropriate container size for each species shall be used by the nursery.

Berkeley Horticultural Nursery*
1310 McGee Ave., Berkeley, CA
510-526-4704
http://www.berkeleyhort.com/

Clyde Robin Seed Company
Castro Valley, CA
510-785-0425
www.clyderobin.com

East Bay Nursery*
2332 San Pablo Ave., Berkeley, CA
510- 845-6490
http://www.eastbaynursery.com/

Larner Seeds
PO Box 407
Bolinas, California
415-868-9407
info@larnerseeds.com
webmaster@larnerseeds.com

Mines Road Natives
17505 Mines Road, Livermore, CA
925-371-0887
Note: by appointment only.

Mostly Natives Nursery
27235 Highway 1, Tomales, CA
707-878-2009
www.mostlynatives.com

Native Here Nursery
101 Golf Course Road, Berkeley, CA
510-549-0211
http://www.ebcnps.org/NativeHereHome.htm

Oaktown Native Plant Nursery
1019 Bella Vista Ave., Oakland, CA
510-534-2552
http://www.oaktownnativenursery.info/

Pacific Coast Seed
533 Hawthorne Place
Livermore, CA
925- 373-4417
www.pcseed.com

Watershed Nursery
Berkeley, CA
510-548-4714
www.thewatershednursery.com

* Nurseries with a dedicated native plant section

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3. A Landscaper's Guide to Mulch

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C. Irrigation water audits, Irrigation Association, www.irrigation.org, and the Irrigation Technology Research Center, www.itrc.org.

D. California Irrigation Management Information System, www.cimis.water.ca.gov, Waste management and recycling, www.ciwmb.ca.gov.

E. The Weed Worker's Handbook, A Guide to Techniques for Removing Bay Area Invasive Plants, The Watershed Council (510) 231-5655 and the California Invasive Plant Council (510) 843-3902

F. Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide, 2nd ed., UC Publication 3359, http://www.ipm.ucdavis.edu

G. A Field Guide to Compost Use, The Composting Council, Alexandria, VA. http://www.compostingcouncil.org/index.cfm

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I. Hogan, E.L., Ed. 1994. Sunset Western Garden Book, Sunset Publishing Corporation, Menlo Park, CA.

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Appendix

C

Example Scenarios

1. Parking Lot Example

2. Podium Type Building Example

C.1 Parking Lot Example

Introduction

- This example shows a typical proposed parking lot in Alameda County, with typical treatment measures as described in this document. This example shows multiple treatment measures to treat stormwater runoff being generated by the site.

Typical Parking Lot

Summary of Stormwater Controls

Site Design Measures

- Using drainage as a design element

Source Controls

- Stenciling storm drain inlets
- Landscape designer will be asked to follow Integrated Pest Management principles

Treatment Measures

- Vegetated swales
- Bioretention areas

The example parking lot site description:

The project site is 2 acres with 1% slope from edge of lot to street.
The site has one ingress/egress point.

The site will be treating the 0.2 inches per hour event which is equivalent to 85% of annual runoff from the site.

Using Chapter 5, the runoff coefficients are determined to be:

Standard Paving	.7
Swale areas	.3

Sidewalks shall be graded toward landscaped areas.
The parking lot will have standard asphalt paving.
The parking lot will have landscaping as an amenity.

All areas will be graded to drain either to bioretention areas or to vegetated swales along the perimeter of the site. Slopes are approximately 1%. Swales will have a slope of 0.5%.

Swales and bioretention areas are sized following the Technical Guidance sheets presented in Chapter 6.

The following tables show sizing and calculations of the site and the treatment measures used.

The following figure shows locations and layout of treatment measures.

Typical Vegetated Swale

Typical Bioretention Area

Procedure for BMP sizing:

1. List areas under land type.
2. List areas then to each outfall.
3. Compute or locate runoff coefficient from table in Chapter 5.
4. Calculate flows to each outfall using Rational Method = Q (flow) = A (areas) * C (runoff coefficient) * I (intensity = 0.2 inches per hour for treatment event). This will be the flow that needs to be treated by a swale (a flow based BMP). In the case of bioretention (a volume based BMP that shares characteristics with a flow based measure), simply measure the impervious surface as in the first 2 steps, then multiply by a sizing factor of 0.04.
5. If using a flow based treatment measure, then use the Swale Worksheet provided.
6. Flow is from the above Rational Formula Q value.
7. Approximate slope to the proposed slope of the location of the flow based treatment measure. This is to reduce the need of excess excavation. The minimum slope of a swale is 0.05 feet /feet. .
8. Flow depth can vary depending on conditions the grasses in swale will be kept. The value of 4-inches (0.33 feet) can be used for seldom mowed bunch grasses, for often mowed grass use 2-inches (.15 feet).
9. Manning's Roughness is set at either 0.2 for mowed grass or 0.25 for seldom mowed grass.
10. Sideslope should be a maximum of 3:1
11. Residence Time is stated as 8 minutes required for concentrated flows, and 12 minutes if flows are dispersed through multiple inlets to the swale.
12. Bottom width will then need to be adjusted until the swale size allows for the treatment flow to be contained within the swale (last column).
13. Calculated top width is the bottom width plus 2 times the product of flow depth and sideslope.
14. Manning's open channel formula is then used to calculate the flow in the swale.
15. If the swale has less than 100-feet of length, but still is sized to handle the treatment flow, it is still recommended to use a swale length of 100-feet.
16. The area of the site used may equal less than 4% of the total impervious area, 4% is a conservative guideline for the purpose of review.

Alameda Countywide Clean Water Program (ACCWP)

Table 1A
Parking Lot Example Flow Calculations

Drainage Areas & Proposed Land Type	Area of Land Type (square feet)	(acres)	Runoff Coefficient	Flow @ 0.2 inches per hour (cfs)
Landscaping Self Treated	420	minor		
AREA A **to North Swale**				
Landscaping	7,448	0.17	0.1	0.00
Paving	6,368	0.15	0.7	0.02
Treatment Flow to North Swale	13,816	0.32		0.02
AREA B **to South Swale**				
Landscaping	11,497	0.26	0.1	0.01
Paving	24,491	0.56	0.7	0.08
Treatment Flow to South Swale	35,988	0.83		0.08
AREA C **to North Bioretention**				
Landscaping	3,222	0.07	0.1	0.00
Paving	11,442	0.26	0.7	0.04
Treatment Flow to North Bioretention	14,664	0.34		0.04
AREA D **to South Bioretention**				
Landscaping	3,877	0.09	0.1	0.00
Paving	18,265	0.42	0.7	0.06
Treatment Flow to South Bioretention	22,142	0.51		0.06
Total	173,640	2.0		0.21

(1) Runoff Coefficients are from Start at the Source Handbook.
(2) Table 5-3 Runoff Coefficients were used
(3) Self Treating areas are flowing through swale and are therefore included in sizing of swale.
(4) See Bioretention and Vegetated Swale C.3 Stormwater Guidance Documents

Table 1B

Treated By Treatment Measure	Area Treated (square feet)	Area Treated (acres)	Sizing Guidelines	Proposed Treatment Measure Size (square feet)	Actual Treatment Measure Size (square feet)
North Vegetated Swale	13,816	0.32	Swale (1)	553	154
South Vegetated Swale	35,988	0.83	Worksheet	1440	347
North Bioretention Area	14,664	0.34	Bioretention	587	590
South Bioretention Area	22,142	0.51	Worksheet	886	890
Total	86,610	2.0		3464	1981

(1) See Tables 1C and 1D C.3 Permit Swale Conformance Worksheet
(2) See Tables 1E and 1F C.3 Permit Bioretention Conformance Worksheet
(3) Sizing factor is storm intensity 0.2 inches/hour / infiltration rate 5 inches/hour = .04 which is unit less.

Table 1C - (Area A) Swale Worksheet

VARIABLES	Input	Comments
Treatment Flow	0.02	cfs from Table 1A
Vegetated Swale Slope (feet/foot)	0.005	* 0.5% slope
Flow Depth (feet)	0.26	0.33 feet maximum, 4 inches of mowed grass, adjusted for treatment flow
Manning's Roughness	0.25	0.20 for mowed lawn, 0.25 for 6 inch grasses.
Sideslope (H:V)	3	3:1 maximum is recommended.
Residence Time (minutes)	12	8 minutes if 90% collected at upstream limit, 12 minutes if interspersed.
Bottom Width	0	Adjust until Flow in vegetated swale is greater than Treatment Flow.

RESULTS:

Vegetated Swale Hydraulics

Vegetated Swale Slope (feet per foot)	Bottom Width (feet)	Flow Depth (feet)	Manning's Roughness n	Sideslope (feet per foot)	Calculated Top Width (feet)	Flow in Vegetated Swale (cfs)
0.005	**0.0**	0.26	0.25	3	1.5	0.020

Minimum Vegetated Swale Length

Residence Time (minutes)	Calculated Vegetated Swale Length (feet)	Used Vegetated Swale Length (feet)
12	96	100

*minimum vegetated swale length is 100 feet

Vegetated Swale Dimensions

Flow Area (square feet)	Wetted Perimeter (feet)	Flow Velocity (feet/sec)	Surface Area (square feet)	Portion of Area Dedicated to BMP (%)	Percentage of Impervious Area (%)
0.20	1.62	0.10	154	1.1%	2.4%

(1) Proceedures are specified in the example.

Alameda Countywide Clean Water Program (ACCWP)

Table 1D - (Swale B) Swale Worksheet
Stormwater C.3. Permit Vegetated Swale Conformance Worksheet

VARIABLES	Input	Comments
Treatment Flow	0.084	cfs from Table 1A
Vegetated Swale Slope (feet/foot)	0.005	* 0.5% slope
Flow Depth (feet)	0.33	0.33 feet maximum, 4 inches of mowed grass, adjusted for treatment flow
Manning's Roughness	0.25	0.20 for mowed lawn, 0.25 for 6 inch grasses.
Sideslope (H:V)	3	3:1 is recommended.
Residence Time (minutes)	12	8 minutes if 90% collected at upstream limit, 12 minutes if interspersed.
Bottom Width	0.76	Adjust until Flow in Vegetated Swale is greater than Treatment Flow.

RESULTS:

Vegetated Swale Hydraulics

Vegetated Swale Slope (feet per foot)	Bottom Width (feet)	Flow Depth (feet)	Manning's Roughness n	Sideslope (feet per foot)	Calculated Top Width (feet)	Flow in Vegetated Swale (cfs)
0.005	**0.8**	0.33	0.25	3	2.7	0.084

Minimum Vegetated Swale Length

Residence Time (minutes)	Calculated Vegetated Swale Length (feet)	Used Vegetated Swale Length (feet)	
12	127	127	*minimum vegetated swale length is 100 feet

Vegetated Swale Dimensions

Flow Area (square feet)	Wetted Perimeter (feet)	Flow Velocity (feet/sec)	Surface Area (square feet)	Portion of Area Dedicated to BMP (%)	Percentage of Impervious Area (%)
0.58	2.85	0.15	347	1.0%	1.4%

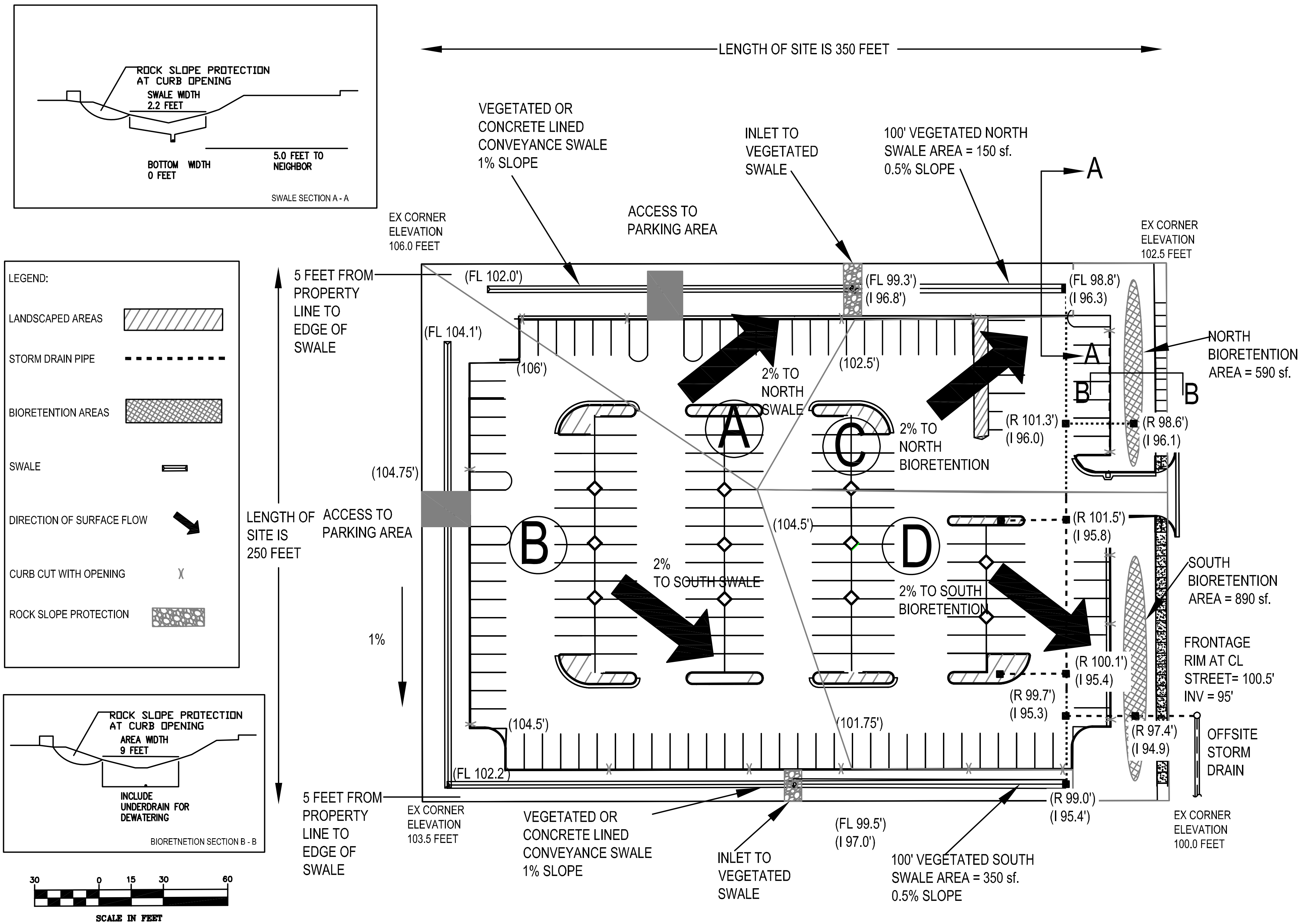
(1) Proceedures are specified in the example.

Alameda Countywide Clean Water Program (ACCWP)

Table 1E - North Bioretention
Stormwater C.3. Permit Bioretention Conformance Worksheet

	Drainage Area (square feet)	Scaling Factor (4%)	Required Bioretention Area (square feet)	Bioretention Area Provided (square feet)
North Bioretention Area	14,664	0.04	587	590
South Bioretention Area	22,142	0.04	886	890

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM



APPENDIX C

TYPICAL 2-ACRE PARKING LOT

C.2 Podium Type Building Example

Introduction

- This example is to show a typical proposed podium type building in Alameda County, with typical treatment measures as described in this document. This example will show multiple treatment measures to treat stormwater runoff being generated by the site.

Typical Podium Building

Summary of Stormwater Controls

Site Design Measures

- Multistory building above covered parking

Source Controls

- Covered trash storage areas
- Landscape designer will be asked to follow Integrated Pest Management principles

Treatment Measures

- Flow-through planters

The example podium style building site description:

The project site is approximately 25,000 square feet.

The site is Type D soil with expected compaction of 95%.

Lot line is assumed to be to the edge of city right-of-way (sidewalks).

The proposed podium building is a zero lot line design with flow through planters in the center of the building around a concrete patio and down at ground level.

The podium building is a mixed use building with residential units on the top floors, retail sites on the second floor and parking on the bottom floor. The building mechanical facilities and trash facilities are also on the bottom floor.

The roof area of the podium building consists of approximately 9,000 square foot patio, 1,000 square feet of flow through planters and 15,000 square feet of roof.

Off site sidewalks and driveways will be graded toward street.

The site will be treating the 0.2 inches per hour event which is equivalent to 85% of annual runoff from the site.

Using Chapter 5, the runoff coefficients are determined to be:

Patio Surfaces	.7
Roof Surfaces	.9
Flow through Planter	.1

The ground floor is a concrete slab with buildings and a covered parking structure. There is no potential for infiltration. The soils within the planter will be at least 18 inches of loamy sand that must pass an in-situ percolation test with a rate of 5 inch/hour. A 6-inch layer of planting soil will be placed on the loamy sand to encourage plant growth. A 12-inch layer of drain rock will be placed around the perforated underdrain to allow for dewatering of the flow through planter.

The flow through planter areas will connect directly to the storm drain system through a system of perforated underdrains and overflow pipes.

Flow through planters shall be sized to be 4% of the area of the impervious patio. The flow through planter shall have splash blocks at rain water leader discharge points to protect against erosion.

The following tables show the sizes and calculations for the Podium building treatment measures.

Source Control

Parking and trash shall be under the building and covered.

Typical Flow Through Planter

City of Portland *2004 Stormwater Manual*

Procedure for BMP sizing:

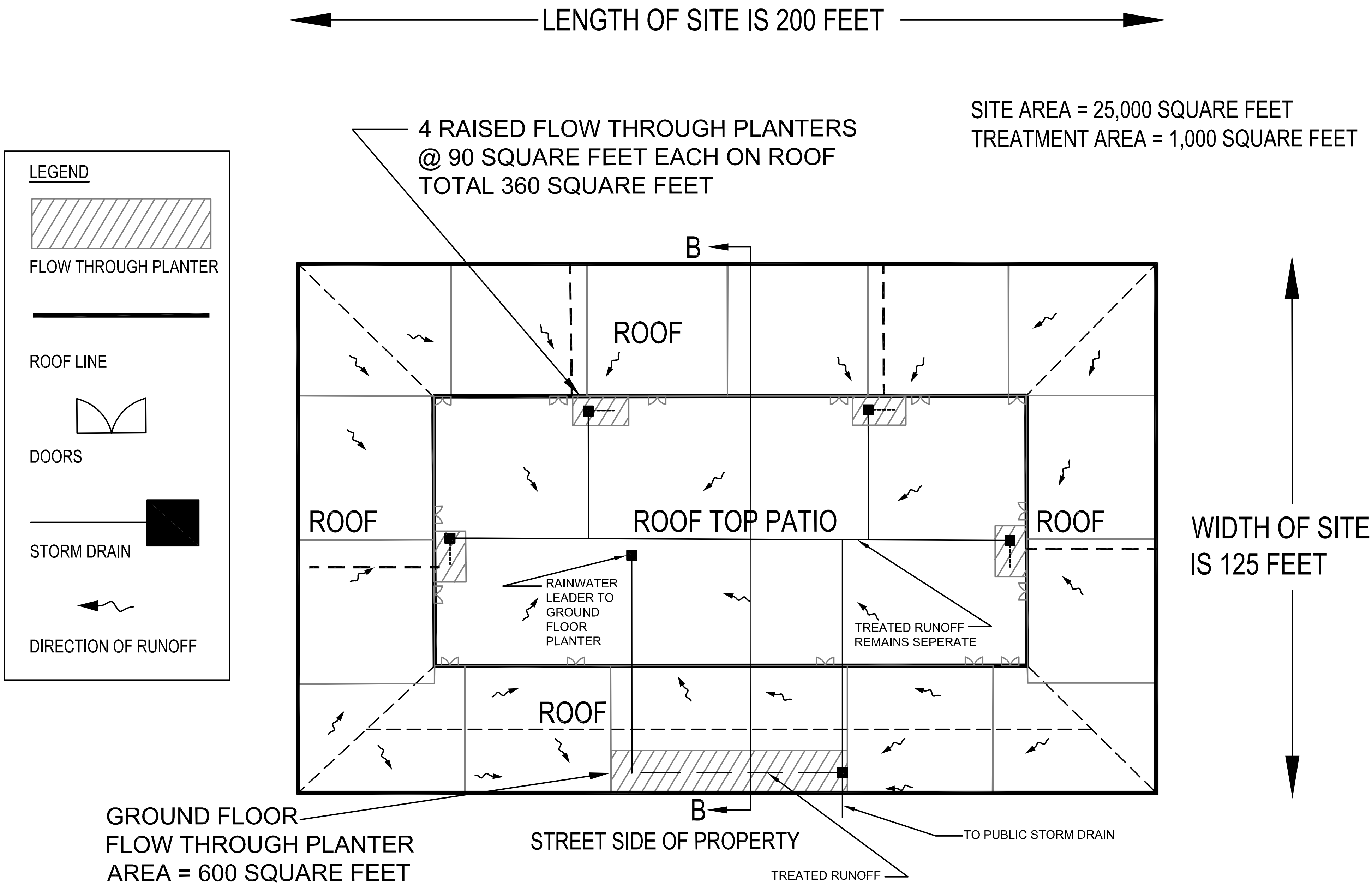
List areas under land type.
List areas then to each outfall.
In the case of a flow through planter (a volume based BMP), simply measure the impervious surface as in the first 2 steps, then multiply by a sizing factor of 0.04.
The 4% ratio is for planning review and is from 0.2 inches of rainfall per hour inflow versus 5 inches/hour infiltration rate.

Alameda Countywide Clean Water Program (ACCWP)

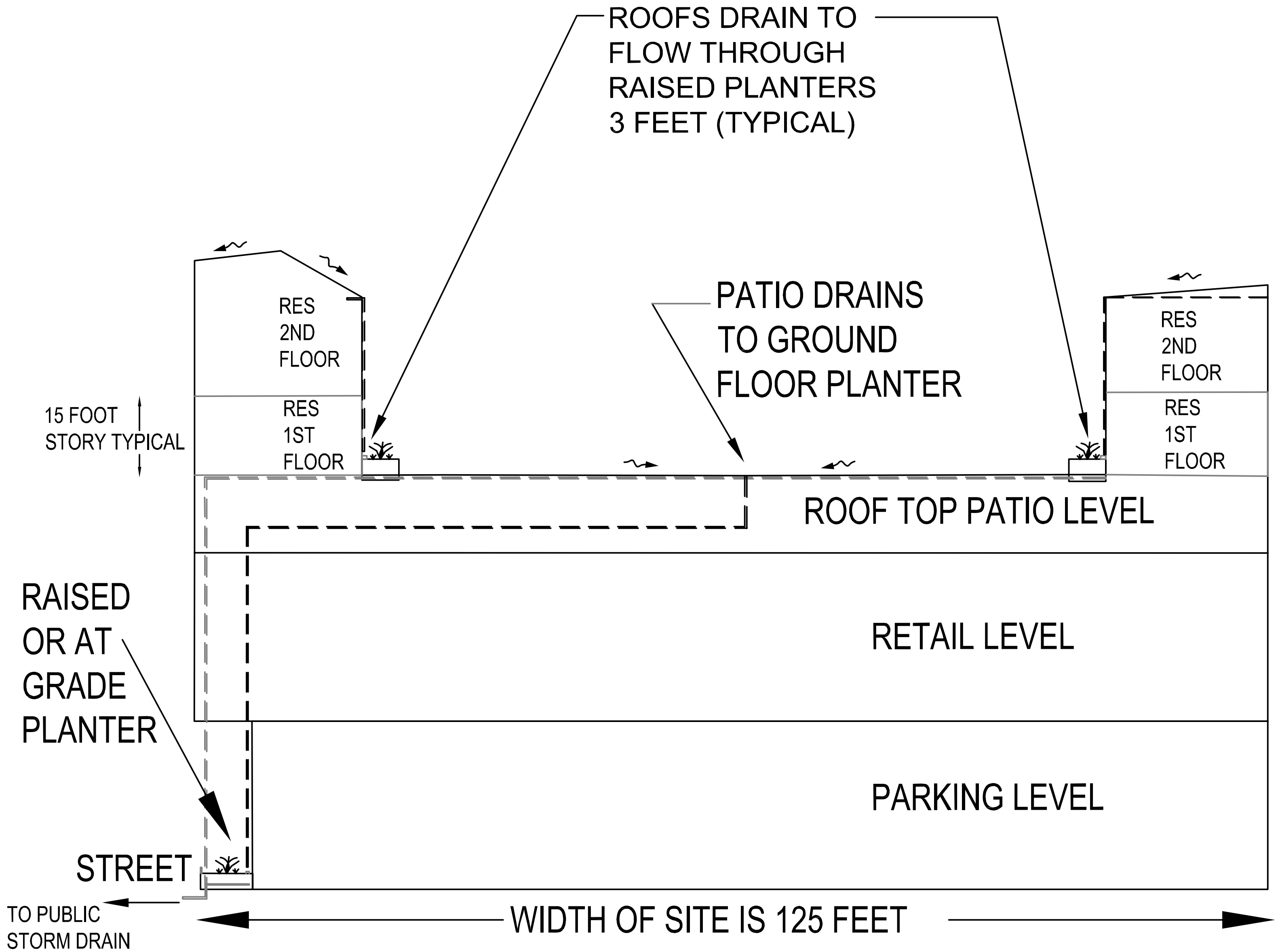
Table 2A
Example 2 Podium Type Structure Sample Calculations, Treatment Measure Sizing

Proposed Land Type	Area Treated (square feet)	Area Treated (acres)	Sizing Guidelines	Required Treatment Measure (square feet)	Provided Treatment Measure (square feet)
Concrete Roof Top Patio to Ground Floor Planter	9,000	0.21	Flow Through Planters Volume Method Multiply	360	360
Roofs to Roof Top Planters	15,000	0.34	Area by 0.04 (1) (3)	600	600
Roof Top Flow (2) Through Planters	1,000	0.02	Self Treating	0	0
Total	25,000	0.57			

(1) See Flow Through Planter C.3 Stormwater Guidance Documents
(2) Flow through planter box areas are included in the sizing of the treatment measure.
(3) Sizing guidline for Flow through planters is 0.04. Area treated 9,000 sf x 0.04 = 360 sf.
(4) Procedures are specified in the example.



TYPICAL ROOF LAYOUT PLAN VIEW 15 UNITS



TYPICAL ROOF LAYOUT CROSS SECTION B - B

Appendix

D

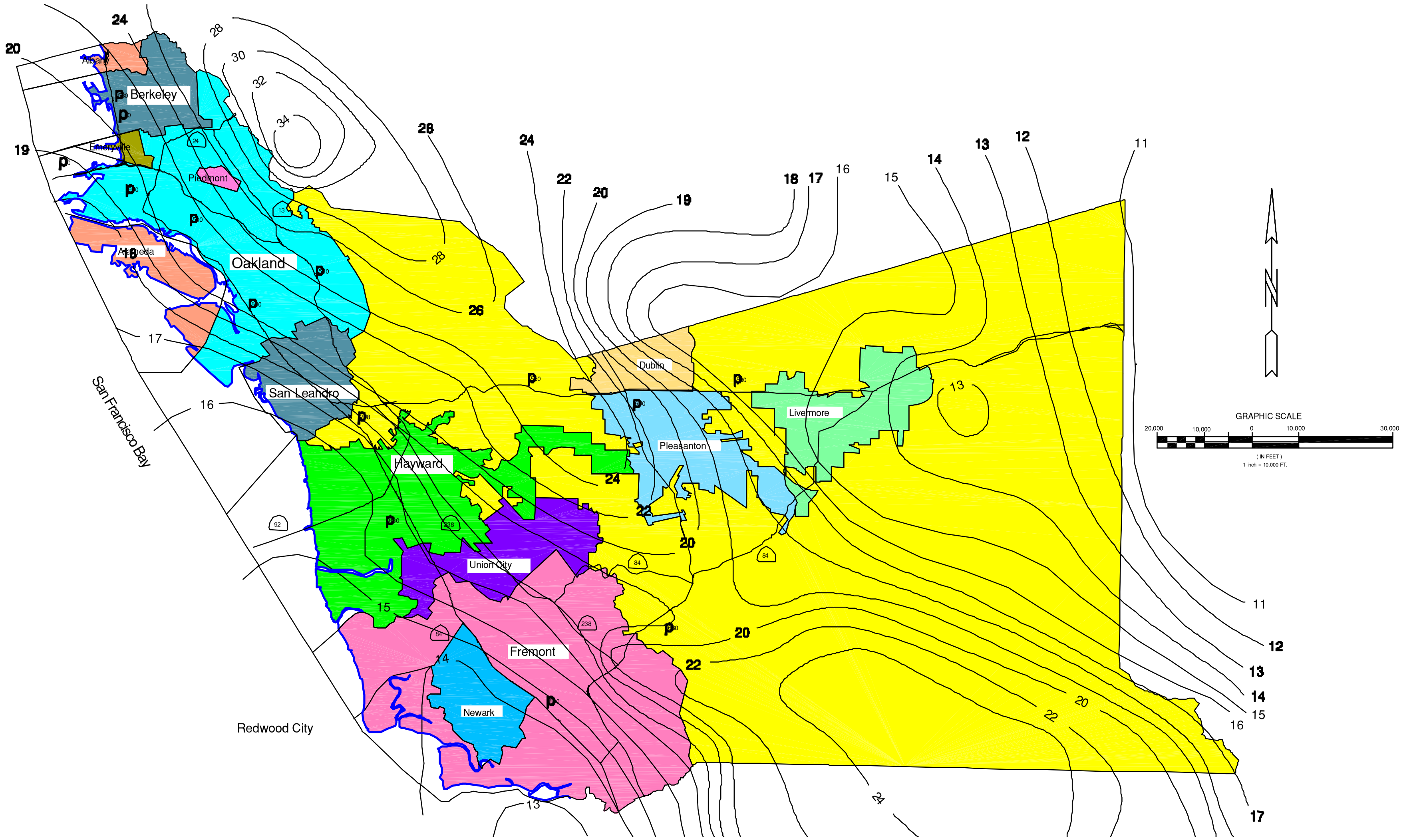
Local Requirements

Each of ACCWP's member agencies has its own requirements that must be met in the C.3 stormwater submittals that are included with planning and building permit applications. The agencies may include copies of these requirements in this Appendix when they distribute this handbook to project applicants. For those agencies that provide information regarding local requirements to ACCWP, links to this information will be posted on the Internet version of this handbook.

Appendix

E

Mean Annual Precipitation Map: Alameda County



ALAMEDA COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

MEAN ANNUAL PRECIPITATION

(VALUES IN INCHES)

DATE: MAY 2003

ATTACHMENT-6

Appendix F

Applicability of Inlet Filters, Oil/Water Separators, and Hydrodynamic Separators

As described in Section 5.2, three types of underground systems have been shown to have particular difficulty meeting the NPDES stormwater permit standard of removing pollutants to the maximum extent practicable (MEP) These three systems -- inlet filters (also called manufactured drain inserts), oil/water Separators (also called water quality inlets), and hydrodynamic separators – are described below. The Water Board staff's August 2004 letter that describes issues associated with these treatment measures is included at the end of this Appendix.

F.1 Inlet Filters

The California Stormwater Quality Association's (CASQA) New Development BMP Handbook describes storm drain inlet filters (which are also called manufactured drain inserts) as manufactured filters or fabric that are placed in a storm drain inlet to remove sediment and debris. In a letter dated August 5, 2004, the Water Board's Executive Officer described its assessment of studies and literature reviews for this type of treatment measure. The letter reported that these filters are subject to clogging, have very limited ability to remove dissolved pollutants, need very frequent maintenance, and are likely to receive inadequate maintenance. The following conclusion was made regarding inlet filters:

> "Based on our review of these references and experience in the Bay Area, it would be very unlikely for a proposal using inlet filters as the sole treatment measures to meet the MEP standard."[1]

Based on the Water Board staff's statements, ACCWP's member agencies do not approve proposals for the use of inlet filters as permanent, post-construction treatment measures, unless they are part of a stormwater "treatment train" approach that includes other, more effective types of stormwater treatment measures. The use of treatment trains is discussed in Section 5.1.4.

F.2 Oil/Water Separators

Oil/water separators, also called water quality inlets, are described in CASQA's New Development BMP Handbook as consisting of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil). The Water Board's August 5, 2004, letter described oil/water separators as originally developed for industrial uses and recognized as generally ineffective in removing the types of pollutants normally found in urban stormwater. The letter included the following summary statement regarding oil/water separators:

> "With the exception of projects where oil and grease concentrations are expected to be very high, and other measures are included in a 'treatment train' approach, Board staff is unlikely to consider oil/water separators as a means of meeting the MEP standard."

As with inlet filters, based on the Water Board staff's statements, ACCWP member agencies do not approve proposals for the use of oil/water separators to treat stormwater, unless they are used to treat high concentrations of oil and grease and the stormwater receives further treatment for fine-particulates associated with pollutants.

F.3 Hydrodynamic Separators

The US Environmental Protection Agency (USEPA) has described hydrodynamic separators as "flow-through structures with a settling or separation unit to remove sediments".[2] The energy from the flowing water allows sediments to settle, so no outside power source is needed.

The Contra Costa Clean Water Program has established a policy that hydrodynamic separators, when used as a sole method of stormwater treatment, do not meet the MEP

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[1] Letter from Bruce H. Wolfe, Executive Officer of the San Francisco Bay Regional Water Quality Control Board to the Bay Area Stormwater Management Agencies Association (BASMAA), dated August 5, 2004, Hhttp://www.cleanwaterprogram.org/uploads/RWQCB_letter_re_inlet_filters_etc.pdfH.

[2] USEPA, Hydrodynamic Separators Fact Sheet, 1999. Hhttp://www.epa.gov/owm/mtb/hydro.pdfH.

standard for stormwater treatment effectiveness.[3] The policy was based, in part, on a literature review that found that hydrodynamic separators were substantially less effective than various landscape-based treatment measures for removing pollutants that are associated with very fine particles and are identified as pollutants of concern in the Contra Costa Countywide NPDES municipal stormwater permit. The technical memorandum supporting the policy also described local experience successfully applying a variety of landscape-based treatment measures to development projects in Contra Costa County, as well as operation and maintenance concerns and mosquito generation potential associated with hydrodynamic separators.

The Water Board staff's August 5, 2004, letter includes vault-based hydrodynamic separators in a list of controls that, when compared to inlet filters, "with few exceptions, … appear to function more reliably to remove pollutants." The letter cautions, however, that for most new development projects, stormwater treatment measures "that address the broad spectrum of urban runoff pollutants, from trash to fine particulates and soluble pollutants, are needed."

F.4 Water Board Staff's Letter

A copy of the Water Board staff's August 2004 letter is included in the following pages.

[3] Contra Costa Clean Water Program, November 16, 2005. Policy on the Use of Hydrodynamic Separators to Achieve Compliance with NPDES Provision C.3. Hhttp://www.cccleanwater.org/construction/publications/hydrodynamicseparatorpolicy_11-16-05.pdfH.

California Regional Water Quality Control Board
San Francisco Bay Region

Terry Tamminen
Secretary for Environmental Protection

1515 Clay Street, Suite 1400, Oakland, California 94612
(510) 622-2300 • Fax (510) 622-2460
http://www.swrcb.ca.gov/rwqcb2

Arnold Schwarzenegger
Governor

Date: August 5, 2004
File No. 1538.09 (KHL, JBO)

BASMAA Managers
c/o Geoff Brosseau
BASMAA Executive Director
1515 Clay Street,
Suite 1400
Oakland, CA 94612

Subject: Use of Storm Drain Inlet Filters and Oil/Water Separators to Meet the Requirements of NPDES Municipal Stormwater Permits

Dear BASMAA Managers:

This letter responds to your requests to clarify the Water Board's review of an aspect of municipal stormwater permittee compliance with requirements to include treatment controls in new development and significant redevelopment projects. Please assist us in distribution of this letter to BASMAA member agencies and other interested parties.

The Board regularly receives inquiries regarding the inclusion of stormwater treatment control measures to remove pollutants from new development and redevelopment project runoff. As a state agency, the Board does not endorse specific treatment control products. Also, there is currently no State certification program that would certify the effectiveness of a particular product.

However, the Board's role does include determining permittees' compliance with their NPDES stormwater permits. This includes determining that municipalities have reduced the discharge of pollutants in storm water to the Maximum Extent Practicable (MEP). While not specifically defined within federal clean water law, MEP refers to implementing best management practices (BMPs) that are effective in addressing pollutants, generally accepted by the public, of reasonable cost, and technically feasible.

When reviewing compliance with permit requirements for new development and redevelopment projects, Board staff looks to see that permittees have required projects to incorporate appropriate source controls to prevent the discharge of pollutants, design measures to reduce impervious surface, and treatment controls to remove pollutants from runoff. We review whether these measures have been appropriately designed to be effective, given the existing state of knowledge. For example, is a vegetated swale designed within parameters specified in existing literature as being effective? Such parameters include minimum residence times, maximum flow depths and velocities, limits on swale longitudinal and side slopes, inclusion of a subdrain if in very tight soils, and similar considerations.

Oil/Water Separators

Another example, vault-based oil-water separators, also known as water quality inlets, was originally designed for industrial use. These have been recognized to be generally ineffective at removing pollutants at concentrations seen in urban stormwater runoff, because removal rates are low and those pollutants that are removed are often flushed out by subsequent storms, especially when a separator is not frequently maintained. With the exception of projects where oil and grease concentrations are expected to be very high, and other controls are included in a “treatment train” approach, Board staff is unlikely to consider oil/water separators as a means of meeting the MEP standard.

Storm Drain Inlet Filters

Storm drain inlet filters, also known as drain inlet inserts, also have been shown to have limited effectiveness in removing pollutants from urban stormwater runoff, due to the nature of their design. Inlet filters are typically either bags or trays of filter media that are designed to catch and treat runoff as it enters the storm drain. They are manufactured stormwater treatment controls, and are typically popular because they have a low capital cost relative to other controls and can be placed into a traditional engineered storm drain design without altering that design.

In determining whether drain inlet filters meet the MEP standard, we reviewed the existing state of knowledge. Board staff’s assessment of studies and literature reviews for this class of controls has found the following:

- Filters are subject to clogging and/or blinding by sediment, trash, and vegetation, resulting in runoff bypassing the filter and/or flooding;
- Maintaining filter performance requires very frequent maintenance (as often as during and after every storm). Manufacturers in practice understate the maintenance requirements for this class of devices. In practice, maintenance is not completed at an effective frequency, particularly to avoid bypass of the filter element clogged with debris;
- Inlet filters, by virtue of their location below a storm drain grate, are out of sight. This can lead to reduced maintenance resulting from the filters being out-of-sight, and thus out-of-mind;
- Filter performance may decay rapidly over a time frame that is significantly shorter than typically recommended replacement or maintenance intervals;
- Filters appear to have very limited ability to remove dissolved pollutants, smaller particulates, and emulsified oil and grease, and may have a limited ability to remove

oil and grease as it is found in urban runoff. The filter element in inlet filters is small and easily bypassed if fouled to prevent flooding.

The limited space within a storm drain inlet appears to preclude highly effective treatment. To the extent that treatment is accomplished, it appears that these controls require an intensive maintenance regime—one that is expensive and which, based on our experience in the Bay Area, is ultimately not completed once the controls have been installed.

A list of references reviewed is attached and includes reports prepared by Bay Area municipal stormwater programs that found the effectiveness of existing inlet filter products to be very limited. Based on our review of these references and experience in the Bay Area, it would be very unlikely for a proposal using inlet filters as the sole treatment measures to meet the MEP standard.

Fortunately, there are a variety of effective controls available to project proponents and designers as alternatives to inlet inserts. These include a range of landscape-based controls (e.g., vegetated swales, bioretention areas, planter/tree boxes, ponds, and stormwater wetlands) and a series of manufactured controls (e.g., vault-based hydrodynamic separators, vault-based media filters, and other solids removal devices). With few exceptions, these controls appear to function more reliably to remove pollutants, and thus would better represent "MEP."

Each type of BMP should be used in situations for which it is appropriate. For example, the City of Oakland is working to limit trash discharged into Lake Merritt. For that project, controls that primarily remove trash may be most appropriate. For most new development projects, however, BMPs that address the broad spectrum of urban runoff pollutants, from trash to fine particulates and soluble pollutants, are needed.

We recognize that inlet filter products with substantially improved performance may be developed in the future. Also, certification programs like Washington State's "Evaluation of Emerging Stormwater Treatment Technologies," which reviews technologies to determine whether they are at least as good as existing non-proprietary measures, may establish viable treatment measures. As with any aspect of the NPDES stormwater program, we anticipate that the municipal stormwater programs and the Board will continue to review information as it is developed so as to best determine what constitutes MEP, and to help ensure the reasonable cost in implementation of effective BMPs.

If you have any questions or further comments, please contact Dale Bowyer at (510) 622-2323 or via email to dcb@rb2.swrcb.ca.gov, or Keith Lichten via email to khl@rb2.swrcb.ca.gov, or at (510) 622-2380.

Sincerely,

--*original signed by*--

Bruce H. Wolfe
Executive Officer

Attachment: References Reviewed

ATTACHMENT: REFERENCES REVIEWED

Author	Title	Date	Notes
McDonald, Jonathan / Kristar	Letter & Attachments	September 19, 2003	
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Application of Water-Quality Engineering Fundamentals to the Assessment of Stormwater Treatment Devices	August 28, 2002	
SCVURPPP	An Update of the 1999 Catch Basin Retrofit Feasibility Study Technical Memorandum	June 26, 2002	
SCVURPPP	Catch Basin Retrofit Feasibility Study Technical Memorandum	July 12, 1999	
Woodward-Clyde for SCVURPPP	Parking Lot Monitoring Report	June 11, 1996	
Woodward-Clyde for SCVURPPP	Parking Lot BMP Manual	June 11, 1996	
Minton, Gary R./Abtech Industries	Technical Review of the AbTech Ultra-Urban Filter	January 4, 2002	
URS Greiner Woodward Clyde (now URS) / Alameda County Urban Runoff Clean Water Program (now ACCWP)	Stormwater Inlet Insert Devices Literature Review	April 2, 1999	
USEPA/NSF International	ETV Joint Verification Statement: Hydro-Kleen Filtration System	September 2003	
USEPA/NSF International	Environmental Technology Verification Report; In-Drain Treatment Technologies Equipment Verification; Hydro Compliance Management, Inc., Hydro-Kleen Filtration System	September 2003	

Othmer, Friedman, Borroum, and Currier / Caltrans	Performance Evaluation of Structural BMPs: Drain Inlet Inserts (Fossil Filter and StreamGuard) and Oil/Water Separator	2001	
Woodward-Clyde Consultants / Alameda County Urban Runoff Clean Water Program	Street Sweeping/Storm Inlet Modification Literature Review	December 21, 1994	
Woodward-Clyde in association with UCLA and Psomas & Associates.	Santa Monica Bay Municipal Storm Water/Urban Runoff Pilot Project—Evaluation of Potential Catchbasin Retrofits	September 24, 1998	Prepared for Santa Monica Cities Consortium
Interagency Catch Basin Insert Committee	Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites	October 1995	ICBIC is comprised of: King County Surface Water Mgmt. Div.; King County Dept. of Metropolitan Svcs.; Snohomish County Surface Water Mgmt. Div.; Seattle Drainage and Wastewater Utility; and Port of Seattle.
Caltrans	BMP Retrofit Pilot Program: Final Report (Report ID CTSW-RT-01-050)	January 2004	
Elizabeth Miller Jennings, Senior Staff Counsel, Office of Chief Counsel, State Water Resources Control Board	Memorandum on Maximum Extent Practicable	February 11, 1993	

Appendix

G

Infiltration Guidelines

As a stormwater management method, infiltration means ***retaining or detaining water within soils*** to reduce runoff. Infiltration can be a cost-effective method to manage stormwater – if the conditions on your site allow. These infiltration guidelines identify categories of stormwater infiltration methods, and describe factors that affect the feasibility of their use.

G.1 Stormwater Controls that Promote Infiltration

A wide-range of site-design measures and stormwater treatment measures allow stormwater infiltration and can be categorized as described below and illustrated in Figure G-1.

A. ***Site design measures*** -- such as clustering development or otherwise laying out the site to reduce impervious area, routing drainage from building roofs to landscaped areas, and using pervious pavement.

B. ***Indirect infiltration methods***, which allow stormwater runoff to percolate into surface soils. The infiltrated water may either percolate down into subsurface soils and eventually reach groundwater, or it may be underdrained into subsurface pipes. Examples of indirect infiltration methods include bioretention areas and vegetated swales.

C. ***Direct infiltration methods***, which are designed to bypass surface soils and transmit runoff directly to subsurface soils and eventually groundwater. These types of devices must be located and designed to limit the potential for groundwater contamination. Examples of direct infiltration methods include infiltration trenches, infiltration basins, and dry wells.

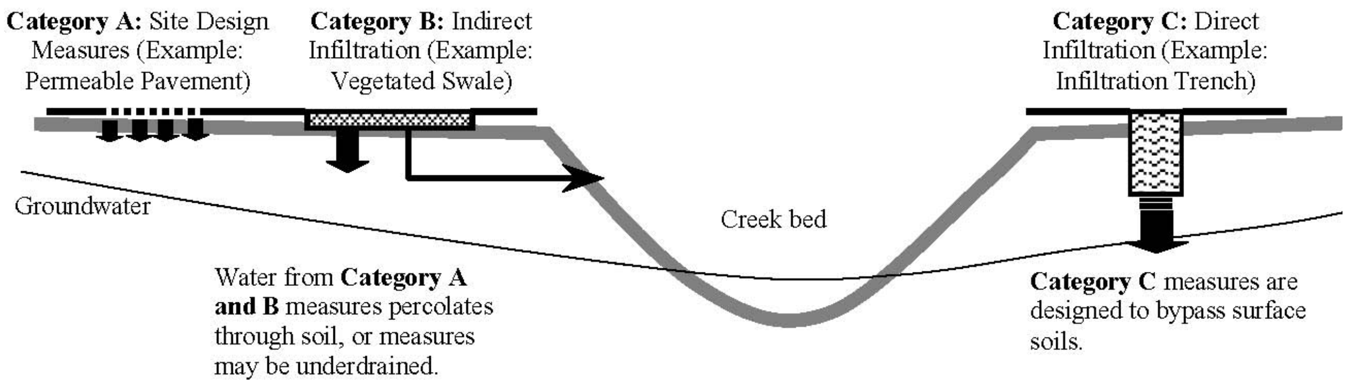

Figure G-2: Stormwater Infiltration Methods (Source: Contra Costa Clean Water Program, 2005)

Table G-1 describes common stormwater controls and groups them according to whether they meet the above definitions of categories A, B and C. References to the applicable section of Chapter 5 or 6 are given for stormwater controls that have specific technical guidance included in this handbook.

Table G-1
Infiltration Methods in Commonly-Used Stormwater Controls

Stormwater Control	Description	Guidance in Section
Category A: Site Design Measures		
Amending Soils	Soil amendments and tilling enhance or restore permeability and storage in the top layer of soils, reducing runoff.	N/A
Cisterns	Above ground storage vessels, sometimes with a manually operated valve, store runoff for post-storm discharge to landscaping.	N/A
Disconnected Downspouts	Instead of connecting directly to storm drains, roof runoff is directed away from the building to nearby landscaped areas.	N/A
Green Roofs	May be “extensive” with a 3-7 inch lightweight substrate and a few types of low-profile plants; or may be “intensive” with a thicker substrate, more varied plantings, and a more garden-like appearance.	4.1
Pervious Pavements	Special mixes of concrete and asphalt. Require a base course of crushed aggregate and installation by experienced crews.	4.2
Site Grading	Using gentler slopes and concave areas to reduce runoff and encourage infiltration.	N/A

Table G-1
Infiltration Methods in Commonly-Used Stormwater Controls

Stormwater Control	Description	Guidance in Section
Category A: Site Design Measures (continued)		
Site Layout Practices	Examples: Use compact, multi-story buildings to reduce building footprint, cluster buildings to reduce street length and protect sensitive areas, design narrow streets, use sidewalks on one side of steet.	N/A
Turf Block	A load-bearing, durable surface of impermeable blocks separated by spaces and joints in which soil is planted with turf.	4.7
Unit Pavers	Traditional bricks or other pavers on sand or fine crushed aggregate.	4.7
Category B: Indirect Infiltration		
Bioretention Area	Briefly ponds stormwater on the surface of a shallow depression and allows it to percolate through permeable soil. May require underdrain if native soils drain poorly.	6.1
Flow-Through Planter Box	Contained planter that receives runoff, which is held in a surface reservoir, infiltrates through a layer of soil, collects in a gravel layer below, seeps into a perforated pipe subdrain, and drains to storm drain.	6.3
Tree Well Filter	A box that contains filtering media in which a small tree or shrub is planted. Water filters through the media and is directed to storm drain.	6.6
Vegetated Buffer Strip	Sloped area with low-growing vegetation that treats runoff by slowing the velocity so sediment and associated pollutants can settle, along with some infiltration.	6.7
Vegetated Swale	Open, shallow channel with thick vegetation that collects and slowly conveys runoff to discharge point. Runoff is treated through settling, filtering, and infiltration. A subdrain may be needed in poorly drained soil.	6.8
	Category C: Direct Infiltration	
Infiltration Trench	A trench with no outlet, filled with rock or open graded aggregate.	6.4
Infiltration Basin	An excavation that exposes relatively permeable soils and impounds water for rapid infiltration.	N/A
Dry Well	Small, deep hole filled with open graded aggregate. Sides may be lined with filter fabric or may be structural (i.e., an open bottom box sunk below grade). Typically receives roof runoff.	N/A
Sources: Contra Costa Clean Water Program, 2005; CASQA, 2003.		

G.2 Factors Affecting Feasibility of Infiltration

A variety of factors may limit or prevent the use of a stormwater control that acts to infiltration stormwater into the soil. Some factors, such as clayey soils or high groundwater, may make direct infiltration infeasible. In these circumstances indirect infiltration methods may be used on the site if an underdrain is provided. Factors affecting the feasibility of stormwater infiltration are listed below.

Surface Slope

Stormwater infiltration is most feasible on flatter sites. Surface flows applied to slopes may runoff rather than soak into the ground. On hillsides, infiltrated runoff will tend to surface a short distance downslope and may also cause geotechnical instability (see Geotechnical Considerations, below).

Soil Type

The US Department of Agriculture, Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) classifies soil types into four hydrologic soil groups:

- ***Group A*** soil are typically sands, loamy sands or sandy loams. Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excesseively drained sands or gravels and have a high rate of water transmission.
- ***Group B*** soils are typically silt loams or loams. They have a moderate infiltration rate when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture.
- ***Group C*** soils are typically sandy clay loams. They have low infiltration rates when thoroughly wetted and consists chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- ***Group D*** soils are typically clay loams, silty clay loams, sandy clays, silty clays or clays. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

If your site has Group A or B soils, the infiltration rates should be high enough to support a stormwater treatment measure that uses direct infiltration. If the site has Group C or D soils, direct infiltration is generally infeasible, but stormwater treatment measures that use indirect infiltration may be feasible if the existing soil is replaced or amended to allow adequate infiltration, and subdrain may also be needed. Most of Alameda County has Group C or D soils, with some exceptions in the eastern part of the county. If the infiltration rate of native subsurface soils will be used to size a stormwater treatment measure, the soils should be tested by a qualified professional. The professional may be a soils scientist, geologist licensed in California, or registered professional engineer.

Geotechnical Considerations

Increased water pressure in soil pores reduces soil strength, making foundations more susceptible to settlement and slopes more susceptible to failure. In general, site design measures and stormwater treatment measures that use infiltration must be set back from building foundations or steep slopes. Recommendations for each site should be determined by a qualified geotechnical engineer based on soils boring data, drainage pattern and the current requirements for stormwater treatment. Implementing the geotechnical engineer's requirements is essential to prevent damage from underground water to surrounding properties, public improvements or slope banks, and even mudslides that can result from accumulated subsurface water.

Existing Groundwater Pollution

Infiltration should be avoided where it could contribute to the movement or dispersion of existing groundwater contamination. This includes sites listed by the Water Boards' Leaking Underground Storage Tanks (LUST) and Spills, Leaks, Investigations, and Complaints (SLIC) programs.

Protecting Groundwater

To protect water quality, the Water Board has specific requirements for stormwater treatment measures that function primarily as infiltration devices (such as infiltration basins and infiltration trenches). These stormwater treatment measures meet the definition of Category C – direct infiltration used in these guidelines. The Water Board's requirements for direct infiltration devices are listed in Table G-2.

Table G-2
Water Board Criteria for Direct Infiltration Devices

Groundwater separation	Minimum 10 feet from bottom of infiltration device to seasonal high groundwater in any location. In areas characterized by highly porous soils and/or high groundwater, treatment measure approvals shall be subject to a higher level of analysis (for example, considering the potential for contamination from on-site chemical use, the level of pretreatment prior to infiltration, and similar factors).
Land use and vehicle traffic	Unless pretreatment is provided prior to infiltration, direct infiltration devices shall not be recommended in the following locations: Areas of industrial or light industrial activity; Areas subject to high vehicular traffic: 25,000 or greater Average Daily Traffic (ADT) on a main roadway or 15,000 or more ADT on any intersecting roadway; Automobile repair shops, car washes, fleet storage areas (bus, truck, etc.); Nurseries and other land uses that pose a high risk of contamination, including activities as designated by the local jurisdiction.
Water supply wells	Locate direct infiltration devices a minimum of 100 feet horizontally from any water supply wells.
Source control measures	Implement pollution prevention and source control measures on the site at a level appropriate to protect groundwater quality.
Water quality objectives	The use of infiltration devices shall not cause or contribute to degradation of water quality objectives.
Maintenance	Infiltration devices shall be adequately maintained to maximize pollutant removal capabilities.

Source: San Francisco Bay Regional Water Quality Control Board, February 2003 (Provision C.3i of ACCWP's Stormwater NDPES permit)

In order to protect underground sources of drinking water, the USEPA regulates some infiltration devices as Class V wells under its Underground Injection Control (UIC) Program.

A Class V injection well is defined as "… any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system."[1] Infiltration trenches are typically not considered Class V injection wells because they are longer than they are wide. The USEPA's regulations state that stormwater drainage wells are "authorized by rule" (40 CFR 144), which means they do not require a permit if they do not endanger underground sources of drinking water, and they comply with federal UIC requirements. The USEPA's fact sheet, "When Are Storm Water Discharges Regulated as Class V Wells?" is included at the end of this appendix.

If your project includes one or more infiltration devices that are regulated as Class V injection wells, you will need to submit basic inventory information about the device(s) to the regional office of the USEPA. Instructions for submitting this information are available on the USEPA Region 9 website at http://www.epa.gov/region09/water/groundwater/uic-classv.html. Project sponsors are responsible for constructing, operating and closing the drainage well in a manner that does not risk contaminating underground sources of drinking water. The USEPA may place additional requirements on the infiltration device. Project sponsors should contact the appropriate USEPA staff, identified on the Internet link provided above, to learn what inventory information should be submitted, and when the submittal should be made.

G.3 Dealing with Common Site Constraints

The following tips are intended to help manage constraints to infiltration that are common in Alameda County.

- On sites with ***clay soils*** (Hydrologic Soil Group "C" or "D"), vegetated swales or bioretention areas may be used if drainage is sufficient or underdrains are provided. Some indirect infiltration to groundwater will occur and will enhance the effectiveness of these treatment measures.. Site design measures such as disconnected downspouts and pervious paving may be used if soils are amended and positively drained.
- Infiltration is generally infeasible on ***steep or unstable slopes***. Site design measures that limit impervious area may be appropriate if approved by a geotechnical engineer. Consider detaining runoff in green roofs and cisterns, or using stormwater treatment measures that do not infiltrate water into the natural ground, such as flow-through planters or tree well filters.
- Green roofs, cisterns, flow-through planters, tree well filters, and other stormwater controls that are isolated from underlying soils are also appropriate for areas with ***high ground water*** and/or ***groundwater contamination***.
- A variety of ***site design measures*** can often be used even on sites with the constraints described above, including (but not limited to) amended soils, structural soils, grading landscaping to a concave form, designing taller buildings with smaller footprints, and concentrating development on less sensitive portions of the site.

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[1] USEPA Office of Ground Water and Drinking Water, "When Are Storm Water Discharges Regulated as Class V Wells?," June 2003.

Appendix

H

Mosquito Control Guidelines

This appendix presents the guidance for designing and maintaining stormwater treatment measures to control mosquitoes from ACCWP's Vector Control Plan. Project sponsors are responsible for incorporating in their treatment measure designs and maintenance plans the Vector Control Plan's design and maintenance guidance, which is presented below.

H.1 Design Guidance for Mosquito Control

The following design considerations were adapted from guidance prepared by the California Department of Health Services,[1] and are provided for project sponsors to use when selecting, designing, and constructing stormwater treatment measures.

General Design Principles

- Preserve natural drainage. Better site design measures reduce the amount of stormwater runoff and provide for natural on-site runoff control. This will reduce the number of stormwater treatment measures required.
- In flat areas, where standing water may occur for more than five days under existing conditions, consider grading to make minor increases in slope to improve surface drainage and prevent standing water.
- Select stormwater treatment measures based on site-specific conditions. Designs that take into account site conditions tend to improve drainage and limit the occurrence of stagnant water.
- Careful consideration should be made before intermittently flooded stormwater treatment measures are selected for handling stormwater. Facilities that pond water temporarily (e.g., extended detention basins) should be designed to drain water completely within five days of a storm event. Avoid placement of extended detention basins and underground structures in areas where they are likely to remain wet (i.e., high water tables). The principal outlet should have positive drainage.

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[1] Metzger, Marco, Vector-Borne Disease Section, California Department of Health Services. "Managing Mosquitoes in Stormwater Treatment Devices," 2004.

- When a new stormwater treatment measure is being installed, consider selecting a type that does not require a wet pond or other permanent pool of water.
- Properly design storm drains. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe. Storm drains should be constructed so that the invert out is at the same elevation as the interior bottom to prevent standing water.
- Use grouted rock energy dissipaters instead of loose rock.
- In practice, many stormwater treatment measures, not only wet ponds, hold water for over five days, sometimes due to their outdated designs, and possibly due to improper construction and maintenance. To ensure that public health and safety are protected, the following suggestions should be considered for any structure that holds water for over five days:
  - Select or design an alternative (or modified) device that provides adequate - pollutant removal and complete drainage in five days. This is the most reliable and cost-effective choice.
  - Contact state or local public health or vector control agencies to determine whether local mosquito species and local factors may preclude rapid mosquito emergence, thus safely allowing water residence times to exceed five days. In some areas this may require a detailed study that should be funded by the soliciting party.

General Access Requirements for Mosquito Control

The following requirements are necessary to provide mosquito abatement personnel access to treatment measures for inspection and abatement activities.

- Design stormwater treatment measures to be easily and safely accessible without the need for special requirements (e.g., OSHA requirements for “confined space”).
- If utilizing covers, include in the design spring-loaded or light-weight access hatches that can be opened easily for inspection.
- Provide all-weather road access (with provisions for turning a full-size work vehicle) along at least one side of large above-ground structures that are less than 25 feet wide. For structures that have shoreline-to-shoreline distances in excess of 25 feet, a perimeter road is required for access to all sides.

Dry System Design Principles for Mosquito Control

- Structures should be designed so they do not hold standing water for more than five days.
- Incorporate features that prevent or reduce the possibility of clogged discharge orifices (e.g., debris screens). The use of weep holes is not recommended due to rapid clogging.

- Use the hydraulic grade line of the site to select a stormwater treatment measure that allows water to flow by gravity through the structure. Pumps are not recommended because they are subject to failure and often require sumps that hold water.
- Design distribution piping and containment basins with adequate slopes to drain fully and prevent standing water. The design slope should take into consideration buildup of sediment between maintenance periods. Compaction during grading may also be needed to avoid slumping and settling.
- Avoid the use of loose riprap or concrete depressions that may hold standing water.
- Avoid barriers, diversions, or flow spreaders that may retain standing water.
- Use mosquito net to cover sand media filter sump pumps.
- Use aluminum "smoke proof" covers for any vault sedimentation basins.
- Properly design storm drain measures. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe.

Sumps, Wet Vaults, and Catch Basin Design Principles for Mosquito Control

- Completely seal structures that retain water permanently or longer than five days to prevent entry of adult mosquitoes. Adult female mosquitoes may penetrate openings as small as 1/16 inch (2 mm) to gain access to water for egg laying. Screening (24 mesh screens) can exclude mosquitoes, but it is subject to damage and is not a method of choice.
- If covers are used, they should be tight fitting with maximum allowable gaps or holes of 1/16 inch (2 mm) to exclude entry of adult mosquitoes. Gaskets are a more effective barrier when used properly.
- Any covers or openings to enclosed areas where stagnant water may pool must be large enough (2 feet by 3 feet) to permit access by vector control personnel for surveillance and, if necessary, abatement activities.
- If the sump, vault, or basin is sealed against mosquitoes, with the exception of the inlet and outlet, use a design that will submerge the inlet and outlet completely to reduce the available surface area of water for mosquito egg-laying (female mosquitoes can fly through pipes).
- Creative use of flapper or pinch valves, collapsible tubes and "brush curtains" may be effective for mosquito exclusion in certain designs.
- Design structures with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering of the unit, if necessary.

Wet Ponds And Wetlands Design Principles for Mosquito Control

- If a wet pond or constructed, modified, or restored wetland must be built, appropriate and adequate funds must be allocated to support long-term site maintenance as well as routine monitoring and management of mosquitoes by a qualified agency.

- Long-term management of mosquitoes in wet ponds and wetlands should integrate biological control, vegetation management and other physical practices, and chemical control as appropriate.
- Provide for regular inspection of sites for detection of developing mosquito populations. Local factors may influence the overall effectiveness of certain approaches for mosquito reduction.
- Wet ponds and wetlands should maintain water quality sufficient to support surface-feeding fish such as mosquito fish (*Gambusia affinis*), which feed on immature mosquitoes and can aid significantly in mosquito control.
- If large predatory fish are present (e.g., perch and bass), mosquito fish populations may be negatively impacted or eradicated. In this case, careful vegetation management remains the only nonchemical mosquito control system.
- Where mosquito fish are not allowed, careful vegetation management remains the only nonchemical mosquito control system. Other predators such as dragonflies, diving beetles, birds, and bats feed on mosquitoes when available, but their effects are generally insufficient to preclude chemical treatment.
- Perform routine maintenance to reduce emergent plant densities. Emergent vegetation provides mosquito larvae with refuge from predators, protection from surface disturbances, and increased nutrient availability while interfering with monitoring and control efforts.
- Whenever possible, maintain wet ponds and wetlands at depths in excess of 4 feet to limit the spread of invasive emergent vegetation such as cattails (*Typha* spp.). Deep, open areas of exposed water are typically unsuitable for mosquito immatures due to surface disturbances and predation. Deep zones also provide refuge areas for fish and beneficial macroinvertebrates should the densely vegetated emergent zones be drained.
- Build shoreline perimeters as steep and uniform as practicable to discourage dense plant growth.
- Use concrete or liners in shallow areas to discourage unwanted plant growth where vegetation is unnecessary.
- Eliminate floating vegetation conducive to mosquito production, such as water hyacinth (*Eichhornia* spp.), duckweed (*Lemna* and *Spirodela* spp.), and filamentous algal mats.
- Make shorelines accessible to maintenance and vector control crews for periodic maintenance, control, and removal of emergent vegetation, as well as for routine mosquito monitoring and abatement procedures, if necessary.
- Improve designs of permanent pools. Minimize shallow depths and increase circulation in ponds. Permanently flooded measures should be stocked with native *Gambusia* minnows to foster biological predation on mosquito larvae.
- Do not use stormwater structures to meet endangered species mitigation requirements. Aquatic habitat for endangered species should not be created near areas populated by humans.

H.2 Maintenance Guidance for Mosquito Control

Routine and timely maintenance is critical for suppressing mosquito breeding as well as for meeting local water quality goals. If maintenance is neglected or inappropriate for a given site, even structures designed to be the least “mosquito friendly” may become significant breeding sites. Although general principles of vector control are described here, maintenance guidelines for individual treatment measures are often site-specific.

The maintenance principles given below are intended to reduce the mosquito population. These principles should be incorporated, as appropriate, in maintenance plans developed for stormwater treatment control measures and in the ongoing maintenance and inspection of treatment measures.

General Maintenance Principles

- With the exception of certain treatment control measures designed to hold permanent water, treatment measures should drain completely within five days to effectively suppress vector production.
- Any circumstances that restrict the flow of water from a system as designed should be corrected. Debris or silt build-up obstructing an outfall structure should be removed. Under drains and filtration media should be inspected periodically and cleaned out or replaced as needed.
- Conduct maintenance activities regularly, in accordance with a municipality-approved maintenance plan.

Vegetation Management Maintenance Principles

- Conduct annual vegetative management, such as removing weeds and restricting growth of aquatic vegetation to the periphery of wet ponds.
- Remove grass cuttings, trash and other debris, especially at outlet structures.
- Avoid producing ruts when mowing (water may pool in ruts).

Dry System Maintenance Principles for Mosquito Control

- Extended detention basins are usually designed to detain water for 40 or 48 hours. If they detain water for longer than five days, they are poorly maintained.
- If a detention basin has been installed at an inappropriate location (e.g., on a site where the water table is too close to the surface), and if elimination or modification of the system isn’t possible then mosquitoes must be controlled with larvicides. The larvicide operation, in order to be effective, must be supported by a quality inspection program. Larvacides should only be applied by licensed pesticide applicators.

Underground Structure Maintenance Principles for Mosquito Control

- Prevent mosquito access to underground treatment control measures that may have standing water (i.e., seal openings that are 1/16-inch in diameter or greater).
- Provide vector control agencies access to underground measures that may have standing water.

Infiltration and Filtration Device Maintenance Principles for Mosquito Control

- Infiltration trenches and sand filter structures should not hold water for longer than 24 hours. If they retain water for longer than 48 hours, they are poorly maintained.

Operation & Maintenance Document Templates

Example templates are provided to assist project applicants in preparing the following documents, which municipalities may require as exhibits to a stormwater treatment measure maintenance agreement:

- Standard Treatment Measure O&M Report Form
- Maintenance Plan for Vegetated Swale
- Maintenance Plan for Extended Detention Basin

Requirements vary from one municipality to the next. Contact the local jurisdiction to obtain electronic files for use in preparing these documents, and to obtain information on municipality-specific requirements.

Stormwater Treatment Measure Operation and Maintenance

Inspection Report to the [[== Insert Name of Agency==]], California

This report and attached Inspection and Maintenance Checklists document the inspection and maintenance conducted for the identified stormwater treatment measure(s) subject to the Maintenance Agreement between the City and the property owner during the annual reporting period indicated below.

I. Property Information:

Property Address or APN: ____

Property Owner: ____

II. Contact Information:

Name of person to contact regarding this report:_____________________________

Phone number of contact person:_______________ Email:______________________

Address to which correspondence regarding this report should be directed:

____

____

III. Reporting Period:

This report, with the attached completed inspection checklists, documents the inspections and maintenance of the identified treatment measures during the time period from ____________ to __________.

IV. Stormwater Treatment Measure Information:

The following stormwater treatment measures (identified treatment measures) are located on the property identified above and are subject to the Maintenance Agreement:

Identifying Number of Treatment Measure	Type of Treatment Measure	Location of Treatment Measure on the Property

V. Summary of Inspections and Maintenance:

Summarize the following information using the attached Inspection and Maintenance Checklists:

Identifying Number of Treatment Measure	Date of Inspection	Operation and Maintenance Activities Performed and Date(s) Conducted	Additional Comments

VI. Sediment Removal:

Total amount of accumulated sediment removed from the stormwater treatment measure(s) during the reporting period: __________ cubic yards.

How was sediment disposed?

- ☐ landfill
- ☐ other location on-site as described in and allowed by the maintenance plan
- ☐ other, explain ____________________

VII. Inspector Information:

The inspections documented in the attached Inspection and Maintenance Checklists were conducted by the following inspector(s):

Inspector Name and Title	Inspector's Employer and Address

VIII. Certification:

I hereby certify, under penalty of perjury, that the information presented in this report and attachments is true and complete:

______________________________________ _________________
Signature of Property Owner or Other Responsible Party Date

____
Type or Print Name

____
Company Name

____
Address

Phone number:__________________ Email:______________________________

Vegetated Swale Maintenance Plan for
[[== Insert Property Address ==]]

[[== Insert Date =]]

The property contains [[== insert number ==]] vegetated swales, located as described below and as shown in the attached site plan.

- **Vegetated swale No. 1** is located at [[== describe location ==]].
- **Vegetated swale No. 2** is located at [[== describe location ==]].
- [[== Add descriptions of other swales, if applicable. ==]]

I. Routine Maintenance Activities

The maintenance objectives for the vegetative swales include keeping up the pollutant removal efficiency of the channel by maintaining a dense, healthy vegetated cover. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Vegetated Swales

No.	Maintenance Task	Frequency of Task
1	Mow turf grass to [[==indicate height ==]]. Remove grass cuttings. Avoid producing ruts when mowing.	[[== insert frequency ==]]
2	Irrigate during dry weather.	[[== insert frequency ==]]
3	Remove obstructions and trash from vegetated swale	Monthly, or as needed
4	Inspect swale to check for erosion and sediment and debris accumulation	Twice a year: 1) one inspection should occur at the end of the wet season in order to plan and schedule summer maintenance, 2) the other inspection should occur after periods of heavy runoff
5	Remove sediment accumulating near culverts and in channels when it builds up to 75 millimeters (3 inches) at any spot, or if it covers vegetation	As needed.
6	Inspect swale using the attached inspection checklist.	Monthly, or as needed

II. Prohibitions

Pesticides and fertilizers shall not be used in vegetated swales.

III. Inspections

The attached Vegetated Swale Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Vegetated Swale
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________

Treatment Measure No.: __________ Date of Inspection: _________ Type of Inspection: ❑ Monthly ❑ End of Wet Season ❑ After heavy runoff ❑ Other:__________

Inspector(s): ________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	**Results Expected When Maintenance Is Performed**
Sediment Accumulation on Vegetation	Sediment accumulating near culverts and/or in channels builds up to 75 millimeters (3 inches) at any spot, or it covers vegetation			Sediment accumulated sediment deposits. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
Standing Water	When water stands in the swale between storms and does not drain freely.			There should be no areas of standing water once inflow has ceased. Any of the following may apply: sediment or trash blockages removed, improved grade from head to foot of swale, removed clogged check dams, added underdrains or converted to a wet swale.
Flow spreader (if any)	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.			Spreader leveled and cleaned so that flows are spread evenly over entire swale width.
Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.			No eroded, muddy channel on the bottom. A low-flow pea-gravel drain may be added the length of the swale.
Poor Vegetation Coverage	When planted vegetation is sparse or bare or eroded patches occur in more than 10% of the swale bottom.			Vegetation coverage in more than 90% of the swale bottom. Determine why growth of planted vegetation is poor and correct that condition. Re-plant with plugs of vegetation from the upper slope: plant in the swale bottom at 8-inch intervals, or re-seed into loosened, fertile soil.

Vegetated Swale Inspection and Maintenance Checklist

Date of Inspection:___________________

Property Address: _________________________

Treatment Measure No.:____________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.)	**Results Expected When Maintenance Is Performed**
Vegetation	When the planted vegetation becomes excessively tall; when nuisance weeds and other vegetation start to take over.			Vegetation mowed per specifications or maintenance plan, or nuisance vegetation removed so that flow is not impeded. Vegetation should never be mowed lower than the design flow depth. Remove clippings from the swale and dispose appropriately.
Excessive Shading	Growth of planted vegetation is poor because sunlight does not reach swale.			Healthy growth of planted vegetation. If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.			Material removed so that there is no clogging or blockage in the inlet and outlet areas.
Trash and Debris Accumulation	Trash and debris accumulated in the swale.			Trash and debris removed from swale.
Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.			No erosion or scouring in swale bottom. For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.
Miscellan-eous	Any condition not covered above that needs attention in order for the vegetated swale to function as designed.			Meet the design specifications.

Extended Detention Basin Maintenance Plan for [[== Insert Property Address ==]]

[[== Insert Date =]]

The property contains [[== insert number ==]] extended detention basins, located as described below and as shown in the attached site plan.

- **Extended Detention Basin No. 1** is located at [[== describe location ==]].
- **Extended Detention Basin No. 2** is located at [[== describe location ==]].
- [[== Add descriptions of other extended detention basins, if applicable. ==]]

I. Routine Maintenance Activities

Primary maintenance activities include vegetation management and sediment removal, although mosquito abatement is a concern if the extended detention basin is designed to include permanent pools of standing water. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Extended Detention Basins

No.	Maintenance Task	Frequency of Task
1	Conduct annual vegetation management during the summer, removing weeds and harvesting vegetation. Remove all grass cuttings and other green waste.	Once a year
2	Trim vegetation at beginning and end of wet season to prevent establishment of woody vegetation, and for aesthetics and mosquito control.	Twice a year (spring and fall)
3	Evaluate health of vegetation and remove and replace any dead or dying plants. Remove all green waste.	Twice a year
4	If turf grass is included in basin design, conduct regular mowing and remove all grass cuttings. Avoid producing ruts when mowing.	[[== insert frequency, if applicable ==]]
5	Remove sediment from forebay when the sediment level reaches the level shown on the fixed vertical sediment marker.	As needed
6	Remove accumulated sediment and regard when the accumulated sediment volume exceeds 10% of basin volume	Every 10 years, or as needed
7	Remove accumulated trash and debris from the extended detention basin at the middle and end of the wet season.	Twice a year (January and April)
8	Irrigate during dry weather.	[[== insert frequency ==]]
9	Inspect extended detention basin using the attached inspection checklist.	Quarterly, or as needed

II. Prohibitions

Pesticides and fertilizers shall not be used in extended detention basins.

III. Inspections

The attached Extended Detention Basin Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Extended Detention Basin
Inspection and Maintenance Checklist

Property Address: ______________________________ Property Owner: ______________________________

Treatment Measure No: __________ Date of Inspection: _______ Type of Inspection: ❑ Quarterly ❑ Other ______________

Inspector(s): ______________________________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.)	**Results Expected When Maintenance Is Performed**
General				
Trash & Debris	• Trash and debris accumulated in basin. • Visual evidence of dumping.			Trash and debris cleared from site.
Poisonous Vegetation and noxious weeds	Poisonous or nuisance vegetation or noxious weeds, e.g., morning glory, English ivy, reed canary grass, Japanese knotweed, purple loosestrife, blackberry, Scotch broom, poison oak, stinging nettles, or devil's club.			Use Integrated Pest Management techniques to control noxious weeds or invasive species.
Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.			No contaminants or pollutants present.
Rodent Holes	If facility acts as a dam or berm, any evidence of rodent holes, or any evidence of water piping through dam or berm via rodent holes.			The design specifications are not compromised by holes. Any rodent control activities are in accordance with applicable laws and do not affect any protected species.
Insects	Insects such as wasps and hornets interfere with maintenance activities.			Insects do not interfere with maintenance activities.

Date of Inspection:___________________

Property Address: ________________________

Treatment Measure No.:___________

Defect	**Conditions When Maintenance Is Needed**	**Maintenance Needed? (Y/N)**	**Comments** (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.)	**Results Expected When Maintenance Is Performed**
Tree/Brush Growth and Hazard Trees	• Growth does not allow maintenance access or interferes with maintenance activity. • Dead, diseased, or dying trees.			• Trees do not hinder maintenance activities. • Remove hazard trees as approved by the City. (Use a certified Arborist to determine health of tree or removal requirements).
Drainage time	Standing water remains in basin more than five days.			Correct any circumstances that restrict the flow of water from the system. Restore drainage to design condition. If the problem cannot be corrected and problems with standing water recur, then mosquitoes should be controlled with larvicides, applied by a licensed pesticide applicator.
Outfall structure	Debris or silt build-up obstructs an outfall structure.			Remove debris and/or silt build-up.
Side Slopes				
Erosion	• Eroded over 2 in. deep where cause of damage is still present or where there is potential for continued erosion. • Any erosion on a compacted berm embankment.			Cause of erosion is managed appropriately. Side slopes or berm are restored to design specifications, as needed.
Storage Area				
Sediment	Accumulated sediment >10% of designed basin depth or affects inletting or outletting condition of the facility.			Sediment cleaned out to designed basin shape and depth; basin reseeded if necessary to control erosion.
Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.			Liner repaired or replaced. Liner is fully covered.
Emergency Overflow/ Spillway and Berms				
Settlement	Berm settlement 4 inches lower than the design elevation.			Dike is built back to the design elevation.

Date of Inspection:___________________
Treatment Measure No.:____________

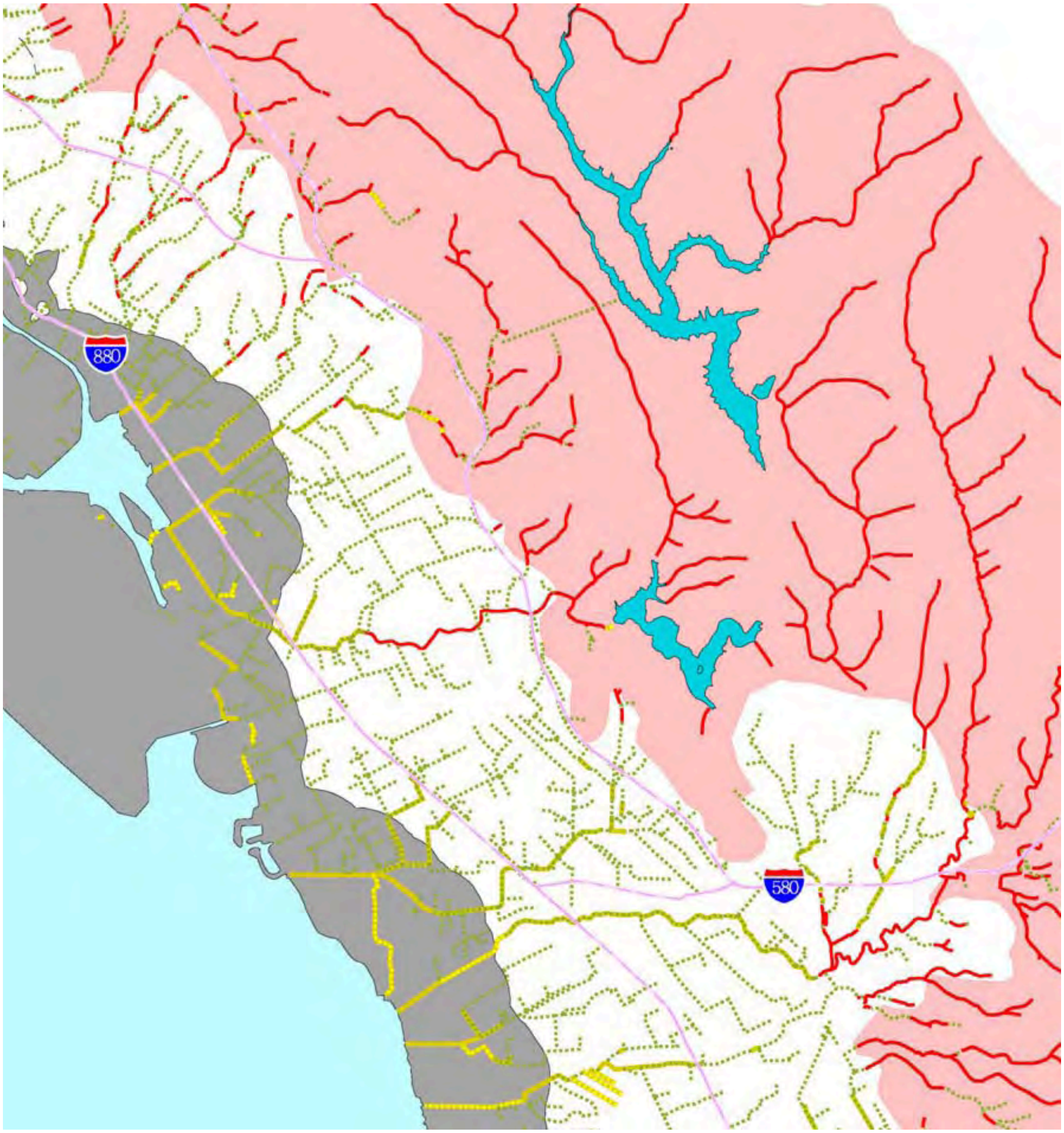
Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.)	Results Expected When Maintenance Is Performed
Tree Growth	Tree growth on berms or emergency spillway >4 ft in height or covering more than 10% of spillway.			• Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. • A civil engineer should be consulted for proper berm/spillway restoration.
Emergency Overflow/ Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.			Rocks and pad depth are restored to design standards.
Debris Barriers (e.g., Trash Racks)				
Trash and Debris	Trash or debris is plugging openings in the barrier.			Trash or debris is removed.
Damaged/ Missing Bars	Bars are missing, loose, bent out of shape, or deteriorating due to excessive rust.			Bars are repaired or replaced to allow proper functioning of trash rack.
Inlet/Outlet Pipe	Debris barrier is missing or not attached to pipe.			Debris barrier is repaired or replaced to allow proper functioning of trash rack.
Fencing and Gates				
Missing or broken parts	Any defect in or damage to the fence or gate that permits easy entry to a facility.			Fencing and gate are restored to design specifications.
Deteriorating Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.			Paint or protective coating is sufficient to protect structural adequacy of fence or gate.
Miscellaneous				
Miscellan-ous	Any condition not covered above that needs attention to restore extended detention basin to design conditions.			Meets the design specifications.

Appendix

J

Draft Hydromodification Susceptibility Map

This appendix includes an excerpt of shows a schematic view of a portion of the draft Hydromodification Susceptibility Map included in the Draft Hydromodification Management Plan (HMP). The final version of this map will be available for download from the ACCWP website in an interactive format that enables zooming to a closer view of the project vicinity with local streets.



Schematic View of a Portion of ACCWP's Draft Hydromodification Susceptibility Map

High slope - vicinity
Bayside near-tidal
Major highways

Channel category
Natural bank or bed
Engineered channel
Underground culvert

Engineered material type
concrete
earthen
unknown