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Alameda County Flood Control and Water Conservation District

Zone 7 Water Agency

C.3 Stormwater Technical Guidance

2nd Revised Draft September 11, 2019

A handbook for developers, builders and project applicants

Version 7

Protecting Alameda County Creeks, Wetlands & the Bay

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Credits

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Glossary of Terms

Alameda Countywide Clean Water Program	The Alameda Countywide Clean Water Program (Program) is established by a memorandum of understanding among the 14 Alameda County cites, Alameda County, the Alameda County Flood Control and Water Conservation District, and the Zone 7 Water Agency. All these agencies are listed as Co-permittees in the Municipal Regional Stormwater NPDES Permit (MRP) adopted by the Regional Water Quality Control Board. The Program 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 to assist project applicants in sizing specialized detention facilities that will allow a project to meet the Flow Duration Control standard where required by the hydromodification management provision (Provision C.3.g) of the Municipal Regional Stormwater NPDES Permit (MRP). The current version of the BAHM (BAHM 2013) is available for download at www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi.
Bay-Friendly Landscaping and Gardening	A holistic approach to gardening and landscaping that works in harmony with the natural conditions of the San Francisco Bay Watershed. Bay-Friendly practices foster soil health, conserve water and other valuable resources while reducing waste and preventing pollution.
Bay-Friendly Landscaping and Gardening Coalition/ ReScape California	The Bay-Friendly Landscaping & Gardening Coalition, also known as ReScape California, is a non-profit organization that partners with local organizations, customizing best management practices for each region to establish sustainable landscape practices in California. See more at: rescapeca.org/.
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.

Bioinfiltration Area	A type of low development treatment measure designed to have a surface ponding area that allows for evapotranspiration, and to filter water through 18 inches of engineered biotreatment soil. After the water filters through the engineered soil, it encounters a 12-inch layer of rock in which an underdrain is typically installed. If the underlying soils have a saturated hydraulic conductivity rate of 1.6" per hour or greater, then the C.3.d amount of runoff is treated by evapotranspiration and infiltration. If the soils have a lower hydraulic conductivity rate, then the bioinfiltration area treats stormwater with evapotranspiration, some infiltration, and the remaining amount of the C.3.d amount of runoff is filtered and released into the underdrain. The difference between a bioinfiltration area and a bioretention area is that the bioinfiltration area is never lined with an impermeable layer; whereas, a bioretention area may be lined or unlined.
Bioretention Area	A type of low development treatment measure designed to have a surface ponding area that allows for evapotranspiration, and to filter water through 18 inches of engineered biotreatment soil. After the water filters through the engineered soil, it encounters a 12-inch layer of rock in which an underdrain is typically installed. If the underlying soils have a saturated hydraulic conductivity rate of 1.6" per hour or greater, then the C.3.d amount of runoff is treated by evapotranspiration and infiltration. If the soils have a lower hydraulic conductivity rate, or if infiltration is prohibited and the bioretention area is lined with an impermeable layer, then the bioretention area treats stormwater with evapotranspiration, some or no infiltration, and the remaining amount of the C.3.d amount of runoff is filtered and released into the underdrain. The difference between a bioinfiltration area and a bioretention area is that the bioinfiltration area is never lined with an impermeable layer; whereas, a bioretention area may be lined or unlined.
Biotreatment	A type of low impact development treatment allowed under Provision C.3.c of the MRP. As required by Provision C.3.c.i(2)(vi), biotreatment systems shall be designed to have a surface area no smaller than what is required to accommodate a 5 inches/hour stormwater runoff surface loading rate and shall use biotreatment soil as specified in the biotreatment soil specifications approved by the Regional Water Board, or equivalent.
Buffer Strip or Zone	Strip of erosion-resistant vegetation over which stormwater runoff is directed.
C.3	Provision of the Municipal Regional Stormwater NPDES Permit (MRP) that requires each Discharger to control the flow of stormwater and stormwater pollutants from new development and redevelopment sites over which it has jurisdiction.
C.3 Regulated Projects	Development projects as defined by Provision C.3.b.ii of the MRP. This includes public and private projects that create and/or replace 10,000 square feet or more of impervious surface, and restaurants, retail gasoline outlets, auto service facilities, and uncovered parking lots (stand-alone or part of another use) that create and/or replace 5,000 square feet or more of impervious surface. Single family homes that are not part of a larger plan of development are specifically excluded.

C.3.d Amount of Runoff	The amount of stormwater runoff from C.3 Regulated Projects that must receive stormwater treatment, as described by hydraulic sizing criteria in Provision C.3.d of the MRP.
California Association of Stormwater Quality Agencies (CASQA)	Publisher of the California Stormwater Best Management Practices Handbooks, available at www.casqa.org. 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. The current Construction General Permit was adopted by the SWRCB on September 2, 2009, and went into effect July 1, 2010.
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.
Discharger	Any responsible party or site owner or operator within the Municipal Regional Stormwater NPDES Permit (MRP) Permittees' jurisdiction whose site discharges stormwater runoff, or a non-stormwater discharge.
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 diminishing or wearing away of land due to wind or water. Often the eroded debris (silt or sediment) becomes a pollutant via stormwater runoff. Erosion occurs naturally, but can be intensified by land disturbing and grading activities such as farming, development, road building, or timber harvesting.
Evapotranspiration	Evaporating water into the air directly or through plant transpiration.
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.
Green Stormwater Infrastructure	Infrastructure that uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green stormwater infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green stormwater infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water – providing a sustainable system that slows runoff by dispersing it to vegetated areas, harvests and uses runoff, promotes infiltration and evapotranspiration, and uses bioretention and other low impact development practices to clean stormwater runoff.
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.
Heritage Tree	An individual tree of any size or species given the ‘heritage tree’ designation as defined by the municipality’s tree ordinance or other section of the municipal code.
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.

Hydrodynamic Separator	A commonly used term for mechanical stormwater treatment systems that are designed as flow-through structures with a settling or separation unit to remove sediment and other pollutants that may settle to the bottom of the separation unit.
Hydrograph	Runoff flow rate plotted as a function of time.
Hydromodification	The modification of a stream's hydrograph, caused in general by increases in flows and durations that result when land is developed (e.g., made more impervious). The effects of hydromodification include, but are not limited to, increased bed and bank erosion, loss of habitat, increased sediment transport and deposition, and increased flooding.
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.
Impervious surface	A surface covering or pavement of a developed parcel of land that prevents the land's natural ability to absorb and infiltrate rainfall/stormwater. Impervious surfaces include, but are not limited to, roof tops; walkways; patios; driveways; parking lots; storage areas; impervious concrete and asphalt; and any other continuous watertight pavement or covering. Landscaped soil and pervious pavement, including pavers with pervious openings and seams, underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Provision C.3.d volume of rainfall runoff are not impervious surfaces. Open, uncovered retention/detention facilities are not considered impervious surfaces for purposes of determining whether a project is a Regulated Project under Provisions C.3.b and C.3.g. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling and meeting the Hydromodification standard.
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 Devices	Infiltration facilities that are deeper that they are wide and designed to infiltrate stormwater runoff into the subsurface and, as designed, bypass the natural groundwater protection afforded by surface soil. These devices include dry wells, injection wells and infiltration trenches (includes French drains).
Infiltration Facilities	A term that refers to both infiltration devices and measures.
Infiltration Measures	Infiltration facilities that are wider than they are deep (e.g., bioinfiltration, infiltration basins and shallow wide infiltration trenches and dry wells).

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. See Bay-Friendly Landscaping and Gardening.
Low Impact Development	A land planning and engineering design approach with a goal of reducing stormwater runoff and mimicking a site's predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, storing, detaining, evapotranspiring, and/or biotreating stormwater runoff close to its source, or onsite.
Low Impact Development (LID) Treatment	Removal of pollutants from stormwater runoff using the following types of stormwater treatment measures: rainwater harvesting and use, infiltration, evapotranspiration, and biotreatment.
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)	A standard for implementation of stormwater management actions to reduce pollutants in stormwater. Clean Water Act (CWA) 402(p)(3)(B)(iii) requires that municipal stormwater permits "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." Also see State Board Order WQ 2000-11.
Media Filter	Two-chambered system that includes a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media.
Municipal Regional Stormwater NPDES Permit (MRP)	The Phase I municipal stormwater NPDES permit under which discharges are permitted from municipal separate storm sewer systems throughout Alameda County and other NPDES Phase I jurisdictions within the San Francisco Bay Region.
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.

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 MRP.
Operation and Maintenance (O&M)	Refers to requirements in the stormwater NPDES permit to inspect stormwater treatment systems and hydromodification controls 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 Paving	For the purposes of this document, pervious paving is defined as (but not limited to) any of the following types of paving or pavement systems: permeable interlocking concrete pavement (PICP), pervious or permeable concrete pavers, pervious grid pavements, pervious concrete, porous asphalt, turf block, grasscrete, and bricks and stones set on a gravel base with gravel joints. Pervious paving or pavement systems are designed to store and infiltrate rainfall at a rate equal to immediately surrounding unpaved, landscaped areas, or store and infiltrate the rainfall runoff volume described in provision C.3.d of the MRP.
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 in the MRP requiring each MRP Discharger to control the flow of stormwater and stormwater pollutants from new and redevelopment sites over which it has jurisdiction.
Rational Method	A method of calculating runoff flows based on rainfall intensity and the amount of runoff from the tributary area.
Redevelopment	Land-disturbing activity that results in the creation, addition, or replacement of exterior impervious surface area on a site on which some past development has occurred. The MRP 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.
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 into water, usually after rain.
Self-Retaining Area	A portion of a development site designed to retain the first one inch of rainfall (by ponding and infiltration and/or evapotranspiration) without producing stormwater runoff. Self-retaining areas must have at least a 2:1 ratio of contributing area to a self-retaining area and a 3” ponding depth. Self-retaining areas may include graded depressions with landscaping or pervious pavement. Areas that Contribute Runoff to Self-Retaining Areas are impervious or partially pervious areas that drain to self-retaining areas.
Self-Treating Area	A portion of a development site in which infiltration, evapotranspiration and other natural processes remove pollutants from stormwater. Self-treating areas may include conserved natural open areas, areas of landscaping, green roofs and pervious pavement. Self-treating areas treat only the rain falling on them and do not receive stormwater runoff from other 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	Land use or site planning practices, or structural or nonstructural measures, that aim to prevent runoff pollution by reducing the potential for contact with rainfall runoff at the source of pollution. Source control measures minimize the contact between pollutants and urban runoff.
Special Projects	Certain types of smart growth, high density and transit oriented development projects that are allowed, under Provision C.3.e.ii of the MRP, to receive LID treatment reductions.
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.
Stormwater Treatment Measure	Any engineered system designed to remove pollutants from stormwater runoff by settling, filtration, biological degradation, plant uptake, media absorption/adsorption or other physical, biological, or chemical process. This includes landscape-based systems such as vegetated swales and bioretention units as well as proprietary systems. Sometimes called a treatment control, treatment control measure treatment system, or treatment control BMP.
Total Project Cost	Total project cost includes the construction (labor) and materials cost of the physical improvements proposed; however, it does not include land, transactions, financing, permitting, demolition, or off-site mitigation costs.
Treatment	Any method, technique, or process designed to remove pollutants and/or solids from polluted stormwater runoff, wastewater, or effluent.

Vector Control	Any method to limit or eradicate 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 Buffer Strip	Linear strips of vegetated surfaces that are designed to treat sheet runoff flow from adjacent surfaces.
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).

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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 Alameda Countywide Clean Water Program (Clean Water Program) 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 and State requirements in the Municipal Regional Stormwater NPDES Permit (MRP). The municipalities have to require post-construction stormwater controls as part of their obligations under Provision C.3 of the MRP. This is a National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board (Water Board), allowing municipal stormwater systems to discharge to local creeks, San Francisco Bay, and other water bodies. In case of conflicting information between this handbook and the MRP, the MRP shall prevail.

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

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. The term "post-construction stormwater control" encompasses low-impact development (LID), which reduces water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, and using stormwater as a resource, rather than a waste product.

Information on best management practices (BMPs) that protect stormwater during construction, is available at www.cleanwaterprogram.org (click on "Businesses," then "Construction").

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 Clean Water Program?

The Clean Water Program 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. The Clean Water Program 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.

The Clean Water Program's member agencies, and other agencies throughout the region, are joint permit holders of the MRP. Each member agency is individually responsible for implementing the MRP requirements, but participating in the Program helps them collaborate on Clean Water Program initiatives that benefit all members. More information on the Program is available on its website, www.cleanwaterprogram.org.

1.3 How to Use this Handbook

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

When using this Clean Water Program 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/LID 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/LID designs into planning permit and building permit application submittals for your project.
- Chapter 4 presents information on ***site design measures***, including guidance for self-treating and self-retaining areas, 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-LID 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 bioretention areas, flow-through planters, vegetated swales, vegetated buffer strips, tree well filters, infiltration trenches, extended detention basins, pervious paving, green roofs, and media filters.
- 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 the MRP's Provision, which allows projects to contribute to off-site ***alternative compliance*** projects instead of constructing on-site stormwater treatment measures.
- Appendix A is provided for each agency to include its own ***local requirements***, such as the agency's conditions of approval, Source Control Measures List, and Impervious Surface Form.
- Appendix B includes a ***list of plants*** appropriate for use in LID 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 consists of the ***Mean Annual Precipitation Map*** for Alameda County.
- Appendix E describes manufactured stormwater treatment measures that have ***limited applicability***, including inlet filters, oil/water separators, hydrodynamic separators, and media filters.
- Appendix F presents guidelines for using stormwater controls that promote on-site ***infiltration*** of stormwater.
- Appendix G provides guidance for ***controlling mosquito production*** in stormwater treatment measures.
- Appendix H includes templates for preparing stormwater treatment measure ***maintenance plans***.
- Appendix I is the Hydromodification Management Susceptibility Map.
- Appendix J provides guidance on using the ***Special Projects Criteria*** approved by the Regional Water Board to identify infill, high density, and transit oriented development projects that may receive LID treatment reduction credits.
- Appendix K includes regional ***Soil Specifications*** approved by the Regional Water Board for use in stormwater biotreatment measures.

- Appendix L contains ***Site Design Requirements for Small Projects***, including guidance on implementation of these permit requirements and four fact sheets on landscape dispersion, rain gardens, pervious paving, and rain barrels and cisterns.
- Appendix M includes information on ***Green Streets***, including local projects in Alameda County, ACCWP's Example GI Typical Details, and resources for more information.

1.4 Precedence

In case of conflicting information between this handbook and the Municipal Regional Stormwater NPDES Permit (MRP), the MRP shall prevail.

Any local policies, procedures and/or design standards that comply with the MRP also take precedence over the guidance in this manual.

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 entering water bodies[1]. In the San Francisco Bay watershed, urban and agricultural runoff is 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.

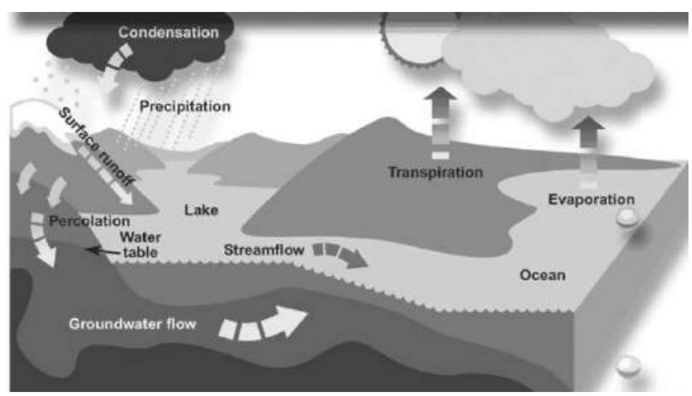

Figure 2-1. The Water Cycle

Source: NGRDC/GDNR, 2005/06

[1] See USEPA's NPDES Stormwater Program webpage, at https://www.epa.gov/npdes/npdes-stormwater-program

[2] San Francisco Bay Regional Water Quality Control Board, Basin Plan, 2004

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 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.

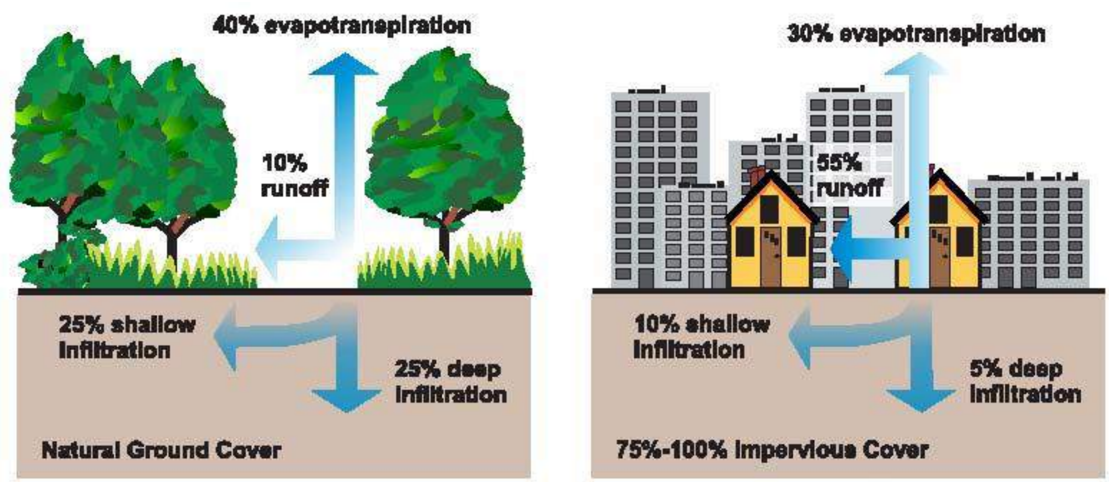

Figure 2-2. Change in Volume of Sormwater Runoff after Development.

Source: 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. Photos 2-1 and 2-2 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/low impact development (LID), 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. LID reduces water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, and then infiltrating, storing, detaining, evapotranspiring (evaporating stormwater into the air directly or through plant transpiration), and/or biotreating stormwater runoff close to its source, or onsite.

Photo 2-1. : Creek Subject to Hydromodification

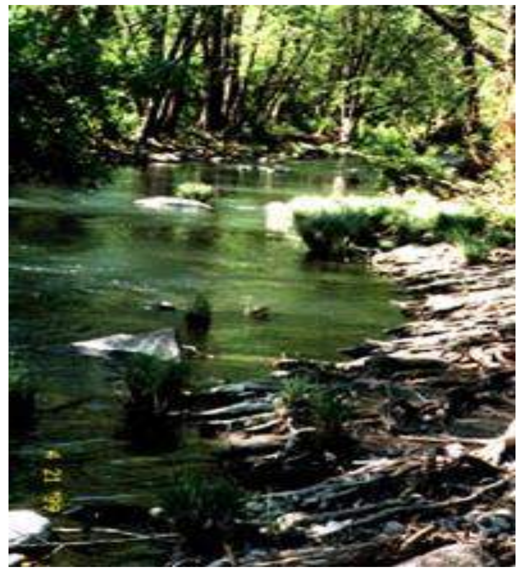

Photo 2-2. : Creek with Natural Banks

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. Chapter 6 provides technical guidance specific to the following treatment measures:

- Bioretention areas,
- Flow-through planter boxes,
- Tree well filters (high flow rate tree well filters are allowed only in Special Projects - see Appendix J),
- Infiltration trenches,
- Extended detention basins,
- Pervious paving,
- Grid pavements,
- Green roofs,
- Rainwater harvesting and use, and
- Media filters (media filters are allowed only in Special Projects - see Appendix J).

The Municipal Regional Stormwater NPDES Permit's (MRP) stormwater treatment requirements must be met by using evapotranspiration, infiltration, rainwater harvesting and reuse, or biotreatment. Media filters and high flow rate tree well filters are allowed only in Special Projects. See Section 2.3.2 for more information on stormwater treatment requirements, and Appendix J for more information on Special Projects.

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 Clean Water Program 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.

The Municipal Regional Stormwater NPDES Permit (MRP), which was reissued by the Water Board in November 2015, includes prescriptive requirements for incorporating post-construction stormwater control/LID measures into new development and redevelopment projects. These requirements are in Provision C.3 of the MRP, which can be found at http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/R2-2015-0049.pdf.

2.3.1 Do the C.3 LID Requirements Affect My Project?

Provision C.3.b establishes thresholds at which new development and redevelopment projects must comply with the LID requirements in Provisions C.3.c and C.3.d, although the municipal stormwater permit also requires agencies to encourage all projects subject to local development review to include adequate source control and site design measures that minimize stormwater pollutant discharges. Regardless of a project’s need to comply with the requirements in Provision C.3, municipalities apply 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 all projects that receive development permits.

PROVISION C.3 LID THRESHOLDS

The thresholds for determining whether a project is a Regulated Project and must comply with the LID requirements in Provisions C.3.c and C.3.d are based on the amount of impervious surface that is created and/or replaced by the project, as described below.

- Since August 15, 2006, private or public projects that create and/or replace ***10,000 square feet or more*** of impervious surface are Regulated Projects under Provision C.3.b.
- Since December 1, 2011**,** the following special land use project categories that create and/or replace ***5,000 square feet or more*** of impervious surface are Regulated Projects

under Provision C.3.b: uncovered parking areas (stand-alone or part of another use), restaurants, auto service facilities[1] and retail gasoline outlets.

Projects that meet or exceed the two thresholds described above are known as Regulated Projects and must comply with the LID requirements described in Provisions C.3.c and C.3.d.

GRANDFATHERED PROJECTS

All projects that meet the descriptions of Regulated Projects in Provision C.3.b are required to implement LID source control, site design, and stormwater treatment requirements as described in Provisions C.3.c and C.3.d of the MRP. However, Provision C.3.b provides for grandfathering of projects that were approved under a previous municipal stormwater permit, have not yet been constructed, and meet specific criteria described as follows:

- Any Regulated Project that has been approved with stormwater treatment measures in compliance with Provision C.3.d (numeric sizing criteria) under a previous municipal stormwater permit is exempt from the requirements of Provision C.3.c. (low impact development requirements).
- Any Regulated Project that was approved with no Provision C.3 stormwater treatment requirements under a previous municipal stormwater permit and that has not begun construction by the January 1, 2016, is required to fully comply with the requirements of the Provisions C.3.c (LID) and C.3.d (numeric sizing criteria).The local agencies may grant exemptions from this requirement as follows:

(a) An exemption may be granted to:

(i) Any Regulated Project that was previously approved with a vesting tentative map that confers a vested right to proceed with development in substantial compliance with the ordinance, policies, and standards in effect at the time the vesting tentative map was approved or conditionally approved, as allowed by State law.

(ii) Any Regulated Project for which the local agency has no legal authority to require changes to previously granted approvals, such as projects that have been granted building permits.

(b) This exemption from the LID requirements of Provision C.3.c. may be granted to any Regulated Project as long as stormwater treatment with media filters is provided that comply with the hydraulic sizing requirements of Provision C.3.d.

OTHER EXCLUSIONS FROM PROVISION C.3

Provision C.3.b of the MRP excludes specific types of development and redevelopment projects from Provision C.3.c LID requirements for stormwater treatment, source controls and site design measures, even if the thresholds described above are met or exceeded. The list of excluded project types is shown in Table 2-1, below.

[1] Auto service facilities include the specific Standard Industrial Classification Codes, as follows:
5013: Wholesale distribution of motor vehicle supplies, accessories, tools, equipment, and parts.
5014: Wholesale distribution of tires and tubes for passenger and commercial vehicles.
7532: Repair of automotive tops, bodies, and interiors, or automotive painting and refinishing.
7533: Installation, repair, or sale and installation of automotive exhaust systems.
7534: Repairing and retreading automotive tires.
7536: Installation, repair, or sales and installation of automotive glass.
7537: Installation, repair, or sales and installation of automotive transmissions.

Table 2-1.Projects Excluded from Provision C.3 Numerically Sized Treatment Requirements	
	Excluded Projects
Residential projects	▪ Detached single-family home projects that are not part of a larger plan of development[4].
Road projects	▪ Roadway reconstruction that does not add one or more new lanes of travel (turn lanes are considered lanes of travel); ▪ Widening of roadways that does not add one or more new lanes of travel; ▪ Impervious trails with a width of 10 feet or less and located more than 50 feet from top of creek banks. ▪ Sidewalk projects in the public right of way that are not built as part of new streets or roads; ▪ Bicycle lane projects in the public right of way that are not built as part of new streets or roads.[5] ▪ Sidewalks built as part of new streets or roads that are constructed to drain to adjacent vegetated areas; ▪ Bicycle lanes built as part of new streets or roads that are not hydraulically connected to the new streets or roads, and that are constructed to direct stormwater runoff to adjacent vegetated areas; ▪ Impervious trails built to direct stormwater runoff to adjacent vegetated areas or other non-erodible pervious areas, preferably away from creeks or toward the outboard side of levees; ▪ Sidewalks, bicycle lanes or trails built with permeable surfaces; ▪ Caltrans highway projects and associated facilities (Caltrans must comply with its own NPDES stormwater permit.).

[4] Detached single-family home projects that are not part of a larger plan of development and that create and/or replace 2,500 square feet or more of impervious surface are required to implement site design measures specified in Provision C.3.i.

[5] If an existing road is widened to add a traffic lane in addition to a new bicycle lane, and the bike lane is not hydraulically separated from the road, treatment of runoff from the bike lane would be required.

Table 2-1.Projects Excluded from Provision C.3 Numerically Sized Treatment Requirements	
	Excluded Projects
Redevelopment projects (including pavement resurfacing)	Interior remodels and routine maintenance or repair, including: ▪ Roof replacement. This exclusion applies to all roof replacement projects, including those that remove the entire roof. ▪ Exterior wall surface replacement; ▪ Pavement resurfacing within the existing footprint. This exclusion applies to any routine maintenance of paved surfaces within the existing footprint, including the repaving that occurs after conducting utility work under the pavement, and the routine reconstruction of pavement, which may include removal and replacement of the subbase. If a repaving project results in changes to the footprint, grade, layout or configuration of the paved surfaces[6], it would trigger the requirements of Provision C.3. The pavement resurfacing exclusion also applies to the reconstruction of existing roads and trails. ▪ Similar types of routine maintenance or repairs

CONSTRUCTION OF IMPERVIOUS SURFACE OVER EXISTING PAVEMENT

In some cases, the construction of impervious surface over existing impervious surface may be considered a C.3 Regulated Project; in some cases it would not. Please see the following examples:

- The construction of a highway overpass that creates 10,000 square feet or more of impervious surface over an existing roadway or rail line would be subject to Provision C.3, since stormwater runoff from the new overpass would be collected and discharged to the storm drain system.
- A parking garage that is constructed over an existing parking lot would be subject to Provision C.3. Although this would not change the use (parking), it would intensify the use.
- The construction of a roof over existing parking spaces would NOT be considered a C.3 Regulated Project, unless the project would change the footprint, grade, layout or configuration of the parking lot surface.

CONSTRUCTION OF IMPERVIOUS SURFACE OVER EXISTING PERVIOUS AREA

Installation of a raised deck is not covered by C.3, unless the deck has a water-tight surface. Installation of awnings and solar panels over a pervious area are excluded from C.3, since they do not provide water-tight covering of land.

ROAD PROJECTS

Please note the following specific requirements for road projects.

- The construction of a new street or road (including sidewalks and bicycle lanes built as part of new streets or roads) that creates 10,000 square feet or more of ***newly***

[6] A change of grade of the paved surface would involve the regrading of the paved area. For example, the existing pavement may be removed, and the underlying soil may be regraded to increase or decrease the grade of the subject area before repaving. A change of layout or configuration of the paved surface would involve changing the overall shape of the paved area and/or connections between paved areas; for example, a driveway may be reconfigured to modify the turning radius from the adjacent street.

constructed, contiguous impervious surface is subject to the requirements of Provision C.3.

- Impervious trails 10 feet wide or more that are constructed within 50 feet of the top of a creekbank are also considered roadway projects, as are roadway projects that widen existing roads with one or more additional traffic lanes.
- Projects that widen existing roads with additional travel lanes are subject to the ***"50 Percent Rule"*** for stormwater treatment (see the C.3 requirements for redevelopment projects, below). Road projects excluded from Provision C.3 are listed in Table 2-1.

2.3.2 What is Required by Provisions C.3.c and C.3.d?

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 ("Regulated Projects") must incorporate the stormwater controls listed below. Projects that consist of restaurants, auto service facilities, retail gasoline outlets, and surface parking areas (stand-alone or part of another use) that create and/or replace ***5,000 square feet or more*** of impervious surface ("Regulated Special Land Use Projects") must also implement the stormwater controls listed below.

- Site design measures,
- Source control measures, and
- Low impact development (LID) treatment measures that are hydraulically sized as specified by Provision C.3.d. LID treatment is defined as ***evapotranspiration, infiltration, rainwater harvesting and reuse, or biotreatment.*** In some limited cases, LID treatment reduction is allowed for certain smart growth, high density or transit-oriented development Special Projects, described below.

Biotreatment systems are landscape-based treatment measures that filter water through soils that are engineered to have a long-term infiltration rate of 5 to 10 inches per hour, in accordance with the soil specifications approved by the Regional Water Board in Appendix K. Biotreatment systems must have a surface area no smaller than what is required to accommodate a 5 inches per hour stormwater runoff surface loading rate. Biotreatment systems generally include an underdrain in a rock layer below the engineered soil, and are used in locations where the saturated hydraulic conductivity (KSAT) rate of native soil is too low to infiltrate the full amount of runoff specified in Provision C.3.d. Except in locations where infiltration is precluded, the underdrain should be in the upper portion of the rock layer, in order to maximize infiltration.

LID treatment requirements are reduced for certain smart growth, high density, or transit-oriented development ***Special Projects***. LID treatment reductions are provided in terms of a percentage of the total C.3.d amount of runoff that requires treatment. The percentage that is not treated with LID must be treated with either a high flow rate tree well filter, or a high flow rate media filter. Guidance for identifying Special Projects, calculating the percentage of LID treatment reduction, and preparing a narrative discussion that establishes the infeasibility of 100 percent LID treatment are provided in Appendix J.

HYDROMODIFICATION MANAGEMENT REQUIREMENTS

Projects that create and/or replace ***one acre or more*** of impervious surface and increase impervious surface area over the pre-project condition need to incorporate hydromodification management measures, if the project is located in an area susceptible to hydromodification. See Chapter 7 for more information.

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:

- ***"50 Percent Rule:"*** 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. Projects that replace more than 50 percent of the existing impervious surface are required to treat runoff from the entire site.
- A redevelopment project that does not increase the amount of impervious surface over the pre-project condition is exempt from the hydromodification management (HM) requirements.

ALTERNATIVE COMPLIANCE

The MRP allows projects to use "alternative compliance," to meet stormwater treatment requirements offsite. See Chapter 9 for more information.

HOW DO PROJECTS MEET THE C.3 REQUIREMENTS?

Your 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 application.

2.3.3 Site Design Requirements for Small Projects

Specific sizes and types of small projects must meet site design requirements in Provision C.3.i of the Municipal Regional Stormwater NPDES Permit (MRP). This applies to:

- Projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface[7]; and
- Individual single family home projects that create and/or replace 2,500 square feet or more of impervious surface.

Applicable projects must implement at least one of the following site design measures:

- Direct roof runoff into cisterns or rain barrels for use.
- Direct roof runoff onto vegetated areas.
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas.
- Direct runoff from driveways and/or uncovered parking lots onto vegetated areas.
- Construct sidewalks, walkways, and/or patios with permeable surfaces.
- Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.

[7] The threshold at which Special Land Use Projects are considered C.3 Regulated Projects is 5,000 square feet of impervious surface. For these projects, the implementation of LID site design and stormwater treatment systems per Provision C.3.b of the MRP will also satisfy the requirements of Provision C.3.i.

The requirements apply to your project if it meets the size thresholds described above, and it received final discretionary approval on or after December 1, 2012. If your project does not require discretionary approval, such as tract map approval, conditional use permit, or design review, then the requirements apply if the building permit was issued on or after December 1, 2012.

Appendix L provides guidance to assist in selecting and implementing appropriate site design measures for small projects. Included in Appendix L are four fact sheets that provide detailed information for implementing the six site design measures listed above.

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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 controls into the development review process. If the C.3 requirements for site design measures, source controls, and stormwater treatment measures 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.

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.

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

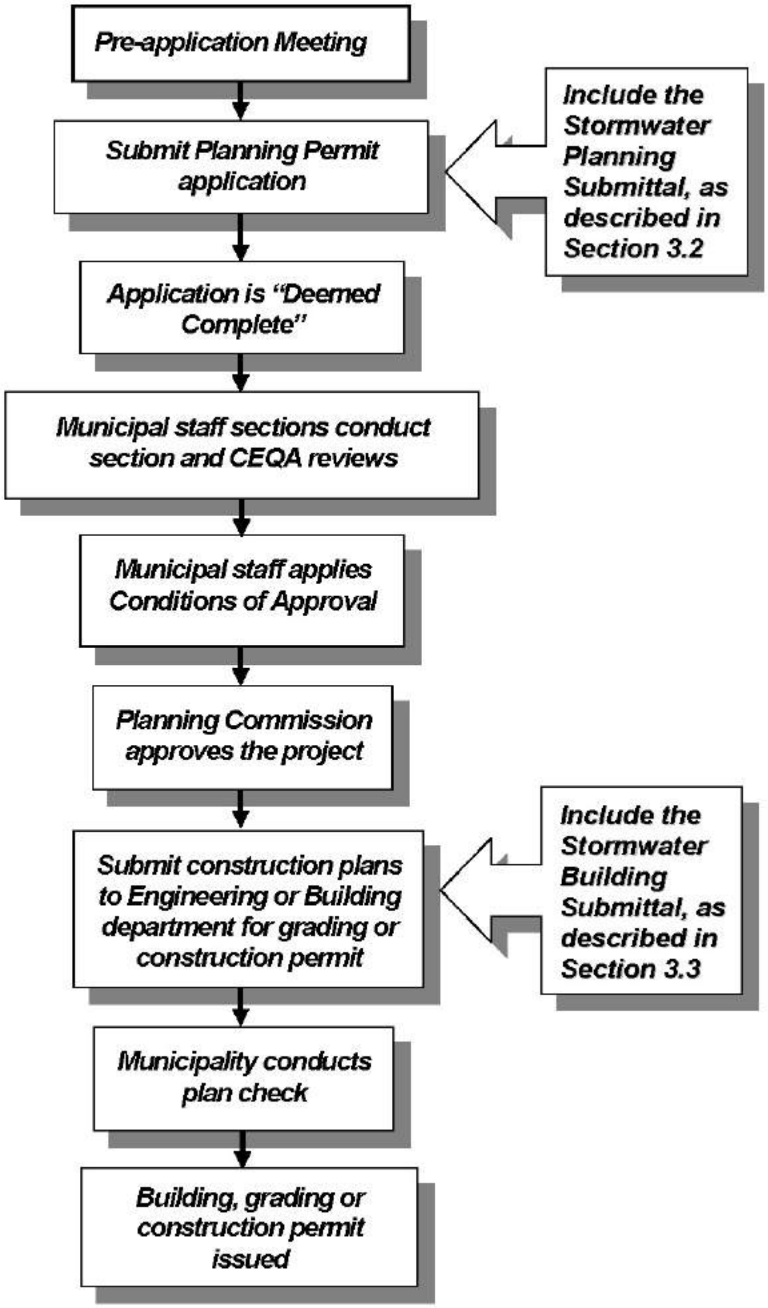

Figure 3-1. Sample Development Review Process for C.3 Regulated Projects

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 present step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

3.2 How to Prepare Planning Permit Submittals

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.

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.

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
❑	❑	Depth to groundwater and soil saturated hydraulic conductivity or soil types.	Step 1
❑	❑	Existing and proposed site drainage network and connections to drainage offsite.	Step 1
❑	❑	For more complex drainage networks, show separate drainage management areas in the existing and proposed site drainage network.	Step 1
❑	❑	Existing condition, including pervious and impervious areas, for each drainage management area.	Step 1
❑	❑	Proposed pervious surfaces, including sensitive natural areas to be preserved and protected from development (for each drainage management area).	Steps 2 and 3
❑	❑	Proposed impervious surfaces, e.g., roof, plaza, sidewalk, street, parking lot (for each drainage management 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 5 - 9
❑	❑	Conceptual planting palette for stormwater treatment measures. [2]	Step 10
❑	❑	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 12
		Written Information on Municipal Forms or in Report Format	
❑	❑	Completed stormwater requirements form provided by local agency.	Step 4
❑	❑	Preliminary calculations for each treatment and hydromodification management measure.	Step 9
❑	❑	Preliminary maintenance plan for stormwater treatment measures.	Step 11
❑	❑	List of source control measures included in the project.	Step 12

[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. The MRP 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

> 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.

Design the project to minimize the overall coverage of impervious 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.

Some examples of site design measures are shown in Photos 3-1 and 3-2. More information on site design measures is provided in Chapter 4 and Appendix L (Site Design Requirements for Small Projects). A range of site design examples is 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.

Photo 3-1. Example of a narrow street with parking pull-outs

- ***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.

Photo 3-2. 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), green roofs and properly designed areas of pervious paving or artificial turf. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. Your drainage design may direct the runoff from self-treating areas directly to the storm drain system or other receiving water. See Section 4.1 for more information.
- Direct ***runoff to depressed landscaped areas.*** You may be able to design an area within your site to function as a "self-retaining area," in which the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas.

A 2:1 ratio of impervious area to the receiving pervious area may be acceptable, where soils permit. See Section 4.2 for more information.

PLANNING PERMIT SUBMITTAL

Step 4: Measure Pervious and Impervious Surfaces

The **Stormwater Requirements Form** (or equivalent form) that is provided by the local jurisdiction must be completed as part of the planning permit application submittal. This form is used to identify project site design measures and source controls, to calculate the amount of impervious surface that will be created and/or replaced, and to determine whether treatment and/or HM measures are required. Impervious surfaces are constructed materials that prevent water from infiltrating into the ground and cause runoff. Impervious surfaces include:

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

Areas of pervious paving or artificial turf that are underlain with pervious storage material, such as a gravel layer sufficient to hold at least the Provision C.3.d volume of rainfall runoff, are not considered impervious surfaces and can be excluded from the calculation of impervious surfaces.

Review the following thresholds of impervious surface to identify the stormwater control requirements for your project:

- Projects that create and/or replace ***10,000 square feet or more*** of impervious surface must implement low impact development (LID) stormwater treatment measures (with some exceptions that are listed in Chapter 2)
- Projects in the following categories that create and/or replace ***5,000 square feet or more*** of impervious surface must implement stormwater treatment measures:
    - Uncovered parking areas (stand-alone or part of another use),
    - Restaurants,
- Auto service facilities[1], and
    - Retail gasoline outlets.

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[1] Auto service facilities include the specific Standard Industrial Classification Codes, as follows:
5013: Wholesale distribution of motor vehicle supplies, accessories, tools, equipment, and parts.
5014: Wholesale distribution of tires and tubes for passenger and commercial vehicles.
7532: Repair of automotive tops, bodies, and interiors, or automotive painting and refinishing.
7533: Installation, repair, or sale and installation of automotive exhaust systems.
7534: Repairing and retreading automotive tires.
7536: Installation, repair, or sales and installation of automotive glass.
7537: Installation, repair, or sales and installation of automotive transmissions.
7538: General automotive repair.
7539: Specialized automotive repair such as fuel service, brake relining, front-end and wheel alignment, and radiator repair.

- Projects that create and/or replace ***2,500 to 10,000 square feet*** and are not in the four categories above, and ***single family home projects that create and/or replace 2,500 square feet or more*** must implement one of six site design measures but are not required to implement stormwater treatment measures (see Section 2.3.3 for more information).

  (See Section 2.3.1 for information on projects that are “grandfathered in” under previous permit requirements.)

Hydromodification management (HM) is required for projects that create and/or replace one acre or more of impervious surface, increase the amount of impervious area over the pre-project condition, AND are located in susceptible areas identified in the Hydromodification Management Susceptibility Map (see Appendix I). Section 7.1 describes this map (available at: http://accwp.maps.arcgis.com/apps/webappviewer/index.html?id=11d7a1bfb90d46ce80f94defc03d012c), and Section 7.2 lists exceptions to the requirements.

PLANNING PERMIT SUBMITTAL
Step 5: Determine If Special Project LID Treatment Reduction Credits Apply

LID treatment reduction credits can be applied to smart growth, high density or transit oriented development projects that meet specific criteria for the Special Projects included in Appendix J. Contact municipal staff to determine whether your project meets the criteria to be considered a Special Project.

PLANNING PERMIT SUBMITTAL
Step 6: Select Treatment/HM Measures

Stormwater treatment requirements must be met using low impact development (LID) measures that provide stormwater treatment using evapotranspiration, infiltration, rainwater harvesting and reuse, and/or biotreatment -- except for limited exceptions for Special Projects that meet specific criteria related to pedestrian scale developments, high density developments and transit oriented development (see Appendix J). – Special Projects). 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:

- ***LID treatment measures are required***, except for a limited number of locations and types of development, referred to as Special Projects, as described above.
- Is ***Hydromodification management*** (HM) required? If your project needs to meet both treatment and HM requirements, it is recommended, to the extent feasible, that stormwater control measures be designed to meet both treatment and HM needs.
- ***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.[2] 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. Bioretention areas installed in group C and D soils typically require subdrains.

- ***Site slope.*** LID treatment measures need to be carefully selected and designed for use on steep slopes, because infiltration of stormwater runoff can cause geotechnical instability. Depending on site conditions, it may be possible to design ***bioretention areas*** using check dams for projects on sites with some slope constraints.
- ***Considerations for larger sites.*** For larger sites that can be divided into separate drainage areas, a variety of smaller stormwater treatment measures may be dispersed throughout the site. It may also be possible to route the stormwater runoff from an individual drainage area to a cistern for non-potable use, such as irrigation or flushing toilets (see Section 4.4, ***Rainwater Harvesting and Use***).
- 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. Maintenance plan templates are provided in ***Appendix H***.

> The ***mosquito control guidance*** (Appendix G) 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 G*** needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water.
- 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 F*** to protect groundwater from contamination by pollutants in stormwater runoff.

PLANNING PERMIT SUBMITTAL

Step 7: 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

[2] 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.

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.*** Treatment measures should be available for ready access by maintenance workers, municipal inspectors, 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 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.

Photo 3-3. This sports field in Dublin also functions as a stormwater detention area.

PLANNING PERMIT SUBMITTAL

Step 8: 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 ***Bay Area Hydrology Model*** (BAHM), a tool for sizing HM measures, developed by the Clean Water Program in cooperation with the Santa Clara Valley Urban Runoff Pollution Prevention Program and the San Mateo Countywide Stormwater Pollution Prevention Program. The current version of the BAHM (BAHM 2013) may be downloaded at www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi. See Chapter 7 for more information on the BAHM and the design of HM measures.

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

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 9: 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.

PLANNING PERMIT SUBMITTAL
Step 10: 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 maintenance plan as part of the planning permit submittal. Otherwise, a maintenance plan is required as part of the building permit submittal. ***Check with your local jurisdiction*** regarding the requirements for your project.

> Source control measures are site planning practices, or operational activities, that aim to prevent runoff pollution by reducing the potential for contact with runoff at the source of pollution.

A 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. Applicants will also need to provide 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. Maintenance plan templates for various stormwater treatment measures are included in Appendix H.

PLANNING PERMIT SUBMITTAL
Step 11: 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.

Projects must 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 13: 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. If not, they may settle more than the surrounding ground, creating depressions that can hold standing water and contribute to mosquito breeding.
  - Prevent Erosion. Erosion may 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.
- ***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, especially if curbs are flush with the pavement. Traffic striping may not be practical for pervious pavements such as crushed aggregate and unit pavers. In these areas, signs and bollards may be needed to help direct traffic.

Photo 3-4. Drain rock is used to prevent erosion of this vegetated swale at Zone 7 Water Agency's office building.

PLANNING PERMIT SUBMITTAL

Step 14: Submit Planning Permit Application

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

3.3 Building Permit Submittals

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

> If your project ***does not require a planning permit***, submit items from both Tables 3-1 and 3-3 with the building permit application.

- ***Construction level detail*** is needed, rather than preliminary plans;
- ***Highlight and explain changes***, if plans differ from the planning permit submittal;
- Include ***detailed maintenance plans*** and documentation for maintenance agreement.

Table 3-3 provides a list of materials that may be required at this stage in the project, followed by brief step-by-step instructions.

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 any changes 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 Stormwater Requirements Checklist, 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, and Appendix H features maintenance plan templates to use when 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 submit 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 H.

BUILDING PERMIT SUBMITTAL

Step 3: Submit Building Permit 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 Subject to Stormwater Treatment Requirements

Some developers of smaller projects may be less familiar with requirements to incorporate stormwater treatment measures. 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 strategies for reducing impervious surfaces, and it offers guidance for using self-treating areas (for example, landscaping, areas paved with turf block, or green roofs) to further ***reduce the size*** of treatment measures. Projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface are required to incorporate site design measures, using specifications that are included in Appendix L.
- ***Use LID treatment measures.*** Even on small sites, LID treatment measures are required, except for projects that may receive LID treatment reduction credits as a Special

Project (described in Appendix J). Chapter 6 includes technical guidance for some treatment measures, such as bioretention areas and flow-through planters, which are well suited for small sites in ***densely developed areas***. Where on-site conditions, such as proximity to buildings, high groundwater or contaminated soils prohibit infiltration, fllow-through planters may be a good option.

- ***Use simplified sizing methods.*** The technical guidance in Chapter 6 includes simplified sizing methods for flow-through planters and bioretention areas. The technical guidance for these treatment measures highlights the easy-to-follow calculations for sizing the treatment measures. In locations where infiltration is precluded by steep slopes, high groundwater, or proximity to building foundations, and the project is an infill or redevelopment project, the combination flow and volume sizing method may be used to potentially reduce the amount of land needed for stormwater treatment (see Chapter 5).
- **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.

Photo 3-5. Flow-through planters are incorporated into the landscaping in a dense, urban setting in Emeryville.

Chapter

4

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 low impact development (LID) 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 emphasizes site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into smaller facilities to meet stormwater treatment requirements than would have been needed without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. A wide variety of site design measures can be incorporated in your project. This Chapter presents the following site design topics:

- *S*elf-Treating Areas;
- Self-Retaining Areas;
- Reducing the Size of Impervious Areas;
- Rainwater Harvesting and Use;
- Tree Preservation/Planting and Interceptor Tree Credits;
- Site Design Requirements for Small Projects

> Site design measures used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without resizing 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 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. Areas of pervious pavement – such as porous concrete, porous asphalt, or unit block pavers – may function as self-treating areas if they are designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the Municipal Regional Stormwater NPDES Permit (MRP). These areas are considered "self-treating" because infiltration and ***natural processes that occur in these areas remove pollutants*** from stormwater. Technical guidance for green roofs, pervious pavement, turf block, and permeable joint pavers is provided in Chapter 6.

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

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.

Even vegetated areas will generate some runoff. ***If runoff from a self-treating area co-mingles with the C.3.d amount of runoff from impervious surfaces***, then your stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating area and the impervious areas. This does not apply to the high flows of stormwater that are in excess of the C.3.d amount of runoff, because stormwater treatment measures are not designed to treat these high flows. If your project requires hydromodification management, then the runoff from self-treating areas will need to be included in the sizing calculations for hydromodification management (HM) treatment measures.

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 4-2 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.

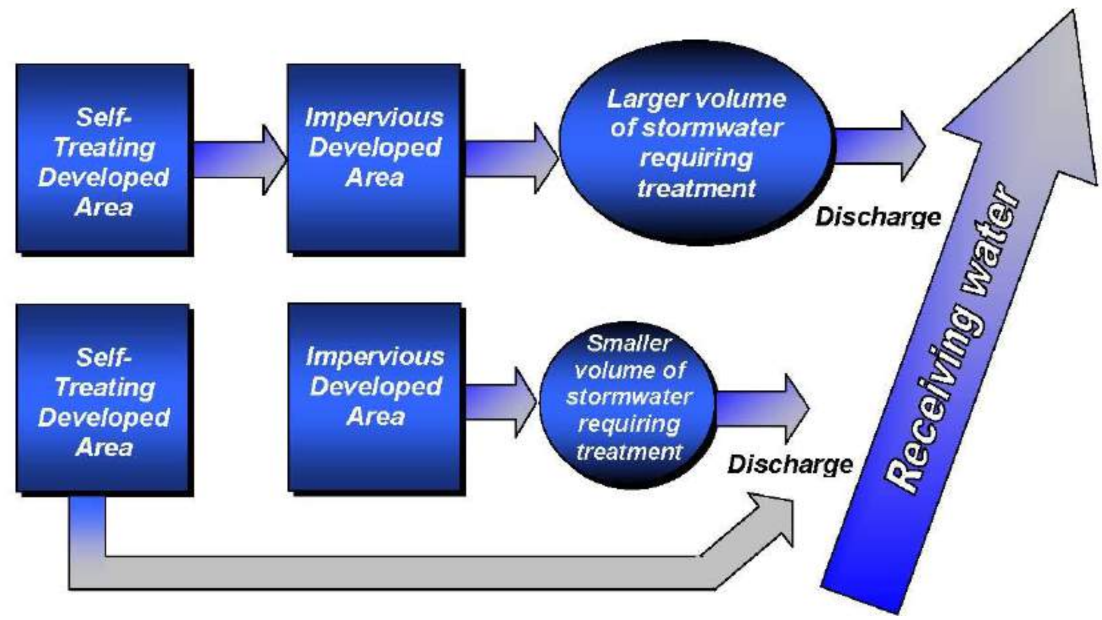


Figure 4-1. Commercial/Industrial Site Compared to Same Site with Self-Treating Areas

Source, BASMAA 2003

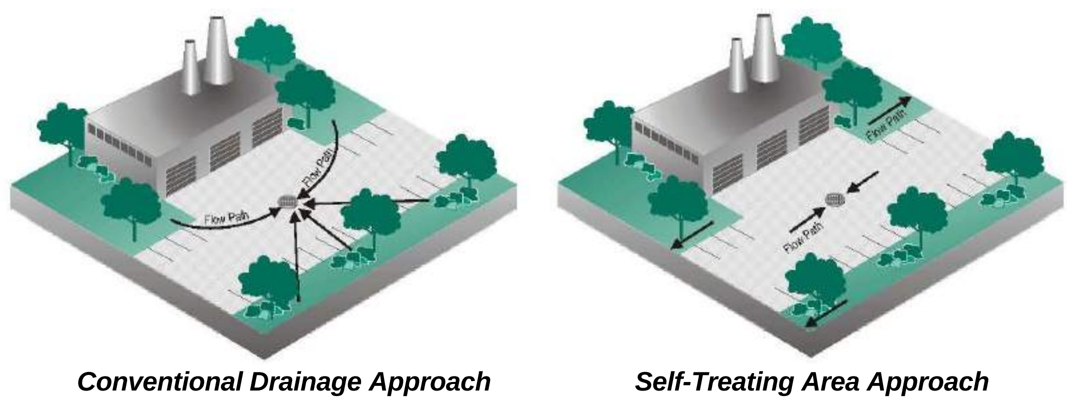


Figure 4-2. Self-Treating Area Usage

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.

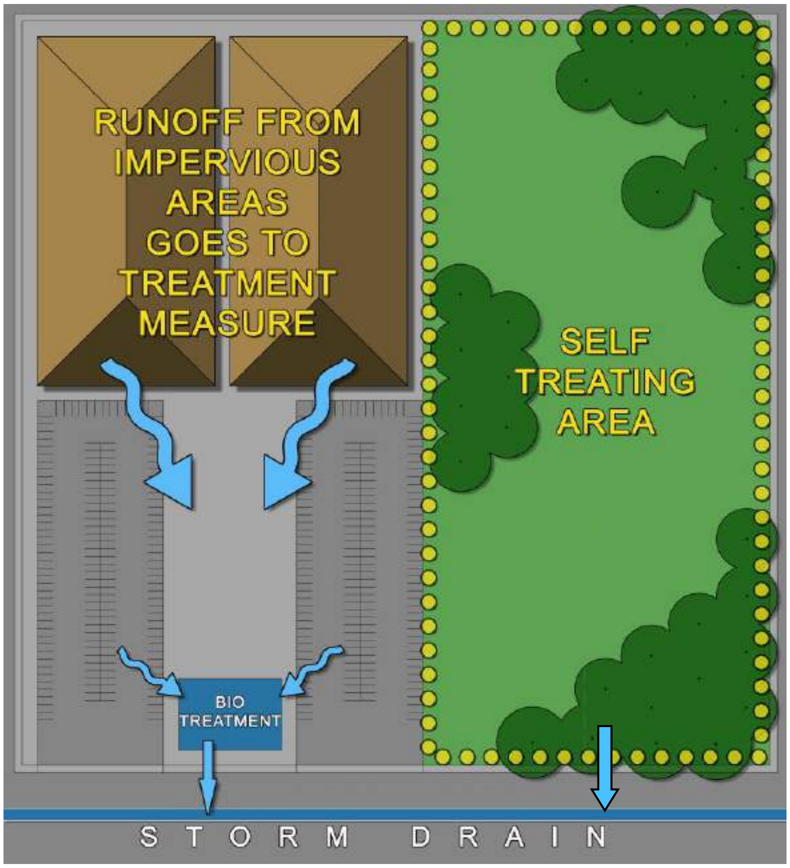


Figure 4-3. Schematic Drainage Plan for Site with a Self-Treating Area

Source: Santa Clara Valley Urban Runoff Pollution Prevention Program

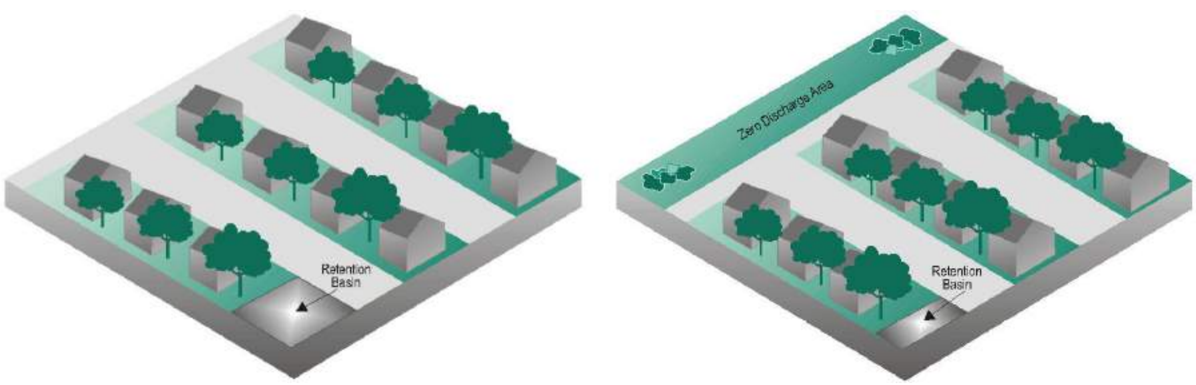
4.2 Self-Retaining Areas

In "self-retaining areas" or "zero discharge areas," a portion of the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas, or in properly designed areas of pervious paving. If it is possible to create a self-retaining area on your site, you can design smaller stormwater treatment measures (as illustrated in Figures 4-4 and 4-5). ***Drainage from roofs and paving is directed to the self-retaining area***, where it can be temporarily stored before infiltrating into the soil. Self-retaining areas may be created by designing concave landscaped areas at a lower elevation than surrounding paved areas, such as walkways, driveways, sidewalks and plazas; or by designing areas of pervious paving to accept runoff from impervious surfaces. Landscaped self-retaining areas are designed as concave areas that are bermed or ditched to retain the first one-inch of rainfall without producing any runoff. To meet the design objectives for self-retaining areas, projects should implement the following design guidance:

- Landscaped self-retaining areas should be designed as concave areas that are bermed or ditched to create a 3-inch ponding depth. Modeling conducted for the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report), prepared by Bay Area Stormwater Management Agencies Association

(BASMAA), demonstrated that a ponding depth of 3 inches is sufficient to meet the C.3 stormwater treatment objective.

- Pervious paving designed as a self-retaining area must provide adequate storage in the void space of the gravel base layer to accommodate the volume of runoff specified in Provision C.3.d of the MRP for both the area of pervious paving and the impervious surfaces that contribute runoff.
- Runoff may enter the self-retaining area as sheet flow, or it may be piped from a roof or area of impervious pavement. The elevation difference between a landscaped self-retaining area and adjacent areas should be sufficient to allow build-up of turf or mulch within the self-retaining area.
- A maximum 2:1 ratio of impervious area to the receiving pervious area (landscaped areas or pervious paving) is acceptable. Modeling conducted for the BASMAA LID Feasibility Criteria Report confirmed that a 2:1 ratio is sufficient to achieve the C.3.d stormwater treatment objective, even for soils with very low permeability. The 2:1 ratio applies to both landscaped areas and pervious paving areas that are designed as self-retaining areas.
- Drainage from self-retaining areas (for amounts of runoff greater than the first one-inch) must flow to off-site streets or storm drains without flowing onto paved areas within the site.
- If overflow drains or inlets to the storm drain system are installed within a landscaped self-retaining area, set them at an elevation of at least 3 inches above the low point to allow ponding. The overflow drain or storm drain inlet elevation should be high enough to allow ponding throughout the entire surface of the self-retaining area.
- Any impervious pavement within a predominantly pervious self-retaining area (e.g., a walkway through a landscaped area) cannot exceed 5 percent of the self-retaining area.
- Slopes may not exceed 4 percent.
- The municipality may require amended soils, vegetation and irrigation to maintain soil stability and permeability.
- Self-retaining areas shall be protected from construction traffic and compaction.



Conventional Design ***Design with "Self-Retaining" or "Zero Discharge" Area***

Figure 4-4. Comparison of Conventional Design and Self-Retaining Area

(Note: Allowing some runoff from impervious surfaces to be retained and infiltrate in a "self-retaining" or "zero discharge" area can reduce the size of the required stormwater treatment measure.)

Source: BASMAA 2003

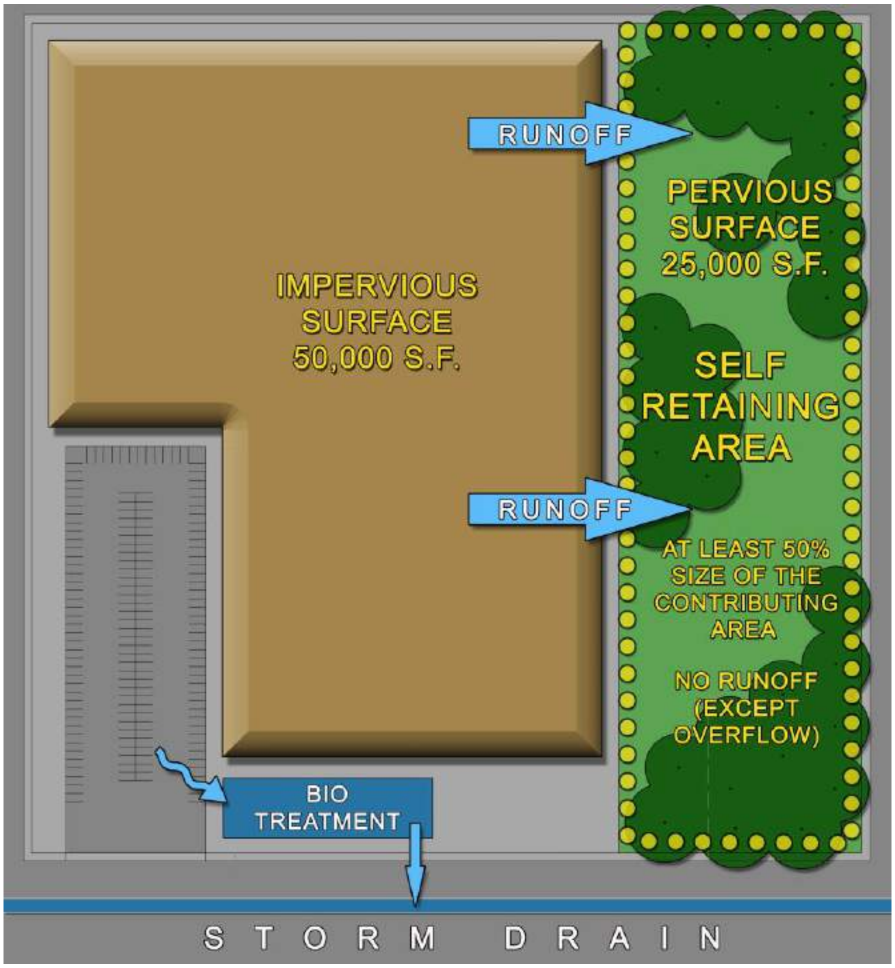


Figure 4-5. Schematic Drainage Plan for Site with a Self-Retaining Area

Source: Santa Clara Valley Urban Runoff Pollution Prevention Program

If you are considering using a self-retaining area in a project that must meet hydromodification management (HM) requirements, use the Bay Area Hydrology Model (BAHM) to identify the appropriate sizing of the self-retaining area to meet the HM objective of matching post-project stormwater flows and durations to pre-project patterns for smaller, frequent storms (ranging from 2- to 10-year storm events). The current version of the BAHM (BAHM 2013) is available for downloading at www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi. See Chapter 7.

4.3 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.

4.3.1 Alternative Site Layout Techniques

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

- Use ***pervious pavement*** – such as porous concrete, porous asphalt, or unit block pavers – which are not considered "impervious" if designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. See section 6.9 for pervious paving technical guidance.
- 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.

4.3.2 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

Photo 4-1. Parking Lifts in Parking Garage, Berkeley

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.

4.4 Rainwater Harvesting and Use

Technical guidance for rainwater harvesting and use is provided in Section 6.10 of Chapter 6. A rainwater harvesting system is considered a stormwater treatment measure if it is designed to capture and use the full amount of rainwater runoff that is required to be treated per Provision C.3.d of the MRP. A rainwater harvesting system is considered a site design measure if it is designed to capture and use less than the C.3.d amount of runoff. If your project will include a rainwater harvesting system as a site design measure, follow the guidance in Section 6.10, with the exception of meeting the C.3.d stormwater treatment sizing criteria.

4.5 Tree Preservation/Planting and Interceptor Tree Credits

Trees perform a variety of functions that reduce runoff volumes and improve water quality. Leaf canopies intercept and hold rainwater on the leaf surface, preventing it from reaching the ground and becoming runoff. Root systems create voids in the soil that facilitate infiltration. Trees also absorb and transpire large quantities of groundwater, making the soil less saturated, which allows more stormwater to infiltrate. Through the absorption process, trees remove pollutants from stormwater and stabilize them. Finally, tree canopies shade and cool paved areas.

Consistent with the Feasibility Report submitted to the Water Board by BASMAA on April 29, 2011, a project may earn stormwater treatment credits by planting new trees and preserving existing trees at the project site. In other words, the stormwater treatment credit can be subtracted from the amount of impervious surface area requiring treatment. To be eligible for these credits, the trees need to meet the minimum requirements listed in Section 4.5.1. The system of interceptor tree credits is described in Table 4-1, and guidance for planting and protection during construction is provided in Section 4.5.2. Additional information about planting trees in dense, urban settings is provided in Section 4.5.3.

Table 4-1. Stormwater Treatment Credits for Interceptor Trees

	New Evergreen Trees	New Deciduous Trees	Existing Trees
Credits for new and existing trees that meet interceptor tree minimum requirements	200 square feet	100 square feet	Square footage under the tree canopy trees with an average DBH of 12 inches or more.

**DBH: Diameter at breast height (4.5 feet above grade)*

Source: BASMAA LID Feasibility Criteria Report, 2011 (based on the tree credit system in the State Construction General Permit standards for post-construction stormwater control)

4.5.1 Minimum Requirements for Interceptor Trees

The following requirements are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions.

PLANTING NEW INTERCEPTOR TREES

To be eligible for stormwater interceptor tree credits, trees planted as part of the project must meet the following minimum requirements:

- Plant tree within 25 feet of ground-level impervious surface;
- Maintain appropriate distance from infrastructure and other structures that could be damaged by roots; avoid overhead power lines, underground utilities, septic systems, sidewalks, curbs, patios, etc.
- Space trees so crowns do not overlap at 15 years of growth;
- Specified trees must be 15 gallon container minimum size at planting;
- Dwarf species are not acceptable; native species and trees with a large canopy at maturity are preferred.
- Clearly label on project plans the trees designated for stormwater interceptor tree credits.
- An interceptor tree must be located in the same Drainage Management Area (DMA) to which the interceptor tree credit is assigned.

PRESERVING EXISTING INTERCEPTOR TREES

To be eligible for stormwater interceptor tree credits, existing trees preserved at the project site must meet the following minimum requirements:

- The tree trunk must be located within 25 feet of ground-level impervious surface that is included in the project's calculation of the amount of stormwater runoff that will require treatment.
- Dwarf species are ineligible.

- Clearly label on project plans the trees designated for stormwater interceptor tree credits.
- An interceptor tree must be located in the same Drainage Management Area (DMA) to which the interceptor tree credit is assigned.

4.5.2 Interceptor Tree Planting and Construction Guidelines

The following guidelines are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions.

PLANTING NEW INTERCEPTOR TREES

- Drainage and soil type must support selected tree species.
- Avoid compaction of soil in planting areas.
- Avoid contamination of planting areas by construction related materials such as lime or limestone gravel.
- Install turf grass no closer than 24 inches from trunk;
- Add 4-6 inches deep of hardwood mulch or aged composed mulch, 6 inches away from trunk;
- Permanent irrigation system may be required;
- Avoid excess irrigation due to mosquito issues;
- Pruning and removal and replacement of diseased/damaged tree may be required.
- If construction is ongoing, install high-visibility protective fencing at the outer limit of the critical root zone area.

PRESERVING EXISTING INTERCEPTOR TREES

- Plan new landscaping under existing trees to avoid grade changes and excess moisture in the trunk area, depending on the tree species. Preserve existing plants that are compatible with irrigation requirements and are consistent with the landscape design.
- Avoid grade changes greater than 6 inches within the critical root zone.
- Avoid soil compaction under trees.
- During construction minimize disruption of the root system.
- Plans and specifications shall clearly state protection procedures for interceptor trees to be preserved.
- Protect existing trees during construction through the use of high-visibility construction fencing at the outer limit of the critical root zone area. The fence must prevent equipment traffic and storage under trees. Excavation in this area should be done by hand and roots ½-inch and larger should be preserved. Pruning of branches or roots should be done by, or under supervision of, an arborist.
- Provide irrigation of trees during and after construction.
- Install turf grass no closer than 24 inches of trunk.

4.5.3 Tree Planting in Dense, Urban Areas

Structural soils may allow the installation of ***large shade trees*** in narrow medians where the tree otherwise may conflict with infrastructure.

When planting trees, particularly along streets where space is limited and roots may damage hard surfaces, ***consider the use of structural soils***. Structural soil is a planting medium that consists of a stone skeleton structure for strength and clay soil for water retention, which allows urban trees to grow under pavement. The structural soil system creates a load-bearing matrix with voids filled with soil and air, essential for tree health. This allows for greater tree growth, better overall heath of trees, and reduced pavement uplifting by tree roots. The voids that benefit the tree roots also provide increased stormwater storage capacity, allowing tree pits in paved areas to serve as a series of small detention basins. See www.hort.cornell.edu/uhi/outreach/csc/ for more information on structural soils. Before including structural soils in your project, please contact the municipality for information and requirements specific to the local jurisdiction.

Load-bearing modular grid products, such as the Silva Cell or approved equal[1], have also been developed to allow the planting of trees in uncompacted native soils, fill soils, or biotreatment soil, extending under sidewalks and other areas of pavement. With the Silva Cell product, for example, each cell is composed of a frame (or frames) and a deck (see Photo 4-2). The frames can be stacked one, two, or three units high before they are topped with a deck to create a maximum amount of soil volume for tree root growth and stormwater infiltration. Cells can be installed laterally as wide as necessary. Void space within the cells may accommodate the surrounding utilities.

[1] The evaluation of product equivalency is anticipated to include a wide range of topics, such as technical specifications, maintenance requirements, warranties, and all other relevant considerations.

Photo 4-2. *Silva Cells, stacked three units high.*

Source: Deep Root Technologies, www.deeproot.com). The use of this photograph is for general information only, and is not an endorsement of this or any other proprietary product.

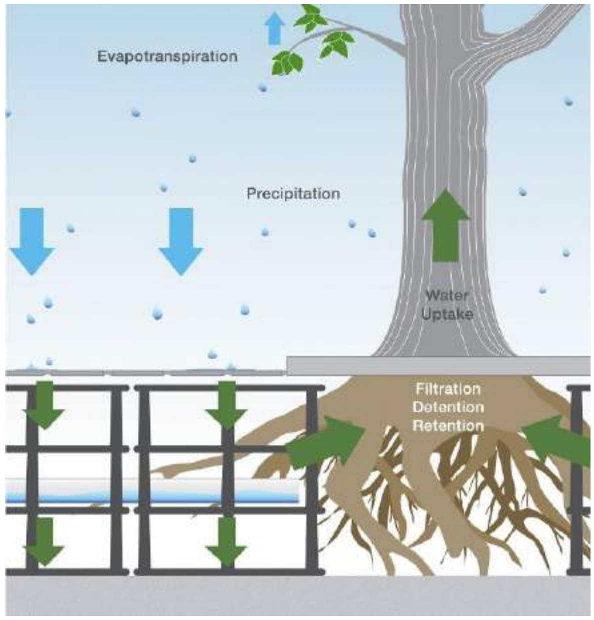


Figure 4-6. Schematic Illustration of an Installed Load-bearing Modular Grid Product

Source: Deep Root Technologies. The use of this image is for general information only, and is not an endorsement of this or any other proprietary product.

4.6 Site Design Requirements for Small Projects

Provision C.3.i of the MRP requires small projects that meet the following thresholds to include site design measures:

- Projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface[2]; and
- Individual single family home projects that create and/or replace 2,500 square feet or more of impervious surface.

Applicable projects must implement ***at least one*** of the following site design measures:

- Direct roof runoff into cisterns or rain barrels for use.
- Direct roof runoff onto vegetated areas.
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas.
- Direct runoff from driveways and/or uncovered parking lots onto vegetated areas.
- Construct sidewalks, walkways, and/or patios with permeable surfaces.
- Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.

[2] The threshold at which Special Land Use Projects (uncovered parking areas, restaurants, auto service facilities, and retail gasoline outlets) are considered C.3 Regulated Projects is 5,000 square feet of impervious surface. For these projects, the implementation of LID site design and stormwater treatment systems per Provision C.3.b of the MRP will also satisfy the requirements of Provision C.3.i.

To help applicants with small projects select site design measures appropriate for their sites, the Clean Water Program collaborated regionally through the Bay Area Stormwater Management Agencies Association (BASMAA) to develop the following four fact sheets:

- Managing Stormwater in Landscapes
- Rain Gardens
- Pervious Paving
- Rain Barrels and Cisterns

These factsheets, and further detail on implementing site design for small projects, are presented in Appendix L.

To supplement guidance provided in the regional fact sheets, refer to Table L-2 to identify key opportunities and constraints for the site design measures listed in Provision C.3.i. Choose one or more site design measures that are a good match for the project site. Only one site design measure is required for small projects, but additional measures may be selected to increase the water quality benefits of your project.

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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 non-landscape based treatment measures,
- Guidance regarding "treatment trains,"
- Infiltration guidelines,
- Using underdrains,
- Using low-flow systems,
- Selecting and maintaining plantings in landscape-based treatment measures,
- Mosquito control requirements,
- Incorporating treatment with hydromodification management measures, and
- Getting water into stormwater treatment 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 Municipal Regional Stormwater NPDES Permit requires that, for all "Regulated Projects"[1] the project site must receive stormwater treatment. Municipalities may require stormwater treatment for projects that are smaller than the Regulated Project threshold, and in these cases, stormwater treatment is required to the maximum extent practicable (MEP). Exceptions to the stormwater treatment requirement for Regulated Projects are pervious areas that are "self-treating" (including areas of pervious pavement with a hydraulically-sized aggregate base layer) as described in Section 4.1, and "self-retaining areas" designed to store and infiltrate runoff from rooftops or paved areas as described in Section 4.2. Other than "self-treating areas" and "self-retaining areas," ***ALL AREAS AT A PROJECT SITE*** must receive stormwater treatment.

Treating runoff from areas that are downgradient from stormwater treatment measures, such as driveway entrances, can be challenging. Consider using pervious pavement in these areas, using interceptor tree credits (see Section 4.5) to account for the amount of impervious surface created and/or replaced by driveway entrances. Opportunities to provide offsite treatment of the applicable amount of impervious surface may also be considered, as described in Chapter 9, Alternative Compliance.

Flow-Based Versus Volume-Based Treatment Measures

For hydraulic sizing purposes, stormwater treatment measures can be divided generally into three groups: flow-based, volume-based, and treatment measures that use a combination of flow and volume capacity. 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 media filters and high flow-rate tree well 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 infiltration trenches and rainwater harvesting systems. Flow-through planters and bioretention areas are typically sized using flow-based hydraulic sizing criteria, but in constrained areas they may use a ***combination of flow and volume capacity*** for stormwater treatment. Table 5-1 shows which hydraulic sizing method is appropriate for commonly used stormwater treatment measures.

[1] "Regulated Projects" are projects that create and/or replace 10,000 square feet or more of impervious surface. Beginning December 1, 2011, this threshold is reduced to 5,000 square feet of impervious surface for surface parking areas, restaurants, auto service facilities, and retail gasoline outlets.

Table 5-1. Flow and Volume Based Treatment Measure Designs		
	Type of Treatment Measure	**Type of Hydraulic Sizing Criteria to Use**
6.1	Bioretention	Flow-based or combination flow and volume
6.2	Flow-through planter	Flow-based or combination flow and volume
6.3	Tree well filter	Flow-based
6.4	Infiltration trench	Volume-based
6.5	Extended detention basin	Volume-based
6.6	Pervious paving	Volume-based
6.7	Grid pavements	Volume-based
6.8	Green roof	Volume-based
6.9	Rainwater harvesting	Volume-based
6.10	Media filter	Flow-based
6.11	Subsurface infiltration system	Volume-based

Volume-Based Sizing Criteria

The Municipal Regional Stormwater NPDES Permit specifies two alternative methods for hydraulically sizing volume-based stormwater treatment measures. One of the permit-approved methods, the "Urban Runoff Quality Management Approach," 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 Clean Water Program recommends the use of the "California Stormwater BMP Handbook Approach," or "80 percent capture method," ***shown in the text box.***

Please note that the Clean Water Program'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, which is described below, under the heading, Simplified Sizing Methods.

The ***80 percent capture method*** should be used when sizing infiltration trenches, rainwater harvesting systems, or 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.

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 (2003), using local rainfall data.

The 80 percent capture method is described in the California Stormwater Quality Association's 2003 Stormwater Best Management Practice Handbook New Development and Redevelopment available at www.casqa.org.

To size volume-based treatment measures, use the following steps, which may be performed using the volume-based sizing criteria Excel worksheet provided in Appendix C.

1. Mean Annual Precipitation

- Determine the *mean annual precipitation (MAP)* for the project site using the Mean Annual Precipitation Map of Alameda County (Appendix D). 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.
- In order to account for the difference between MAP of the project site and the two rainfall locations shown, calculate the **MAP adjustment factor** by dividing the project MAP by the MAP for the applicable rain gauge, as shown below:

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

2. Effective Impervious Area for the Drainage Management Area

- Based on the topography of the site and configuration of buildings, divide the site into drainage management areas (DMAs), each of which will drain to a treatment measure. Implement the steps below for each DMA with a volume-based treatment measure.
- Minimize the amount of landscaping or pervious pavement that will contribute runoff to the treatment measures. Refer to Sections 4.1 and 4.2 to design areas of landscaping or pervious pavement as "self-treating areas" or "self-retaining areas," so that they do not contribute runoff to the LID treatment measure and may be excluded from the DMAs for the treatment measures.
- For each DMA in which the area that will contribute runoff to the treatment measure includes pervious surfaces (landscaping or properly designed pervious paving), multiply the area of pervious surface by a factor of 0.1.
- For applicable DMAs, add the product obtained in the previous step to the area of impervious surface, to obtain the "effective impervious area." (For DMAs that are 100% impervious, use the entire DMA area.)

3. Unit Basin Storage Volume

- The effective impervious area of a DMA has a runoff coefficient of 1.0. Refer to Table 5-2 to obtain the ***unit basin storage volume*** that corresponds to your rain gauge area. For example, using the Oakland Airport gauge, the unit basin storage volume would be 0.67 inches. Adjust the unit basin storage volume for the site by multiplying the unit basin storage volume value by the MAP adjustment factor calculated in Step 1.

Calculate the ***required capture volume*** by multiplying the effective impervious area of the DMA calculated in Step 2 by the adjusted unit basin storage volume. 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. For example, say you determined the adjusted unit basin storage volume to be 0.5 inches, and the effective impervious area draining to the bioretention facility is 7,000 square feet. Then the required capture volume would be 0.5 inches × (1 foot/12 inches) × 7,000 square feet = 292 cubic feet.

Table 5-2. Unit Basin Storage Volume (Inches) for 80 Percent Capture with 48-Hour Drawdown Time

		Unit Basin Storage Volume for Effective Impervious Area of Drainage Management Area
Location	**Mean Annual Precipitation (inches)**	**Coefficient of 1.00**
Oakland Airport	18.35	0.67
San Jose	14.4	0.56

Source: California Stormwater Quality Association (CASQA 2003).

4. *Depth of Infiltration Trench or Pervious Paving Base Layer*

If you are designing an infiltration trench, or area of pervious paving that will receive runoff from adjacent impervious surfaces, determine the surface area that is available for the trench, or the area of pervious paving. Given that surface area, the depth required for the trench, or for the rock base below the pervious paving, may be calculated by dividing the required capture volume by 0.35 (which represents the assumed void space available within the rock-filled trench or base), and then dividing the rock volume by the surface area of the proposed trench or area of pervious paving.

Flow-Based Sizing Criteria

The Municipal Regional Stormwater NPDES Permit specifies three alternative methods for hydraulically sizing flow-based stormwater treatment control measures, such as flow through planter boxes, and media filters. These three methods are described in Table 5-3.

The percentile rainfall intensity method is based on ranking the hourly depth of rainfall from storms over a long period, and determining the 85^{th} percentile hourly rainfall depth and multiplying this value by two. In the Bay Area, this value is generally around 0.2 inches/hour at low elevation rain gauges. 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.

Table 5-3. Flow-based Sizing Criteria Included in MRP Provision C.3.d		
Flow-based Sizing Criteria	**Description**	**Practice Tips**
Percentile Rainfall Intensity Method	Ranks the hourly depth of rainfall from storms over a long period, determines the 85th percentile hourly rainfall depth, and multiplies this value by two.	This approach requires hydrologic studies that have not been conducted in Alameda County. Results of studies in other Bay Area locations showed a rainfall intensity of about 0.2 inch/hour.
0.2 Inch-per-Hour Intensity Method ***(Recommended Method)***	Simplification of the Percentile Rainfall Intensity Method.	The 4 percent method, which is recommended for use throughout Alameda County, is derived from this approach.
10% of the 50-year peak flow rate ("Factored Flood Flow Approach")	Rainfall intensity is determined using Intensity-Duration-Frequency curves published by the local flood control agency or climactic data center.	This approach may be used if the 50-year peak flow has been determined. This approach has not been used locally.

Sizing Bioretention Areas

The simplified method for sizing bioretention areas and flow-through planters, known as the "4 percent method," is based on a runoff inflow of 0.2 inches per hour, with an infiltration rate through the biotreatment soil of 5 inches per hour (0.2 in/hr divided by 5 in/hr = 0.04). Because two of the permit allowed methods yield similar results and the third method requires data that may not be readily available, the ***Clean Water Program recommends using the 4 percent method to design bioretention areas***, flow-through planters, and tree well filters that use biotreatment soil.

The 4 percent method requires the surface area of the treatment measure to be 4 percent of the impervious area that drains to it (1,750 square feet of bioretention area per impervious acre). If areas of landscaping or pervious paving contribute runoff to the treatment measure, the area of these pervious surfaces is multiplied by a factor of 0.1 to obtain the amount of "effective impervious area" (as described in the volume-based sizing approach earlier in this chapter).

To apply the 4 percent method, use the following steps:

1. Based on the topography of the site and configuration of buildings, divide the site into drainage management areas (DMAs), each of which will drain to an LID treatment measure. Implement Steps 2 through 5 for each DMA.
2. Minimize the amount of landscaping or pervious pavement that will contribute runoff to the LID treatment measures. Refer to Sections 4.1 and 4.2 to design areas of landscaping or pervious pavement as "self-treating areas" or "self-retaining areas," so that they do not contribute runoff to the LID treatment measure and may be excluded from the DMAs for the treatment measures.

3. For each DMA in which the area that will contribute runoff to the treatment measure includes pervious surfaces (landscaping or pervious paving), multiply the area of pervious surface by a factor of 0.1.
4. For applicable DMAs, add the product obtained in Step 3 to the area of impervious surface, to obtain the "effective impervious area."
5. Multiply the impervious surface (or effective impervious area in applicable DMAs) by a factor of 0.04. This is the required surface area of the LID treatment measure.

Appendix C includes an example of sizing bioretention areas using the 4 percent method.

Sizing Other Flow-Based Treatment Measures

Other flow-based stormwater treatment measures, such as media filters (where allowed on a project), are sized using the Rational Method, which computes the runoff resulting from the design rainfall intensity. The Rational Method formula is:

$$Q=CiA$$

Where:

Q= flow in cubic feet/second
i = rainfall intensity in inches/hour
C= composite runoff coefficient (unitless – see Table 5-4)

A= drainage area in acres

To compute the water quality design flow, use the following steps:

1. Determine the ***drainage area***, "A," in acres for the stormwater treatment measure.
2. Determine the ***runoff coefficient,*** "C," from Table 5-4. Note that it is more accurate to compute an area-weighted "C-factor" based on the surfaces in the drainage area, if possible, than to assume a composite C-factor.
3. Use a design intensity of ***0.2 inches/hour*** for "i" in the Q=CiA equation.
4. Determine the design flow (Q) using Q = CiA:

   Q = [Step 2] × 0.2 in/hr × [Step 1] = _____ cubic ft/sec[2]

[2] Note that the Rational Method formula produces a result with units of "acre-in/hour"; however, the conversion factor from acre-in/hour to cubic feet/second is approximately 1.0.

Table 5-4. Estimated Runoff Coefficients for Various Surfaces During Small Storms

Type of Surface	Runoff Coefficients "C" factor
Roofs	0.90
Concrete	0.90
Asphalt	0.90
Grouted pavers	0.90
Pervious concrete	0.10
Pervious asphalt	0.10
Permeable interlocking concrete pavement	0.10
Grid pavements with grass or aggregate surface	0.10
Crushed aggregate	0.10
Grass	0.10

Note: These C-factors are only appropriate for small storm treatment design and should not be used for flood control sizing. When available, locally developed small storm C-factors for various surfaces may be used.

Combination Flow and Volume Design Basis

See Appendix C for an example of sizing bioretention areas using the combination flow- and volume method.

For projects on sites where infiltration should be avoided, or for which the agency determines that plans to maximize density will result in substantial environmental benefits, staff may allow the use of the combination flow and volume design basis for bioretention areas and flow-through planters that include a surface ponding area. In these treatment measures, volume-based treatment is provided when stormwater is stored in the surface ponding area. The surface ponding area may be sized so that the ponding area functions to retain water before it enters the soil at the minimum 5 inches per hour required by Municipal Regional Stormwater NPDES Permit (MRP) Provision C.3.c(2)(b)(vi). This may allow for a reduced footprint of the bioretention area or flow-through planter. However, it is recommended that agencies not approve any bioretention areas or flow-through planters sized using this method that propose a surface area that is less than 3 percent of the effective impervious area that drains to the treatment measure.

The 4 percent method for sizing bioretention areas and flow-through planters, in which the surface area of the treatment measure is designed to be 4 percent of the effective impervious area that drains to the treatment measure, is a flow-based sizing approach. This approach tends to result in the design of a conservatively large treatment measure because it does not account for any storage provided by the surface ponding area.

Photo 5-1. Bioretention area, Emeryville (example of a combination flow- and volume-based treatment measure)

Provision C.3.d of the MRP specifies that treatment measures that use a combination of flow and volume capacity shall be sized to treat at least 80 percent of the total runoff over the life of the project, using local rainfall data. This sizing approach is best applied when using a continuous simulation hydrologic model to demonstrate that a treatment system is in compliance with C.3.d. However, when doing sizing calculations by hand, compliance with C.3.d. can be demonstrated by showing how the treatment system design meets both the flow-based and volume-based criteria.

To apply the combination flow and volume approach, use the following steps, which may be performed using the combination flow and volume sizing criteria Excel worksheet provided in Appendix C.

1. ***Mean Annual Precipitation***

   - Determine the ***mean annual precipitation (MAP)*** for the project site using the Mean Annual Precipitation Map of Alameda County (Appendix D). Use the Oakland Airport unit basin storage volume values from Table 5-4 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.

   - In order to account for the difference between MAP of the project site and the two rainfall locations shown, calculate the ***MAP adjustment factor*** by dividing the project MAP by the MAP for the applicable rain gauge, as shown below:

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

2. ***Effective Impervious Area for the Drainage Management Area***

   - Based on the topography of the site and configuration of buildings, divide the site into drainage management areas (DMAs), each of which will drain to a treatment measure. Implement the steps below for each DMA in which you will design a combined flow- and volume-based treatment measure.

- Minimize the amount of landscaping or pervious pavement that will contribute runoff to the treatment measures. Refer to Sections 4.1 and 4.2 to design areas of landscaping or pervious pavement as "self-treating areas" or "self-retaining areas," so that they do not contribute runoff to the LID treatment measure and may be excluded from the DMAs for the treatment measures.
- For each DMA in which the area that will contribute runoff to the treatment measure includes pervious surfaces (landscaping or properly designed pervious paving), multiply the area of pervious surface by a factor of 0.1.
- For applicable DMAs, add the product obtained in the previous step to the area of impervious surface, to obtain the "***effective impervious area***." (For DMAs that are 100% impervious, use the entire DMA area.)

3. *Unit Basin Storage Volume*

- The effective impervious area of a DMA has a runoff coefficient of 1.0. Therefore, refer to Table 5-4 to obtain the ***unit basin storage volume*** that corresponds to your rain gauge area. For example using the Oakland Airport gauge, the unit basin storage volume would be 0.67 inches. Adjust the unit basin storage volume by multiplying the unit basin storage volume value by the MAP adjustment factor calculated in Step 1.
- Calculate the ***required capture volume*** by multiplying the area of the DMA (or the effective impervious area if it includes landscaping), calculated in step 2, by the adjusted unit basin storage volume. 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. For example, say you determined the adjusted unit basin storage volume to be 0.5 inches, and the effective impervious area draining to the bioretention facility is 7,000 square feet. Then the required capture volume would be 0.5 inches $\times$ (1 foot/12 inches) $\times$ 7,000 square feet = 292 cubic feet.

Table 5-2 (repeated)

Unit Basin Storage Volume (Inches) for 80 Percent Capture with 48-Hour Drawdown Time[3]

		Unit Basin Storage Volume for Effective Impervious Area of Drainage Management Area
Applicable Rain Gauge	**Mean Annual Precipitation (inches)**	**Runoff Coefficient of 1.0**
Oakland Airport	18.35	0.67
San Jose	14.4	0.56
Source: CASQA 2003		

4. Duration of Rain Event

- Assume that the rain event that generates the required capture volume of runoff determined in Step 3 occurs at a constant rainfall intensity of 0.2 inches/hour from the start of the storm (i.e., assume a rectangular hydrograph). Calculate the ***duration of the rain event*** by dividing the unit basin storage volume by the intensity. In other words, determine the amount of time required for the unit basin storage volume to be achieved at a rate of 0.2 inches/hour. For example, if the unit basin storage volume is 0.5 inches, the rain event duration is 0.5 inches ÷ 0.2 inches/hour = 2.5 hours.

5. Preliminary Estimate of the Surface Area the Facility

- Make a ***preliminary estimate of the surface area*** of the bioretention facility by multiplying the DMA's impervious area (or effective impervious surface if applicable) by the 4 percent method sizing factor of 0.04. For example, a drainage area of 7,000 square feet of impervious surface × 0.04 = 280 square feet of bioretention treatment area.
- Assume a bioretention area that is about 25% smaller than the bioretention area calculated with the 4 percent method. Using the example above, 280 – (0.25 × 280) = 210 square feet.
- ***Calculate the volume of runoff that filters through the biotreatment soil*** at a rate of 5 inches per hour (the design surface loading rate for bioretention facilities), for the duration of the rain event calculated in Step 4. For example, for a bioretention treatment area of 210 square feet, with an infiltration rate of 5 inches per hour for a duration of 2.5 hours, the volume of treated runoff = 210 square feet × 5 inches/hour × (1 foot/12 inches) × 2.5 hours = 219 cubic feet. (Note: when calculating ponding depth, the mulch layer is not included in the calculation.)

6. Initial Adjustment of Depth of Surface Ponding Area

- Calculate the portion of the required capture volume ***remaining after treatment is accomplished by filtering*** through the treatment soil. The result is the amount that must be stored in the ponding area above the reduced bioretention area assumed in Step 6. For example, the amount remaining to be stored comparing Step 3 and Step 5 is 292 cubic feet – 219 cubic feet = 73 cubic feet. If this volume is stored over a surface area of 210 square feet, the ***average ponding depth*** would be 73 cubic feet ÷210 square feet = 0.35 feet or 4.2 inches.
- Check to see if the ***average ponding depth is between 6 and 12 inches***, which is the recommended allowance for ponding in a bioretention facility or flow-through planter.

7. Optimize the Size of the Treatment Measure

- If the ponding depth is greater than 12 inches, a larger surface area will be required. (In the above example, the optimal size of the bioretention area is 190 square feet with a ponding depth of 6 inches.) In order to build conservatism into this sizing method, the Countywide Program recommends that municipalities not approve the design of any bioretention areas or rain gardens that have a surface area that is less than 3 percent of the effective impervious area within the DMA.

In addition to the Excel worksheet for performing the above calculations, Appendix C includes an example of sizing bioretention areas using the combination flow- and volume-based method.

5.2 Applicability of Non-Low Impact Development (LID) Treatment

Since December 1, 2011, the MRP has placed ***restrictions on the use of non-LID treatment measures.*** Only Special Projects are allowed some limited use of non-LID treatment measures for stand-alone treatment of stormwater. Special Projects, as defined in Appendix J, are allowed to treat specified percentages of the C.3.d amount of stormwater runoff with vault-based media filters or tree well filters that have a high flow rate. See Appendix J for additional guidance on Special Projects.

Since December 1, 2011, there have been restrictions on the use of non-LID treatment measures.

Underground vault-based, non-LID 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 to prevent mosquito access and include suitable access doors and hatches to allow for frequent inspections and maintenance. But even when maintained properly, some types of underground vault systems lack the detention time required to remove ***pollutants associated with fine particles.*** See Appendix E for more information regarding inlet filters, oil/water separators, hydrodynamic separators and media filters.

5.3 Using Treatment Trains

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 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. Targeting specific treatment processes by constituent is referred to as "unit process" design. ***Each stormwater treatment measure in a treatment train should be sized using the Provision C.3 numeric sizing criteria.***

What Is A Treatment Train?
A treatment train is a multiple treatment system that uses two or more stormwater treatment measures in series, for example, a settling basin/ infiltration trench combination.

The ***simplest version*** and most common use of a treatment train consists of pretreatment prior to the stormwater reaching the main treatment system. For example, bioretention areas may use vegetated buffer strips to settle out sediment before the stormwater enters the bioretention area. This type of pretreatment helps prevent sediment from clogging the bioretention area, which maximizes its life. Another example is when a hydrodynamic separator is used to remove trash and coarse sediment upstream of a media filter or subsurface infiltration system. ***Note that non-LID treatment measures may be used in the treatment train as long as the last measure in the train is an LID treatment measure***.

Another option for a treatment train is to provide upstream storage for a treatment measure which may allow the treatment measure to be reduced in size. For example, a rainwater cistern may be used to store and slowly release water to a bioretention facility. Conversely, the bioretention facility can be used to treat the overflow from the cistern if there is insufficient irrigation or toilet flushing demand to empty the cistern prior to the next rain event.

5.4 Infiltration Guidelines

Infiltration is prioritized by the MRP, and it 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. Bioretention is an example of indirect infiltration. Unless geotechnical considerations preclude it, all projects should maximize infiltration of stormwater runoff through methods such as raising the underdrain in unlined bioretention areas (see Section 6.1).
- ***Direct infiltration*** methods***,*** which are designed to ***bypass surface soils*** and transmit runoff directly to subsurface soils, may allow infiltration to groundwater. These types of devices must be located and designed to limit the potential for stormwater pollutants to reach groundwater. Deep infiltration trenches are an example of a direct infiltration method.

The local jurisdiction may require a geotechnical review for your project, or, at a minimum, information regarding the site's hydrologic soil type. 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 infiltrating water from damaging surrounding properties, structures and/or public improvements.

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

5.5 Underdrains in Biotreatment Measures

Where the existing soils have a lower infiltration rate than soils specified for a landscaped-based stormwater treatment measure, or “biotreatment measure,” it may be necessary to install an underdrain to allow the treatment measure to function as designed and ***prevent the accumulation of standing water.***

Underdrains are perforated to allow water to enter the pipe and flow to the storm drain system. To help prevent clogging, two rows of perforation may be used, and should be installed facing downward. Cleanouts should be installed to allow access to underdrains to remove clogs. ***Underdrains should NOT be wrapped in filter fabric,*** to help avoid clogging. Underdrains are typically installed in a layer of washed drain rock or Class 2 perm aggregate, beneath high-percolation stormwater biotreatment soils.

Where conditions allow, place the underdrain near the top of the underlying rock layer, to promote infiltration, as shown in technical guidance for specific stormwater treatment measures in Chapter 6.

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.*** However, the design should insure that treatment measures do not re-suspend and flush out pollutants that have been accumulating during small storms, and that stormwater treatment measures do not erode during flows that will be experienced during larger storms. Some treatment measures may be designed to handle flood flows, although they would not be providing much treatment during these flows. The C.3 technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards to accommodate flood flows associated with larger storms.

Bioretention areas, flow-through planter boxes, and other treatment systems that rely on filtering or infiltrating stormwater through soils must have ***overflow systems*** that allow flood flows larger than the increment of flow that can be treated to bypass the stormwater treatment measure. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards for overflow drains or high-flow bypasses.

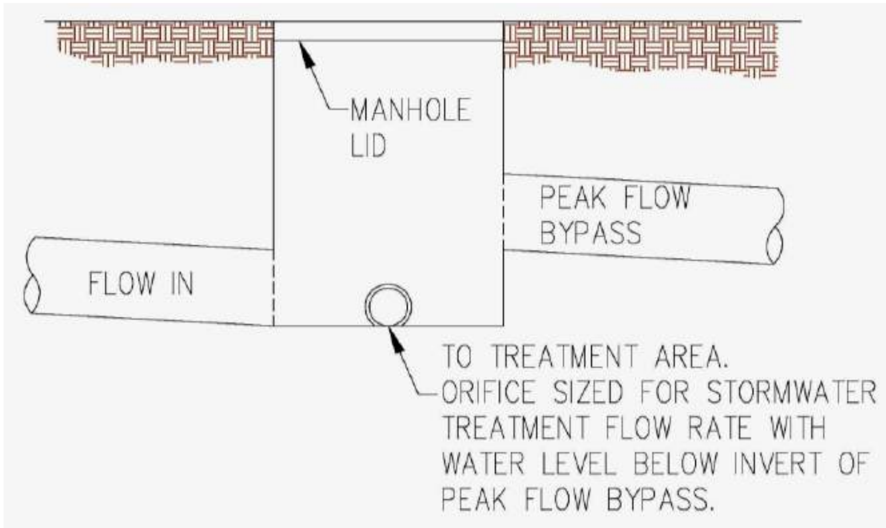


Figure 5-1. Stepped Manhole Design

Note: A stepped manhole design directs low-flows to treatment measure and diverts high flows to storm drain system.

Source: BKF Engineers

Another option is to restrict stormwater flows to the treatment measure or ***bypass high flows around the treatment measure.*** Since stormwater treatment measures are generally designed to treat only the water from small storm events, bypassing larger flows helps prevent hydraulic overload and resuspension of sediment, and it can also protect stormwater treatment measures from erosion.

Flow splitter devices may be used to direct the design runoff flow into a stormwater treatment measure, and bypass excess flows from larger storm events around the facility into a bypass pipe or channel. The bypass may connect directly to the storm drain system, or to another stormwater treatment measure that is designed to handle high flows. This can be accomplished using a stepped manhole (Figure 5-1) or a proprietary flow splitter (Figure 5-2). As illustrated in Figure 5-2, runoff enters the device by way of the inlet at the left side of the figure; low flows are conveyed to the stormwater treatment measure by way of the outlet pipe at the lower right. Once the treatment measure reaches its design capacity, water backs up in the low-flow outlet pipe and into the flow splitter. When the water level in the flow splitter reaches the bypass elevation, stormwater begins to flow out the overflow pipe, shown at the upper right of the figure, bypassing the stormwater treatment measure. The bypass generally functions by means of a weir inside the flow splitter device.

Figure 5-2. StormGate^{TM} Flow Splitter Structure

Note: Use of this illustration is for general information only and is not an endorsement of this or any other proprietary device.

Source: Contech Construction

5.7 Plant Selection and Maintenance

Selecting the appropriate plants and using sustainable, horticulturally sound landscape design 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, while Appendix K provides biotreatment soil mix installation guidance.

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 (available at www.rescapeca.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, properly maintained stormwater treatment measures are not waters of the United States subject to Sections 401 and 404 of the federal Clean Water Act.

Water Efficient Landscaping Requirements

The California Water Conservation in Landscaping Act of 2010, and the 2015 amendments of Title 23, California Code of Regulations, Chapter 2.7 Model Water Efficient Landscape Ordinance, Sections 490 through 495, requires municipalities to adopt, by December 1, 2015, landscape water conservation ordinances that are at least as effective in conserving water as the 2015 update of the Model Water Efficient Landscape Ordinance prepared by the Department of Water Resources. The Model Ordinance automatically went into effect, on December 1, 2015, four individual municipalities that had not adopted a comparable local ordinance. For local land use agencies working together to develop a regional water efficient landscape ordinance, the reporting requirements of Model Ordinance became effective December 1, 2015, and the remainder of this ordinance went into effect February 1, 2016.

The updated Model Ordinance applies to (1) new construction projects with an aggregate landscape area equal to or greater than 500 square feet requiring a building or landscape permit, plan check or design review; (2) rehabilitated landscape projects with an aggregate landscape area equal to or greater than 2,500 square feet requiring a building or landscape permit, plan check, or design review; (3) existing landscapes that were installed before December 1, 2015, and are over 1 acre in size. The Green Building Code also requires water budgeting for non-residential projects consistent with the Ordinance. Contact the municipality to ***determine whether your project is subject to the updated Model Ordinance*** or other water efficient landscaping ordinance.

Irrigation of Biotreatment Facilities

Bioretention facilities, flow-through planters, and other stormwater treatment facilities that use biotreatment soil may need to receive more frequent irrigation than other landscaped areas, due to the sand content of biotreatment soil. ***Provide separate irrigation control for bioretention areas, flow-through planters, and other stormwater treatment measures that use biotreatment soil***. Specify weather-based irrigation controllers, sometimes called "smart" irrigation controllers, which use soil moisture sensors to signal the irrigation controller. Drip emitters should be used instead of spray irrigation.

Inspections should be conducted on an ongoing basis, including cleaning and adjusting all drip emitters and valves, and any sprinkler and bubbler heads, for proper coverage. Inspections should include monitoring the irrigation system while operating to identify and correct problems with water runoff or standing water. More information regarding irrigation is provided in Section B.5, Monitoring and Maintenance of Appendix B, Plant List and Planting Guidance.

5.8 Mosquito Control

Some types of stormwater treatment measures are designed to hold water, and even treatment measures that are designed to eliminate standing water between storms may 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 Clean Water Program 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 has identified a ***72-hour maximum*** allowable water retention time for stormwater treatment facilities. 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 72 hours to effectively suppress vector production. *Please note that the design of stormwater treatment measures* ***does not require*** *that water be standing for 72 hours. During 72 hours 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 the Vector Control Plan, included in Appendix G.

> Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** included in Appendix G.

5.9 Incorporating Hydromodification Management

In addition to requiring stormwater treatment, the MRP also requires that stormwater runoff be detained and released in a way that ***prevents increased creek channel erosion*** and siltation in susceptible areas. The amount of stormwater flow and the duration of flows that cause erosion must be limited to match what occurred prior to the 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. See Chapter 7 for more information.

The HM requirements have been in effect since 2007 and may be required on your project in addition to stormwater treatment, low impact development, and flood control requirements (if any). To prevent hydromodification, HM facilities are designed to match pre-project flow durations ***for a range of flows from 10 percent of the two-year storm peak flow up to the ten-year storm peak flow.*** This is different from the sizing criteria that are used for stormwater treatment and LID measures, and from the design criteria used for flood control facilities.

Photo 5-2. Detention pond in Pleasanton provides hydromodification management.

To help applicants meet the HM requirements, the Clean Water Program developed the Bay Area Hydrology Model (BAHM) with assistance from the municipal stormwater programs in Santa Clara and San Mateo Counties. You can use the BAHM to automatically size stormwater detention measures such as detention vaults, tanks, basins and ponds for Flow Duration Control of post-project runoff (go to www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi to download the current version of the BAHM [BAHM 2013]). Chapter 7 provides more detail on HM requirements and the BAHM.

5.10 Getting Water into Treatment Measures

Stormwater may be routed into stormwater treatment measures using ***sheet flow or curb cuts.*** The following pages from the San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook show common curb cut types. An 18-inch width at bottom of curb is recommended for curb cuts, to avoid clogging. To avoid erosion, cobbles or other energy dissipater is recommended. A minimum two-inch drop in grade between the impervious surface and the finish grade of the stormwater treatment facility is recommended. This drop in grade needs to take into consideration the height of any vegetation.

Photo 5-3. Cobbles are placed at the inlet to this stormwater treatment measure in Fremont, to help prevent erosion.

Standard Curb Cut: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities 12" width may be allowed subject to municipal approval.
- Curb cut can have vertical sides or have chamfered sides at 45 degrees (as shown).
- Works well with relatively shallow stormwater facilities that do not have steep side slope conditions.
- Need to slope the bottom of the concrete curb toward the stormwater facility.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Provide cobbles or other energy dissipater to prevent erosion.

Photo 5-4. Standard Curb Cut

Note: This standard curb cut at parking lot rain garden has 45-degree chamfered sides.

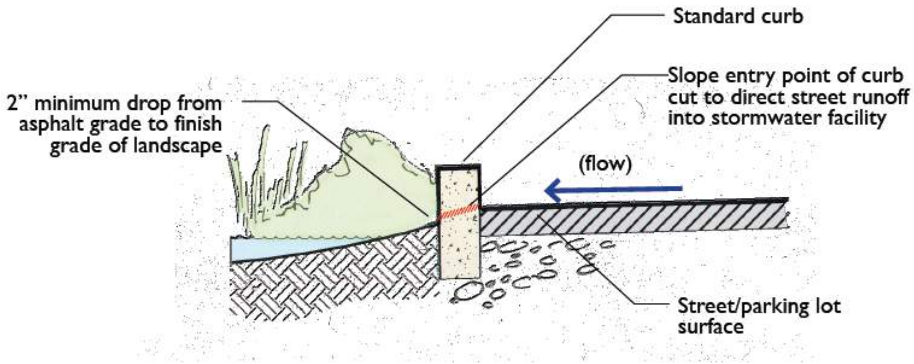


Figure 5-3. Standard Curb Cut: section view

Source: San Mateo Countywide Water Pollution Prevention Program [SMCWPPP] 2009

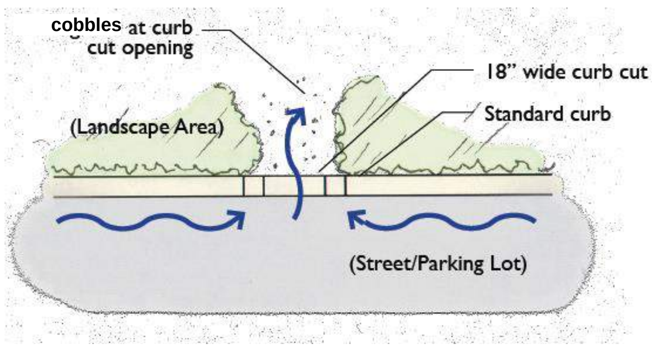


Figure 5-4. Standard Curb Cut: plan view

Source: SMCWPPP 2009

Standard Curb Cut with Side Wings: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities 12" width may be allowed subject to municipal approval.
- Works well with stormwater facilities that have steeper side slope conditions.
- Need to slope the bottom of the concrete curb toward the stormwater facility.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Provide cobbles or other energy dissipater to prevent erosion.

Photo 5-5. The side wings of this standard curb cut help retain the side slope grade on each side of the curb cut opening.

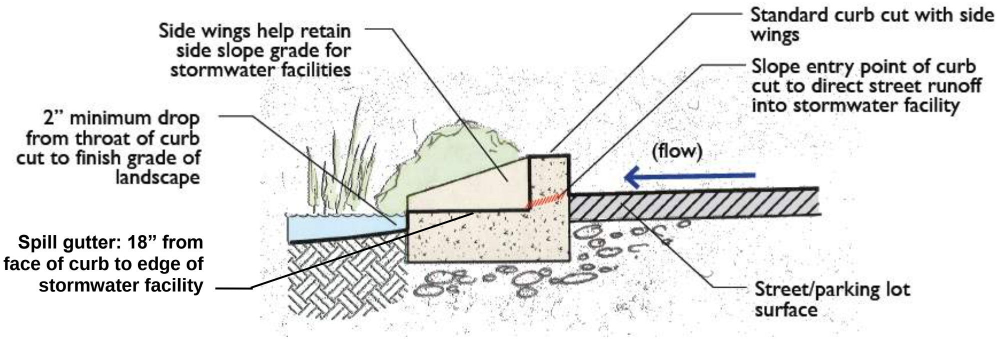


Figure 5-5. Standard Curb Cut with Side Wings: cut section view
Source: SMCWPPP 2009

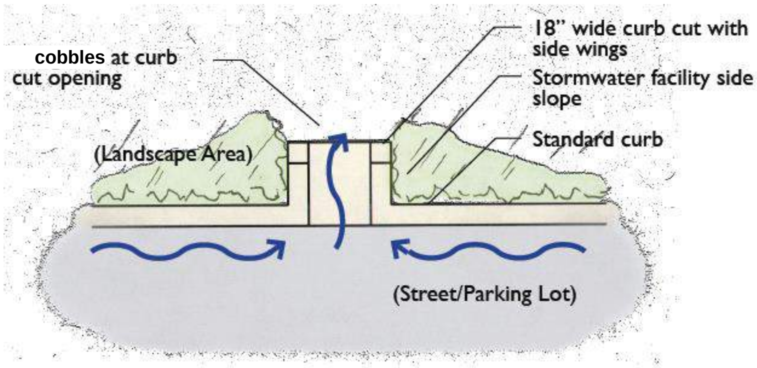


Figure 5-6. Standard Curb Cut with Side Wings: plan view
Source: SMCWPPP 2009

Wheelstop Curbs: Design Guidance

- Wheelstops allow water to flow through frequently spaced openings.
- Wheelstops are most common in parking lot applications, but they may also be applied to certain street conditions.
- Need to provide a minimum of 6 inches of space between the wheelstop edge and edge of paving. This is to provide structural support for the wheelstop.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Provide cobbles or other energy dissipater at the wheel stop opening to prevent erosion.

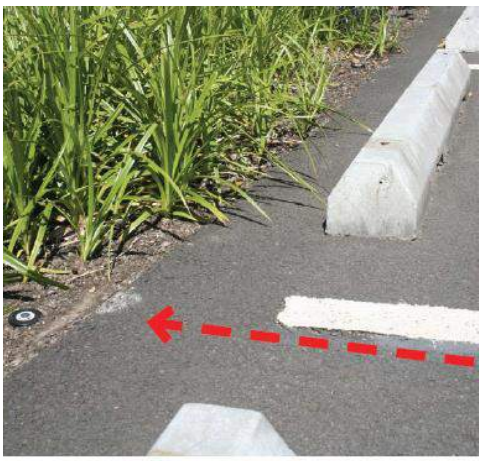


Photo 5-6. Stormwater runoff enters the stormwater facility through the 3-foot space between these wheelstops. The design could be improved by providing more of a drop in grade between the asphalt and landscape area.

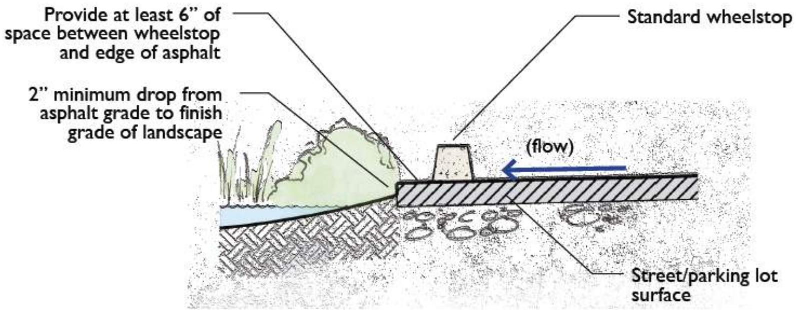


Figure 5-7. Opening between Wheelstop Curbs: section view
Source: SMCWPPP 2009

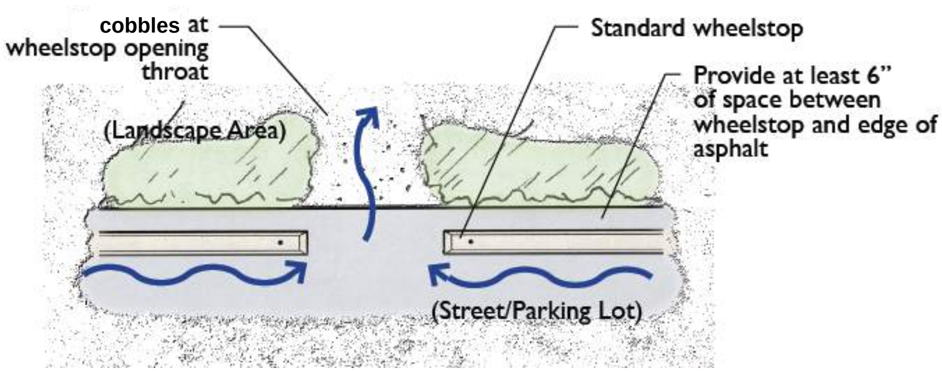


Figure 5-8. Opening between Wheelstop Curbs: plan view
Source: SMCWPPP 2009

Grated Curb Cut: Design Guidance

- Grated curb cuts allow stormwater to be conveyed under a pedestrian walkway. The curb cut opening should be at least 18 inches wide; 12" may be allowed for smaller facilities subject to municipal approval.
- Grates need to be Americans with Diabilities Act (ADA) compliant and have sufficient slip resistance.
- A 1-to-2 inch high asphalt or concrete berm should be placed on the downstream side of the curb cut to help direct runoff into the curb cut.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.

Photo 5-7. A grated curb cut allows stormwater to pass under a pedestrian egress zone to the stormwater facility.

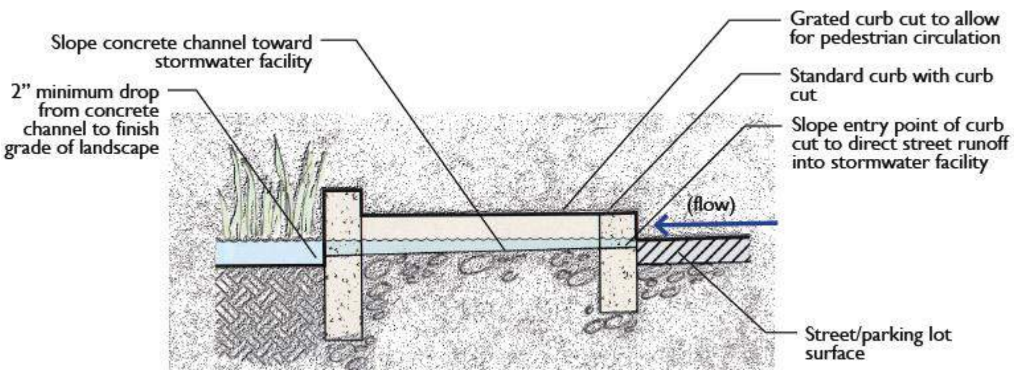


Figure 5-9. Grated Curb Cut: section view

Source: SMCWPPP 2009

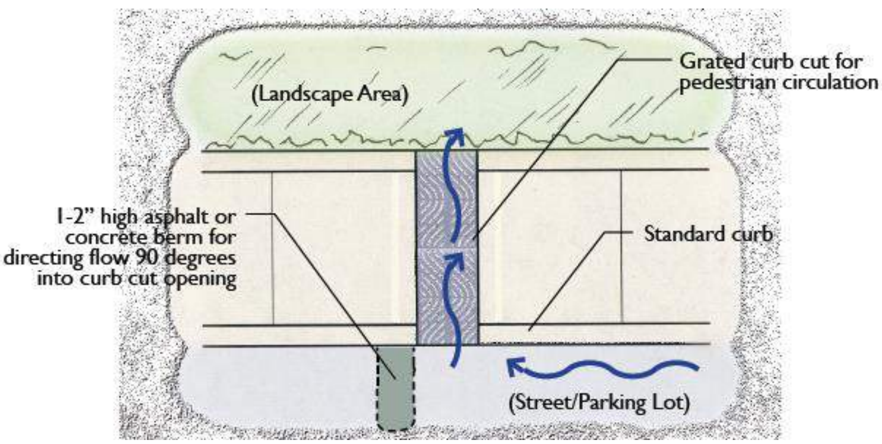


Figure 5-10. Grated Curb Cut: plan view

Source: SMCWPPP 2009

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
Bioretention[1] area	6.1
Flow-through planter	6.2
Tree well filter	6.3
Infiltration trench	6.4
Extended detention basin	6.5
Pervious paving	6.6
Grid pavements	6.7
Green roof	6.8
Rainwater harvesting and use	6.9
Media filter	6.10
Subsurface infiltration system	6.11

Guidance in this chapter is intended to assist you in preparing project permit application submittals. Municipalities will require permit applications to include more specific drawings to address project site conditions, materials, plumbing connections, etc. This technical guidance was prepared using best engineering judgment and based on a review of various regional documents. Input from Water Board staff was incorporated where available. The Clean Water Program looks forward to working with Water Board staff to continue to improve this guidance.

[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

6.1 Bioretention Area

Photo 6.1-1. Bioretention area, Fremont

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 where soil is unstable
- Requires irrigation
- Susceptible to clogging – especially if installed prior to construction site soil stabilization.

Bioretention[1] areas, or "rain gardens," 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 ponding area, organic layer or mulch layer, planting soil, and plants. Bioretention areas are designed to distribute stormwater runoff evenly along a ponding area. Percolation of stored water in the bioretention area's engineered planting soil with a high rate of infiltration will enter an underlying rock layer, from which water will either percolate into the underlying soil or enter the underdrain, so that the bioretention area empties over two days. Unless the geotechnical engineer identifies conditions, such as steep slope or a high groundwater table, that would make infiltration unsafe, bioretention areas should be designed to maximize infiltration by raising the underdrain toward the top of the rock layer. Bioretention areas can be any shape, including a linear treatment measure. The guidelines listed below apply to bioretention areas. Additionally, the countywide Example Green Infrastructure (GI) Typical Details, included in Appendix M, Green Streets, may be used in designing bioretention areas located in the street right of way, subject to approval by the local jurisdiction.

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK REQUIREMENTS

- Set back from structures 10' or as required by structural or geotechnical engineer, or local jurisdiction.
- If the treatment measure is designed to infiltrate stormwater to underlying soils, a minimum 50-foot setback is needed from septic system leach fields. (Check with the local water district or health department for additional setback requirements.)

[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration may also be called a "bioinfiltration area".

- The "drainage management area" (DMA) that drains to the bioretention area typically should not exceed 2 acres. If used for a DMA larger than 2 acres, divert high flows away from the facility (see Section 5.6), use pretreatment (vegetated filter) to reduce input of sediment, and evaluate the need for a flow spreader to distribute flows throughout the facility.
- There should be one bioretention area per DMA.
- The DMA should not contain a significant source of soil erosion, such as high velocity flows along slopes not stabilized with vegetation or hardscape.
- Areas immediately adjacent to bioretention area should have slopes more than 0.5% for pavement and more than 1% for vegetated areas.
- Bioretention facilities work best as one level, shallow basin—or a series of basins. As shown in Figure 6.1-1, runoff enters each basin, and should flood and fill throughout before runoff overflows to the outlet or to the next downstream basin. This will help prevent movement of surface mulch and soil mix.[2]

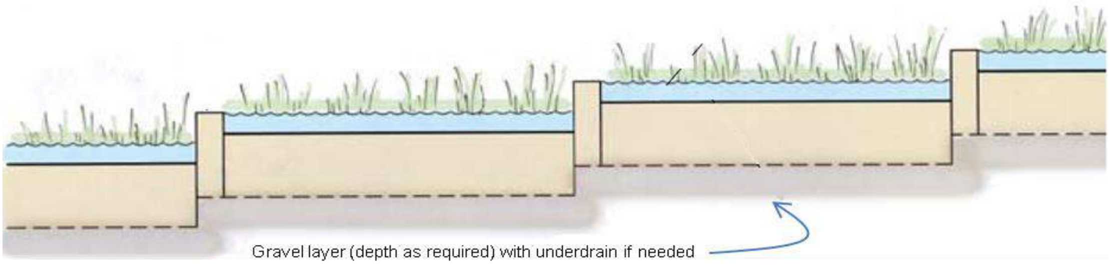


Figure 6.1-1 Planter on Slope Provides more Storage

Note: Check dams should be keyed into planter sides[2]

- If the bioretention cells cannot be level they can be designed as in Figure 6.1-2 below. Slopes within cells over 4% are not recommended. Consultation with a geotechnical engineer is recommended when the slope of the total facility is over 6%. Key check dams into the slopes as shown in Figure 6.1-3.

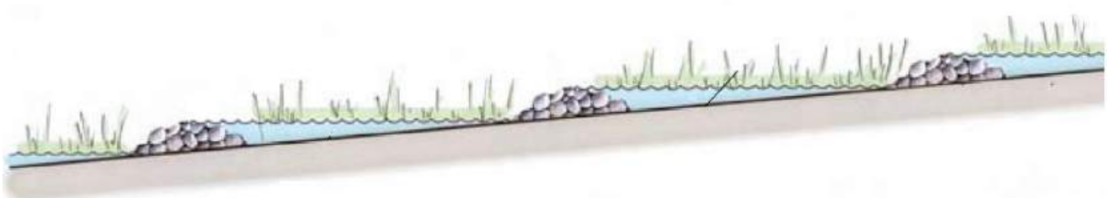


Figure 6.1-2 Bioretention Cells with Check Dams

Note: provides limited storage[2]

[2] Figures 6.1-1 through 6.1-3 and related guidance are from the Contra Costa Clean Water Program. February 2012. C.3 Stormwater Guidebook, 6th Edition and the Stormwater Management Handbook: Implementing Green Infrastructure in Northern Kentucky Communities, 2009. www.epa.gov/smartgrowth/publications.htm)

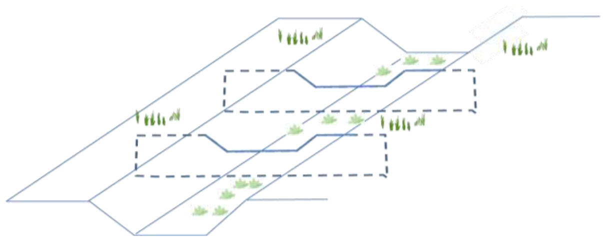


Figure 6.1-3 Key Check Dams into Bottom and Side Slopes

- In a linear bioretention area, check dams should be placed for every 4 to 6 inches of elevation change and so that the lip of each dam is at least as high as the toe of the next upstream dam. A similar principle applies to bioretention facilities built as terraced roadway shoulders.

TREATMENT DIMENSIONS AND SIZING

- The surface area of bioretention areas should be equal to 4% of the effective impervious area of the drainage management area (DMA). The effective impervious area multiplied by 0.04 sizing factor will equal the footprint of the bioretention area. For sizing purposes, the footprint of the bioretention area is defined as the area that achieves the required ponding depth and that is underlain with 18 inches of the Bioretention Soil Mix (see the note in the box in each of the Figures 6.1-4-6.1-8 below.) Instructions for calculating the effective impervious area are provided in Section 5.1. Where allowed by the municipality for redevelopment or infill sites, bioretention facilities may be sized using the combination flow- and volume-based method described in Section 5.1.
- The elevation of the surface area should be level, in order to distribute stormwater flows throughout the surface area.
- Side slopes of the bioretention area should not exceed 3:1.
- The surface ponding depth may range from 6 to 12 inches. The landscape architect should select a planting palette for the desired depth. The surface of the biotreatment soil is assumed to be the bottom of the ponding area; there is no adjustment for depth of mulch. Check with your local agency for the maximum ponding depth allowed.
- The inlet to the overflow catch basin should be at least 6 inches above the low point of the bioretention planting area.
- If the native soil has a KSAT > 1.6 in/hr, a bioinfiltration area may be sized as described above without an underdrain. Otherwise use of an underdrain is recommended.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

- As overland flow from landscaping (no special requirements)
- As overland flow from pavement (cutoff wall required)
- Through a curb opening (minimum 18 inches)
- Through a curb drain
- With drop structure through a stepped manhole (refer to Figure 5-1 in Chapter 5)
- Through a bubble-up manhole or storm drain emitter
- Through roof leader or other conveyance from building roof

- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- A concrete pad, cobbles or rocks should be installed to dissipate flow energy where runoff enters the treatment measure. The use of a concrete pad may facilitate removal of accumulated sediment, which may become trapped between cobbles.
- Install overflow drains as far as possible from inlets to treatment measure.

VEGETATION

- Plant species should be suitable to well-drained soil and occasional inundation. See planting guidance in Appendix B.
- Shrubs and small trees should be placed to anchor the bioretention area cover.
- Tree planting should be as required by the municipality. If larger trees are selected, plant them at the periphery of bioretention area. A pedestal of native soil below the tree is recommended, as shown in Figure 6.1-8.
- Underdrain trench should be offset at edge of tree planting zone, as needed, to maximize distance between tree roots and underdrain. Consider installing solid pipe for underdrains in the vicinity of trees, to avoid root intrusion into perforations of the underdrain pipe.
- Use integrated pest management (IPM) and/or Bay-Friendly Landscaping principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Drought tolerant plants are preferred. Provide sufficient irrigation to maintain plant life. Provide separate irrigation control for bioretention areas. Specify weather-based irrigation controllers, sometimes called "smart" irrigation controllers, which use soil moisture sensors to signal the irrigation controller. Drip emitters should be used instead of spray irrigation (see irrigation guidance in Appendix B).
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- Soils in the facility should meet biotreatment soil specifications approved by the Regional Water Board (Appendix K). A long term minimum infiltration rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time). Planting soil layer should be at least 18 inches deep.
- An underdrain system is generally required. Depending on infiltration rate of in situ soils, the local jurisdiction may allow installation without an underdrain on a case-by-case basis.
- Consideration of groundwater level and placement of the underdrain:
    - If there is less than a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, or infiltration is not allowed due to other site constraints, an impermeable liner should be placed between the drain rock and the bottom of the facility and the underdrain placed on top of that liner.
    - If there is at least a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, and geotechnical conditions allow infiltration, the

facility should be unlined and the underdrain should be raised at least 6 inches above the bottom of the drain rock to allow storage and infiltration of treated water.

  - Check with your local water district to determine if a greater separation from the seasonal high groundwater level is required.

- Filter fabric should not be used in or around underdrain trench.
- The underdrain should include a minimum 4-inch diameter, schedule 40 perforated pipe (perforations facing downward) with cleanouts and connection to a storm drain or discharge point. To help prevent clogging, two rows of perforation may be used. Clean-out should consist of a vertical, rigid, non-perforated polyvinylchloride (PVC) pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- There should be adequate fall from the underdrain to the storm drain or discharge point.
- Underdrain trench should include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2. Virgin rock shall be used in biotreatment systems.
- Install and maintain a 3-inch layer of “arbor”, “aged” or “composted” mulch on any exposed soil areas between plantings. Washed and clean pea gravel, rock, cobble, or other mulches that resist floating may also be used. Bark and “gorilla hair” mulches are not recommended. Only non-dyed mulch should be used.
- When using the combination flow and volume method, the surface of the biotreatment soil is assumed to be the bottom of the ponding area; there is no adjustment for depth of mulch.

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. All debris should be removed from bioretention area excavation pit (i.e. concrete or other construction debris) prior to soil scarification.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas should be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided.
- Maintenance Agreement should state the parties’ responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

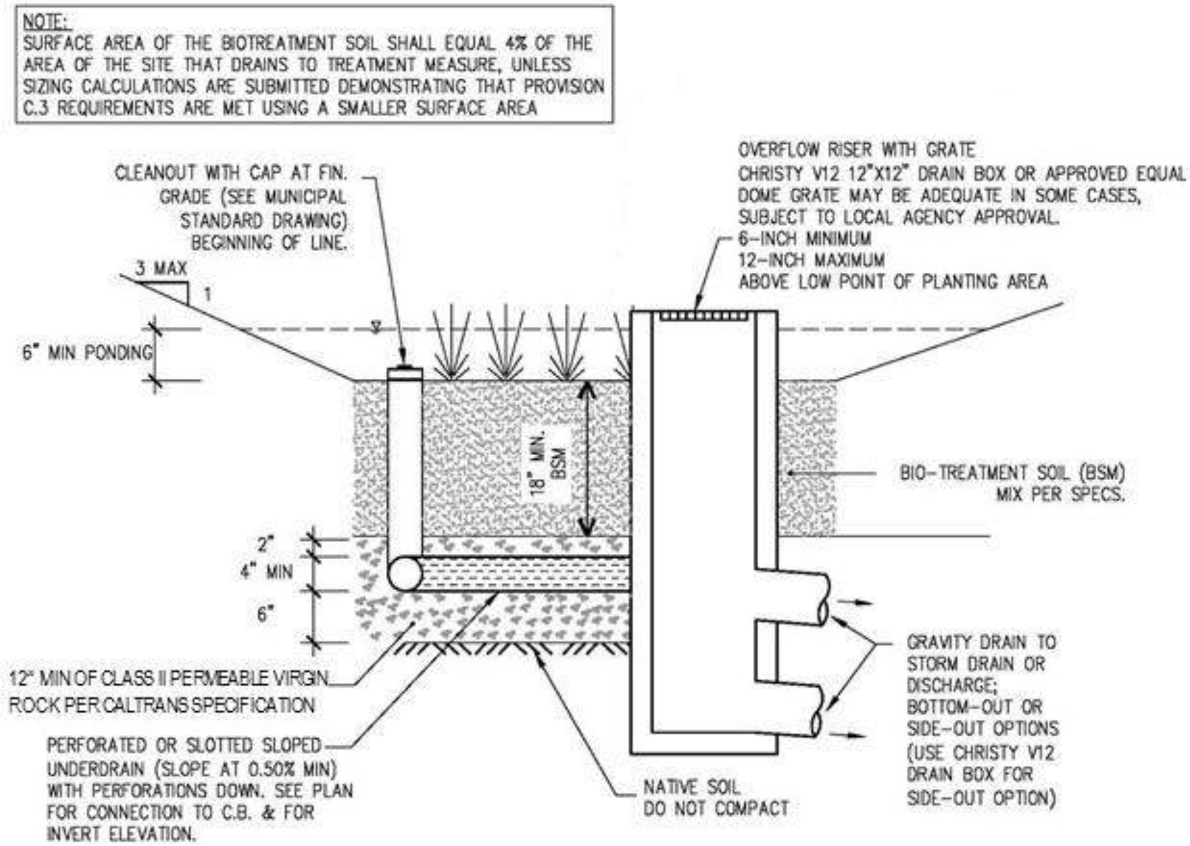


Figure 6.1-4. Cross Section, Bioretention Area: side view

Note: Not to Scale

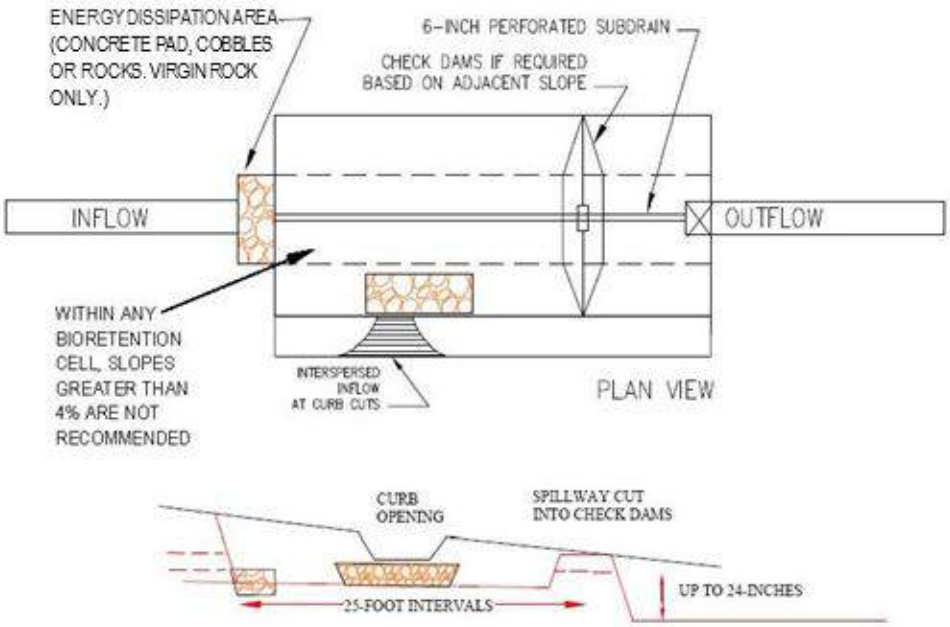


Figure 6.1-5. Check Dam for Installing a Series of Linear Bioretention Cells in Sloped Area: plan view and profile

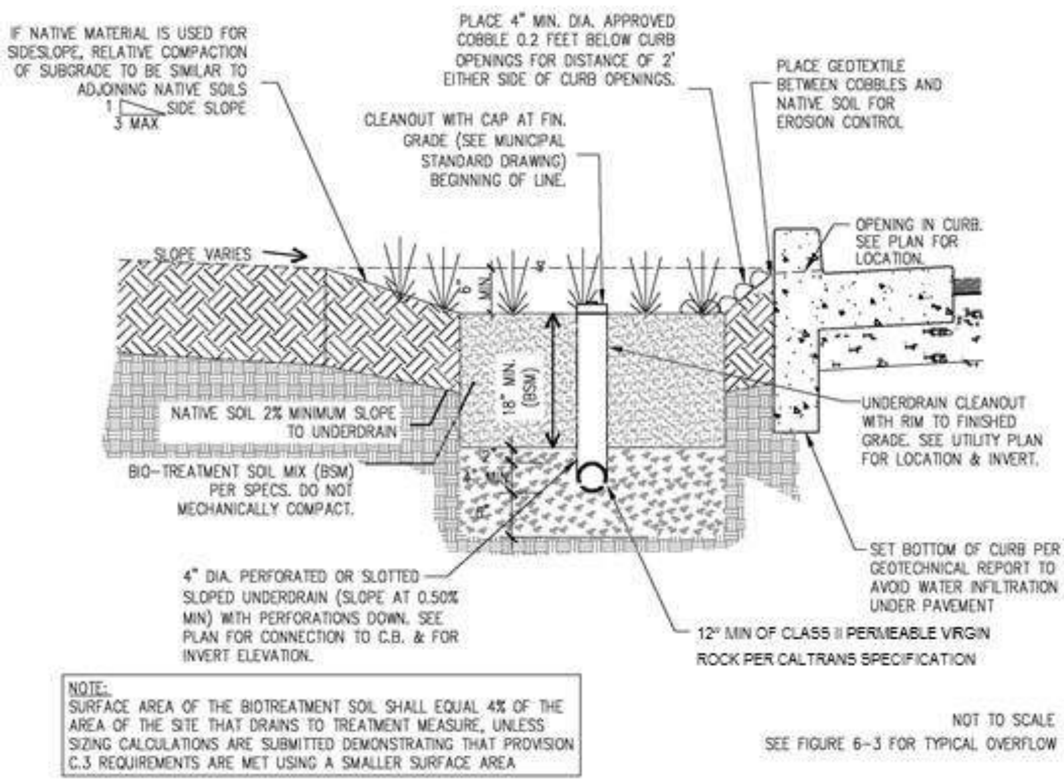


Figure 6.1-6. Cross-section of Bioretention Area Showing Inlet from Pavement

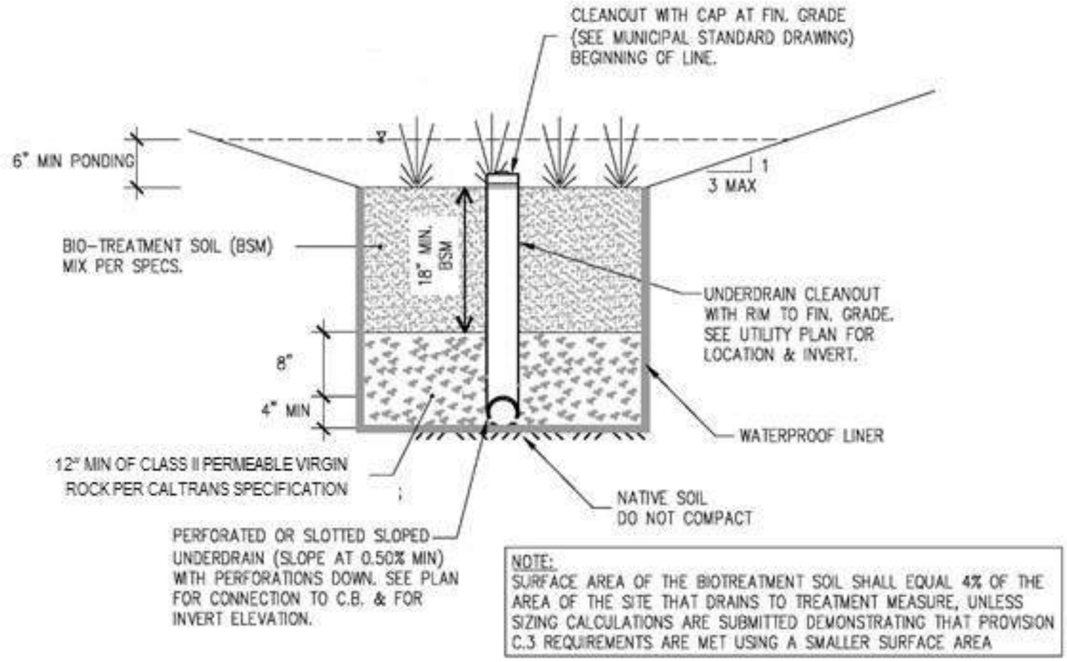


Figure 6.1-7. Cross-section of Lined Bioretention Area

Note: Not to Scale

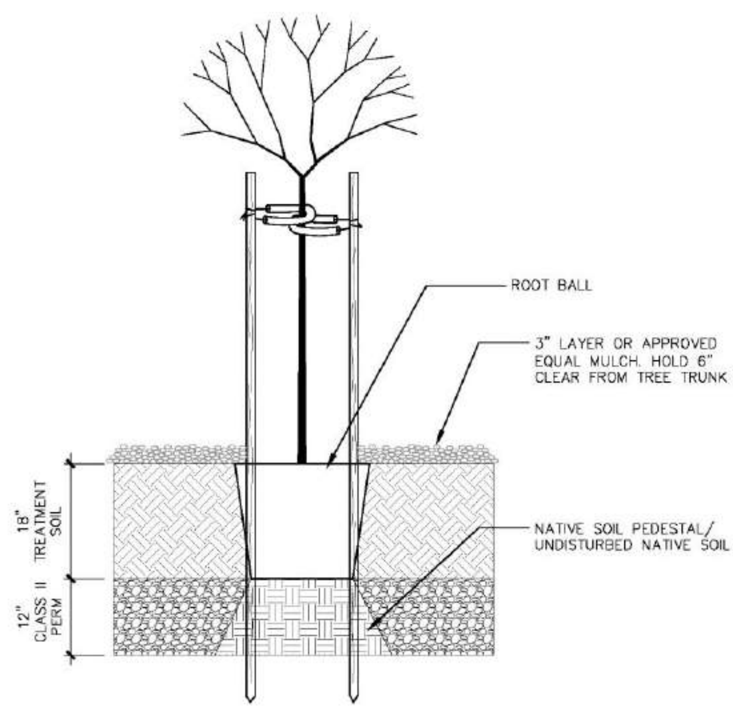


Figure 6.1-8. Tree Planting on Soil Pedestal

6.2 Flow-Through Planter

Photo 6.2-1. At-grade flow-through planters.

Source: City of Emeryville

Best uses

- Treating roof runoff
- Next to buildings
- Dense urban areas
- Locations where infiltration is not desired
- Drainage area up to 2 acres

Advantages

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

Limitations

- Requires sufficient head
- Careful selection of plants
- Requires level installation
- Susceptible to clogging

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 is required and 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

TREATMENT DIMENSIONS AND SIZING

- Flow-through planters may be sized using either the 4% method described in Section 5.1, or the combination flow- and volume-based method described in Section 5.1, where allowed by the municipality.
- The drainage management area (DMA) that drains to the flow-through planters typically should not exceed 2 acres. If used for a DMA larger than 2 acres, divert high flows away from the facility (see Section 5.6), use pretreatment (vegetated filter) to reduce input of sediment, and evaluate the need for a flow spreader to distribute flows throughout the facility.
- Flow-through planters can be used adjacent to building and within set back area.

- Flow-through planters can be used above or below grade. Below grade planters are also required to have a minimum of 6 inches of ponding depth.
- Install an overflow structure adequate to meet municipal drainage requirements Size overflow structure for building code design storm, and set top of overflow riser below top of planter box walls.
- The elevation of the biotreatment soil surface should be level, in order to distribute stormwater flows throughout the surface area.
- Allow a minimum of 6 inches and a maximum of 12 inches of water surface storage between the planting surface and the top of the overflow riser. The surface of the biotreatment soil is assumed to be the bottom of the ponding area; there is no adjustment for depth of mulch.

VEGETATION

- Plantings should be selected for viability in a well-drained soil. See planting guidance in Appendix B.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation should be provided, as needed, to maintain plant life. Provide separate irrigation control for flow-through planters. Specify weather-based irrigation controllers, sometimes called “smart” irrigation controllers, which use soil moisture sensors to signal the irrigation controller. Drip emitters should be used instead of spray irrigation (see irrigation guidance in Appendix B).
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

  - As overland flow from landscaping (no special requirements)
  - As overland flow from pavement (cutoff wall required)
  - Through a curb opening (minimum 18 inches)
  - Through a curb drain
  - With drop structure through a stepped manhole (refer to Figure 5-1 in Chapter 5)
  - Through a bubble-up manhole or storm drain emitter
  - Through roof leader or other conveyance from building roof

- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- A concrete pad, splash blocks, cobbles or rocks should be installed to dissipate flow energy where runoff enters the treatment measure. The use of a concrete pad may facilitate removal of accumulated sediment, which can become trapped between cobbles.
- For long linear planters, space inlets to planter at 10-foot intervals or install flow spreader.

SOIL AND DRAINAGE CONSIDERATIONS SPECIFIC TO FLOW THROUGH PLANTERS

- Waterproofing should be installed as required to protect adjacent building foundations.
- To avoid excess hydraulic pressure on subsurface treatment system structures:
  - The depth to seasonal high groundwater level should be at least 5 feet from the bottom of the structure.

- A geotechnical engineer should be consulted for situations where the bottom of the structure is less than 5 feet from the seasonal high groundwater level.
- An underdrain system is required for flow through planters.

SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- Soils used in the facility should meet biotreatment soil specifications approved by the Regional Water Board (Appendix K). A long term minimum percolation rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time). Planting soil layer should be at least 18 inches deep.
- Filter fabric should not be used in or around underdrain trench.
- The underdrain should include a minimum 4-inch diameter, schedule 40 perforated pipe (perforations facing downward) with cleanouts and connection to a storm drain or discharge point. To help prevent clogging, two rows of perforations may be used. Clean-out should consist of a vertical, rigid, non-perforated polyvinyl chloride (PVC)pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- There should be adequate fall from the underdrain to the storm drain or discharge point.
- Underdrain trench should include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2. Virgin rock shall be used in biotreatment systems.
- Install and maintain a 3-inch layer of “arbor”, “aged” or “composted” mulch on any exposed soil areas between plantings. Washed and clean pea gravel, rock, cobble, or other mulches that resist floating may also be used. Bark and “gorilla hair” mulches are not recommended. Only non-dyed mulch should be used.
- When using the combination flow and volume method, the surface of the biotreatment soil is assumed to be the bottom of the ponding area; there is no adjustment for depth of mulch.

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas should be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided.
- Maintenance Agreement should state the parties’ responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

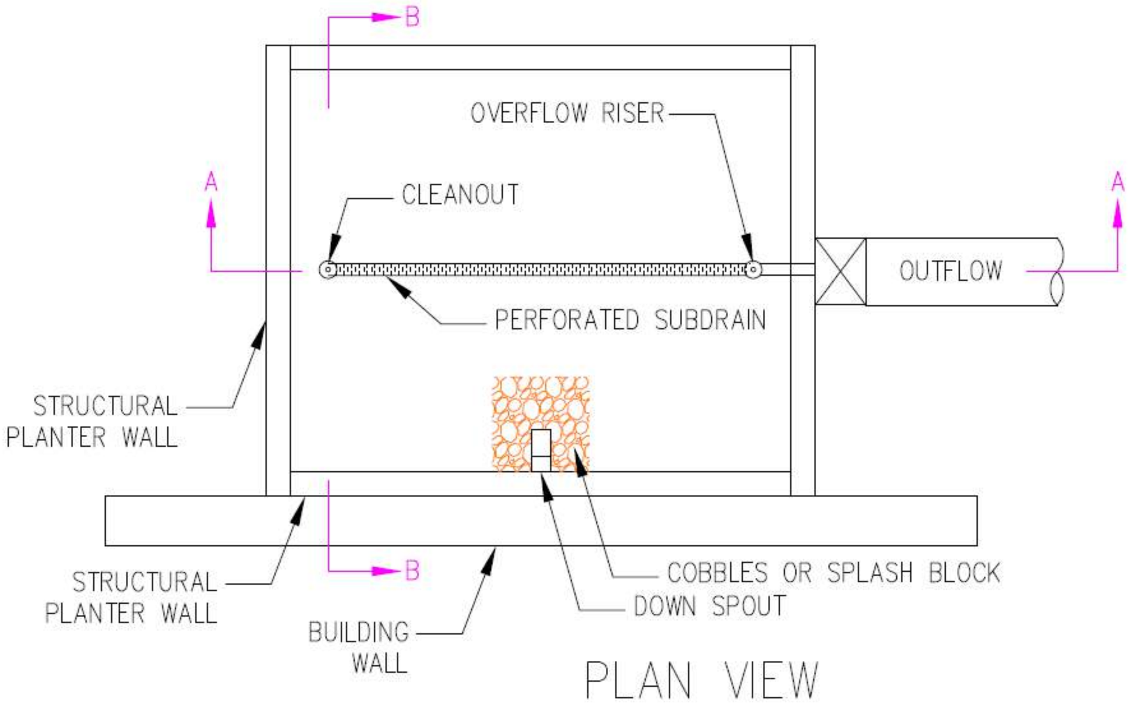


Figure 6.2-1. Plan View of Planter with One Inlet

(note: Plan view of planter designed to disperse flows adequately with only one inlet to planter)

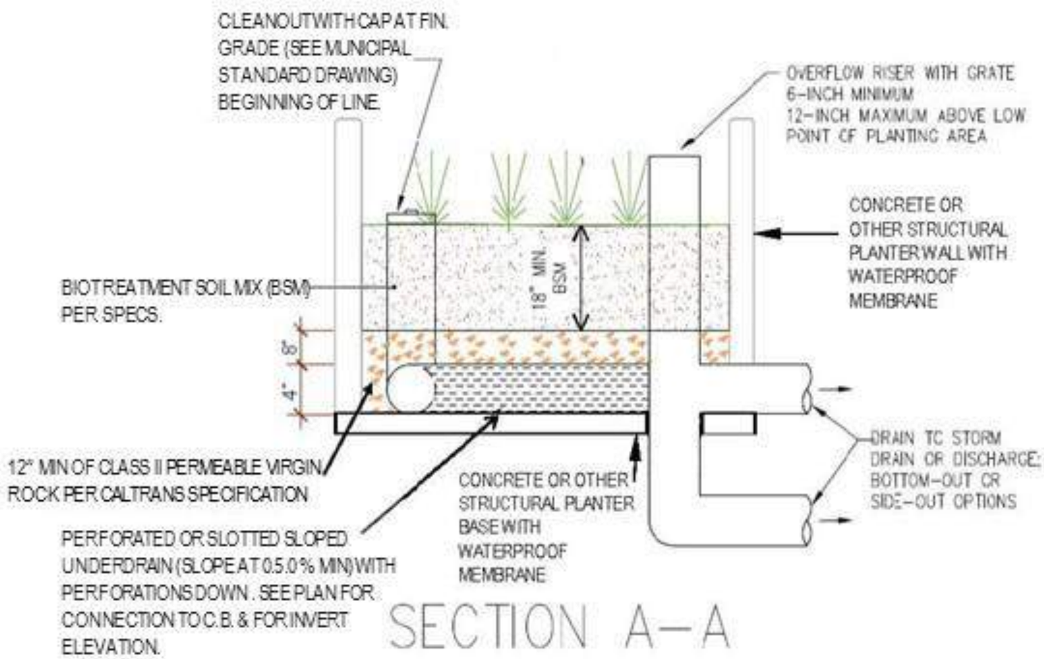


Figure 6.2-2. Cross-section A-A of Flow Through Planter

Note: Cross section A-A of flow-through planter, shows side view of underdrain

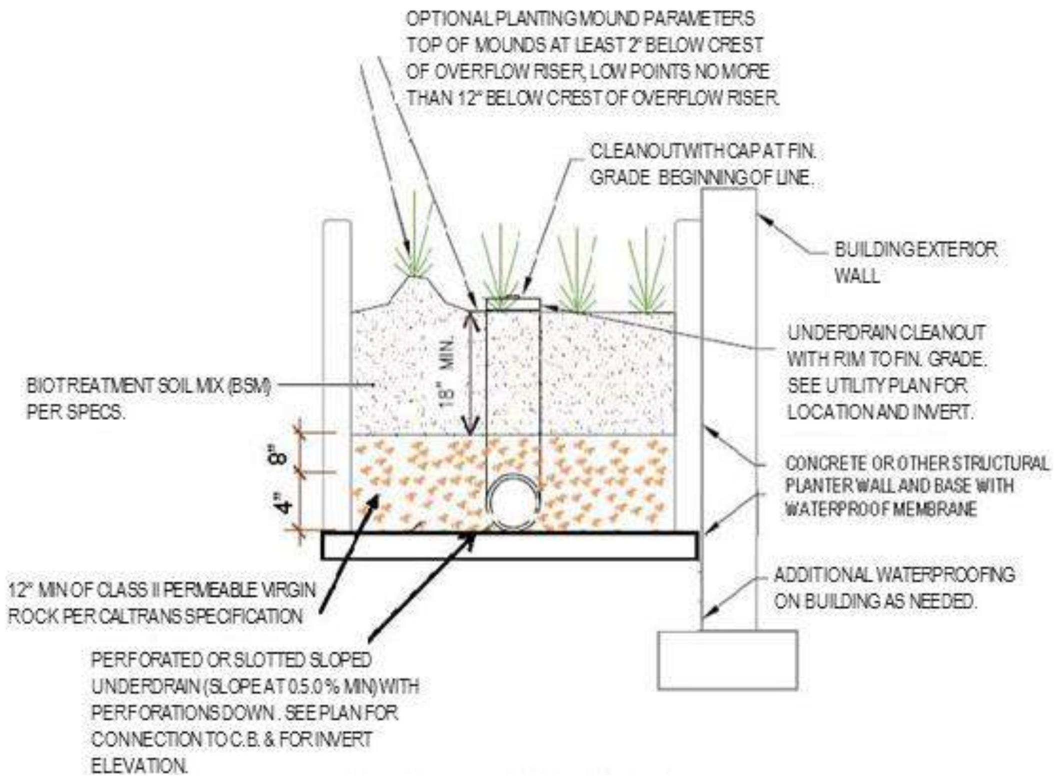


Figure 6.2-3. Cross-Section B-B of Flow Through Planter

(note: Cross section B-B of flow-through planter, shows cross section of underdrain)

Photo 6.2-2. Half-buried, perforated flexible pipe serves as a flow spreader to distribute stormwater evenly throughout long, linear flow-through planter in Emeryville

Source: GreenGrid / Weston Solutions

Photo 6.2-3. The same planter as shown in Photo 6.2-2, after vegetation has matured and partially conceals the half-buried pipe from view

Source: San Francisco Estuary Partnership

6.3 Tree Well Filter

Photo 6.3-1. Non-proprietary tree well filters in Fremont use bio-retention soils with an infiltration rate of 5 to 10 inches per hour. Spacing the units closely together provides a total tree well filter surface area that is 4 percent of the impervious surface area from which stormwater runoff is treated.

Best Uses

- Special Projects, per Appendix J
- Limited space
- Parallel to roadways

Advantages

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

Limitations

- Can clog without maintenance
- High installation cost
- Systems with very high infiltration rates are allowed only in Special Projects

Tree well filters are especially useful in settings where available space is at a premium. They can be installed in open- or closed-bottom chambers where infiltration is undesirable or not possible, such as tight clay soils, sites with high groundwater, or areas with highly contaminated runoff. Tree well filters may be installed along urban sidewalks, but they are highly adaptable and can be used in most development scenarios. In urban areas, tree filters can be used in the design of an integrated street landscape – a choice that transforms isolated street trees into stormwater filtration devices. In general, tree well filters are sized and spaced much like catch basin inlets, and design variations are abundant. The tree well filter's basic design is a vault filled with bioretention soil mix, planted with vegetation, and underlain with a subdrain. Modular suspended pavement system products, such as Silva Cells or approved equal[1], may be used for tree well filter construction and filled with biotreatment soil. This product type is described in Section 4.5.3. Manufactured tree well filters, and other ***tree well filters with long-term infiltration rates that exceed 10 inches per hour are not allowed for compliance with Provision C.3 requirements for Regulated Projects, except in Special Projects***, as described in Appendix J. Please note that manufactured tree well filters may potentially be allowed in non-Regulated Projects that are included in a local agency's Green Infrastructure Plan, if approved by the local agency.

[1] The evaluation of product equivalency is anticipated to include a wide range of topics, such as technical specifications, maintenance requirements, warranties, and all other relevant considerations.

Design and Sizing Guidelines

- Flows in excess of the treatment flow rate should bypass the tree filter to a downstream inlet structure or other appropriate outfall.
- Tree filters cannot be placed in sump condition; therefore tree filters should have flow directed along a flow line of curb and gutter or other lateral structure. Do not direct flows directly to a tree filter.
- Tree well filters designed as biotreatment measures may be sized using the 4% method described in Section 5.1, or, where allowed by the municipality, the combination flow- and volume-based method described in Section 5.1.
- High flow-rate tree well filters used for Special Projects should be sized to meet both Provision C.3.d criteria for flow-based treatment measures and the Western Washington TAPE GULD “Basic Treatment” criteria, as described in Appendix J.
- If a proprietary tree filter is used, the design should be reviewed by the manufacturer before installation.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

  - As overland flow from landscaping (no special requirements)
  - As overland flow from pavement (cutoff wall required)
  - Through a curb opening (minimum 18 inches)
  - Through a curb drain
  - With drop structure through a stepped manhole (refer to Figure 5-1 in Chapter 5)
  - Through a bubble-up manhole or storm drain emitter
  - Through roof leader or other conveyance from building roof

- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- A concrete pad, cobbles or rocks should be installed to dissipate flow energy where runoff enters the treatment measure. The use of a concrete pad may facilitate removal of accumulated sediment, which can become trapped between cobbles.

VEGETATION

- Suitable plant species are identified in Appendix B planting guidance.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation should be provided, as needed, to maintain plant life. Provide separate irrigation control for tree well filters that use biotreatment soil. Specify weather-based irrigation controllers, sometimes called “smart” irrigation controllers, which use soil moisture sensors to signal the irrigation controller. Drip emitters should be used instead of spray irrigation (see irrigation guidance in Appendix B).
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

SOIL AND DRAINAGE REQUIREMENTS SPECIFIC TO HIGH FLOW RATE TREE WELL FILTERS

- Use of a high flow rate tree well filter, for which the long term infiltration rate of the media exceeds 10 inches per hour, is only allowed for Special Projects (see Appendix J).
- Filter media in high-flow rate tree well filters should follow manufacturer specifications.
- An underdrain system is required for high flow-rate tree well filters.

SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS (NOT APPLICABLE TO HIGH FLOW RATE TREE WELL FILTERS)

- Soils in the facility should meet biotreatment soil specifications approved by the Regional Water Board (Appendix K). A long term minimum percolation rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time). Planting soil layer should be of adequate depth for tree roots, as indicated by the project's landscape architect, at least 18 inches and up to 36 inches deep.
- Design details should be consistent with those for a bioretention facility or flow-through planter (Sections 6.1 and 6.2).
- An underdrain system is generally required. Depending on infiltration rate of in situ soils, the local jurisdiction may allow installation without an underdrain on a case-by-case basis.
- Consideration of groundwater level and placement of the underdrain:
  - If there is less than a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, or infiltration is not allowed due to other site constraints, an impermeable liner should be placed between the drain rock and the bottom of the facility and the underdrain placed on top of that liner.
  - If there is at least a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, and geotechnical conditions allow infiltration, the facility should be unlined and the underdrain should be raised at least 6 inches above the bottom of the drain rock to allow storage and infiltration of treated water.
  - Check with your local water district to determine if a greater separation from the seasonal high groundwater level is required.
- To avoid excess hydraulic pressure on subsurface treatment system structures:
  - The depth to seasonal high groundwater level should be at least 5 feet from the bottom of the structure.
  - A geotechnical engineer should be consulted for situations where the bottom of the structure is less than 5 feet from the seasonal high groundwater level.
- Filter fabric should not be used in or around underdrain pipe or trench.
- The underdrain should include a minimum 4-inch diameter, schedule 40 perforated pipe (perforations facing downward) with cleanouts and connection to a storm drain or discharge point. To help prevent clogging, two rows of perforation may be used. Clean-out should consist of a vertical, rigid, non-perforated polyvinyl chloride (PVC) pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- There should be adequate fall from the underdrain to the storm drain or discharge point.

- Underdrain trench should include a 12-inch thick layer Caltrans Standard Section 68-1.025 permeable material Class 2. Virgin rock shall be used in biotreatment systems.
- Install and maintain a 3-inch layer of “arbor”, “aged” or “composted” mulch on any exposed soil areas between plantings. Washed and clean pea gravel, rock, cobble, or other mulches that resist floating may also be used. Bark and “gorilla hair” mulches are not recommended. Only non-dyed mulch should be used.
- When using the combination flow and volume method, the surface of the biotreatment soil is assumed to be the bottom of the ponding area; there is no adjustment for depth of mulch.

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas should be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided.
- Maintenance Agreement should state the parties’ responsibility for maintenance and upkeep. Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

Photo 6.3-2. Non-proprietary Tree Filter with Overflow Bypass. Source: University of New Hampshire Environmental Research Group, 2006

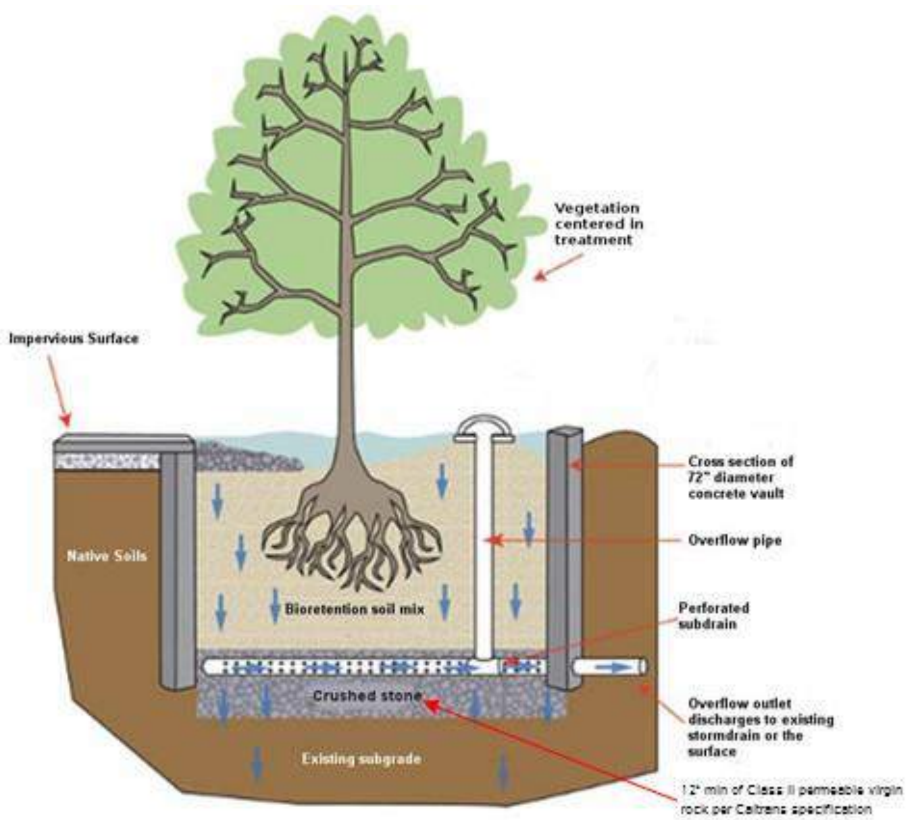


Figure 6.3-1. Schematic of a Non-proprietary Tree Well Filter

Note: Design details should be consistent with those for a bioretention facility or flow-through planter - Sections 6.1 and 6.2.

Source: University of New Hampshire Environmental Research Group, 2006

6.4 Infiltration Trench

Photo 6.4-1. Infiltration trench.

Source: CASQA, 2003

Best Uses

- Limited space
- Adjacent to paved surfaces
- Landscape buffers

Advantages

- Increases groundwater recharge
- Removes suspended solids
- No surface outfalls

Limitations

- Susceptible to clogging; fails with no maintenance
- No high water tables
- Infiltration rate of existing soils must exceed 0.5 in/hr
- No steep slopes
- Drainage area less than 5 acres

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. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment, 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 have a high rate of failure where soil conditions are not suitable. If an infiltration trench is designed to be deeper than its widest surface dimension, it may meet the USEPA definition of a Class V injection well and information about the device may need to be submitted to the USEPA. See Appendix F for more information regarding Class V injection wells.

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK CONSIDERATIONS

- When the drainage area exceeds 5 acres, other treatment measures should be considered.
- Infiltration trenches work best when the upgradient drainage area slope is less than 5 percent. The downgradient slope should be no greater than 20 percent to minimize slope failure and seepage.

- In-situ/undisturbed soils should have a low silt and clay content and have percolation rates greater than 0.5 inches per hour. In-situ testing is required to confirm percolation rate of trench site. CASQA's BMP Handbook recommends against using infiltration trenches in Type C or D soils. To test the infiltration rate of underlying soils, use the ASTM D3385-09 Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer, or other test method approved by the local agency. Due to site variability and the potential for uncertainty in conducting tests, it is recommended that multiple tests be conducted and a representative corrected infiltration rate be selected.
- There should be at least a 10-foot separation between the bottom of the trench and the seasonal high groundwater level to prevent potential groundwater contamination.
- Trenches should also be located at least 100 feet upgradient from water supply wells.
- A setback of 100 feet from building foundations is recommended, unless a smaller setback is approved by geotechnical engineer and allowed by local standard.

TREATMENT DIMENSIONS AND SIZING

- The infiltration trench should be sized to store and infiltrate the water quality design volume.
- 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 approximately 35 percent. A minimum drainage time of 6 hours should be provided to ensure satisfactory pollutant removal in the infiltration trench. Trenches may be designed to provide temporary storage of storm water. Trench depths are usually between 3 and 8 feet, with a depth of 8 feet most commonly used.
- The trench surface may consist of stone or vegetation (contact local municipality to determine if vegetation is allowed) 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.
- 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.
- Place permeable filter fabric around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric should 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 infiltration trench should 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.

INLET TO THE TREATMENT MEASURE

- A vegetated buffer strip at least 5-feet wide, swale or detention basin should be established adjacent to the infiltration trench to capture large sediment particles in the runoff before runoff enters the trench. If a buffer strip or swale is used, installation should occur immediately after trench construction using sod instead of hydroseeding. The buffer strip should 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 should be sized according to Sections 6.4 and 6.7 respectively.
- If runoff is piped or channeled to the trench, a level spreader should be installed to create sheet flow.

IF VEGETATION IS ALLOWED AT TRENCH SURFACE

- If surface landscaping of the trench is desired, contact local municipality to determine if this is allowed.
- Trees and other large vegetation should be planted away from trenches such that drip lines do not overhang infiltration beds.

CONSTRUCTION REQUIREMENTS

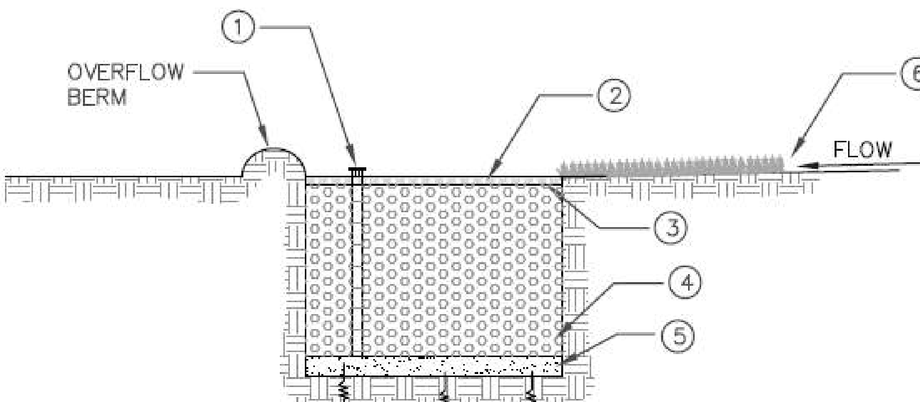
- The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. During project construction, runoff from unstabilized areas should be diverted away from the trench into a sedimentation control BMP until vegetation is established.
- When excavating, avoid spreading fines of the soils on bottom and sides. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided.
- Maintenance Agreement should state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

Photo 6.4-2. Infiltration trench next to parking structure, Palo Alto.

Source: EOA, Inc.



1. OBSERVATION WELL WITH LOCKABLE ABOVE–GROUND CAP
2. 2" PEA GRAVEL FILTER LAYER
3. PROVIDE FILTER FABRIC IF NO PRETREATMENT IS PROVIDED
4. 3' – 5' DEEP TRENCH FILLED WITH 2" – 6" DIAMETER CLEAN STONE WITH 30% – 40% VOIDS
5. 6" DEEP SAND FILTER LAYER (OR FABRIC EQUIVALENT)
6. RUNOFF FILTERS THROUGH GRASS FILTER STRIP OR VEGETATED SWALE

Figure 6.4-1. Infiltration Trench Section.

Source: County of Los Angeles, 2010.

6.5 Extended Detention Basin

Photo 6.5-1. Extended detention basin.

Source: California BMP Handbook (CASQA, 2003)

Best uses

- Hydromodification management
- Detain low flows
- and peak flows
- Settling of suspended solids
- Sites larger than 5 acres

Advantages

- Easy to operate
- Inexpensive to construct
- Low maintenance

Limitations

- Land requirements
- Since 12/1/11, this has not been allowed as a stand-alone treatment measure

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 a minimum of 48 hours to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a permanent pool.

Since December 1, 2011, projects have not been allowed to meet stormwater treatment requirements with stand-alone extended detention basins that are designed to treat stormwater through the settling of pollutants and gradual release of detained stormwater through an orifice. However, this type of extended detention basin could be used as part of a treatment train, in which the basin stores a large volume of water, which is gradually released to a bioretention area that meets the Municipal Regional Stormwater NPDES Permit (MRP) requirements for biotreatment soils and surface loading area. They can also be used to provide hydromodification management and/or flood control depending on the size of the basin and the design of the outlet structure.

Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- Extended detention basins should be sized to capture the required water quality volume over at least a 48-hour period. At least 10 percent additional storage should be provided to account for storage lost to deposited sediment.
- Extended detention basin should have no greater than 3:1 side slopes.
- The optimal basin depth is between 2 and 5 feet.

- A safety bench should be added to the perimeter of the basin wall for maintenance when basin is full.
- Extended detention basin should empty within 72 hours to avoid vector generation.
- A 12-foot wide maintenance ramp leading to the bottom of the basin and a 12-foot wide perimeter access road should be provided. If not paved, the ramp should have a maximum slope of 5 percent. If paved, the ramp may slope 12 percent.
- The extended detention basin should have a length to width ratio of at least 1.5:1.
- A fixed vertical sediment depth marker should be installed in the sedimentation forebay. The depth marker should have a marking showing the depth where sediment removal is required. The marking should be at a depth where the remaining storage equals the design water quality volume.

INLETS TO TREATMENT MEASURE

- The inlet pipe should have at least 1 foot of clearance to the basin bottom.
- Piping into the extended detention basin should have erosion protection. As a minimum, a forebay with a 6-inch thick layer of Caltrans Section 72, Class 2 rock slope protection should be placed at and below the inlet to the extent necessary for erosion protection.
- Check with municipality regarding trash screen requirements. Trash screen installation may be required upstream of the pipe conveying water into the pond, in order to capture litter and trash in a central location where it can be kept out of the pond until it is removed.

OUTLETS AND ORIFICES

- If the detention basin is to be used as part of a treatment train, the outlet should be sized with a drawdown time of 48 hours for the design water quality volume.
- If the detention basin is to be used for hydromodification management, see Chapter 7 for guidance.
- Orifices should 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 should be protected from clogging using a welded stainless steel wire mesh screen. The screen should protect the orifice openings from runoff on all exposed sides. For example, see Caltrans standard detail for Water Quality Outlet Riser Type 1.

VEGETATION

- Plant species should be adapted to periods of inundation. See planting guidance in Appendix B.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation should be provided as needed to maintain plant life.
- If vegetation is not established by October 1st, sod should be placed over loose soils. Above the area of inundation, a 1-year biodegradable loose weave geofabric may be used in place of sod.

SOIL AND DRAINAGE CONSIDERATIONS

- Extended detention basins are not designed to infiltrate the entire volume of water captured, but they may infiltrate some water if conditions allow.
- Consideration of groundwater level:
  1. If there is less than a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, or infiltration is not allowed due to other site constraints, an impermeable liner should be placed at the bottom of the facility.
  2. If there is at least a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, and geotechnical conditions allow infiltration, the facility may be unlined.

CONSTRUCTION REQUIREMENTS

- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas should be diverted away from the facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided.
- Maintenance Agreement should state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

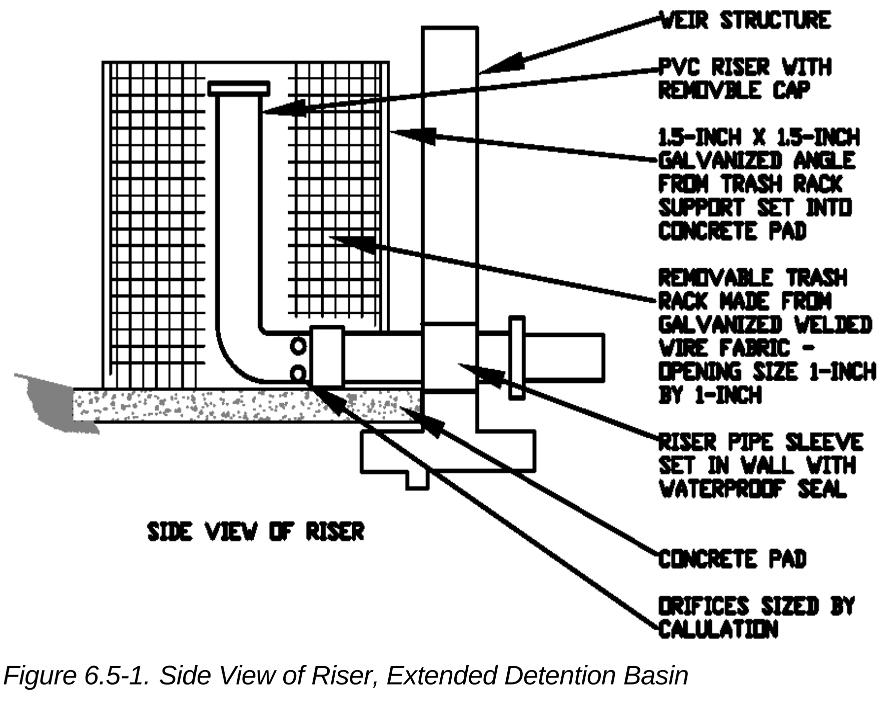


Figure 6.5-1. Side View of Riser, Extended Detention Basin

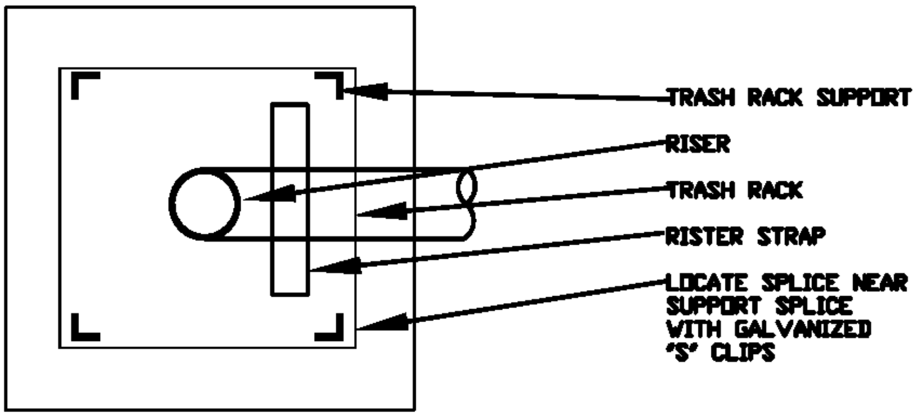


Figure 6.5-2. Top View of Riser, Extended Detention Basin (square design)

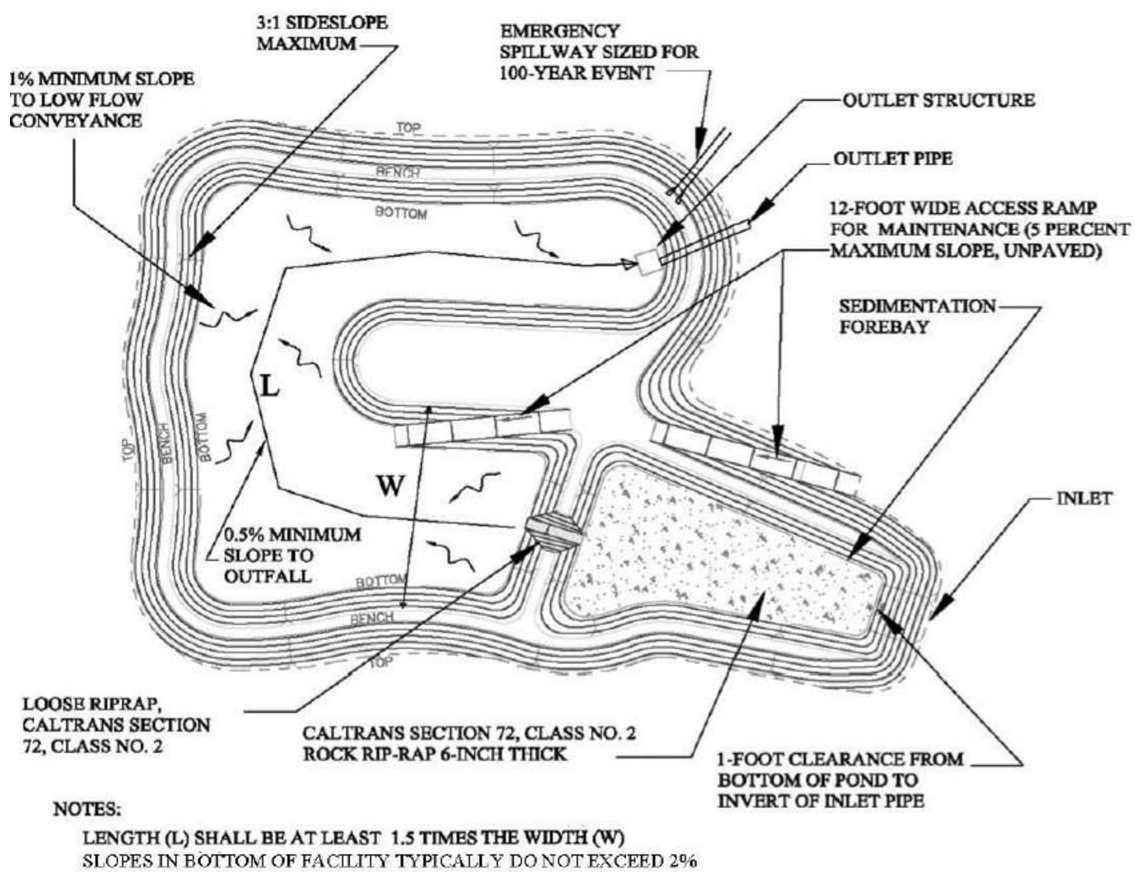


Figure 6.5-3. Plan View, Typical Extended Detention Basin

6.6 Pervious Pavement

Photo 6.6-1. Parking Lot with Pervious Concrete Pavement, Emeryville

Best uses

- Parking lots
- Low-speed residential roads
- Alleys and driveways
- Sidewalks, pathways and plazas

Advantages

- Flow attenuation
- Volume reduction
- Removes fine particulates
- Reduces need for treatment

Limitations

- May clog without periodic vacuum cleaning
- Low speed areas only
- Higher installation costs than conventional paving

Pervious pavement types include pervious concrete, porous asphalt, pervious or permeable concrete pavers, permeable interlocking concrete pavement (PICP), and grid pavements such as turf block and grasscrete. (Grid pavements are described in Section 6.7.) 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 constructed over a subbase/base structure typically consisting of compacted, open-graded aggregate. This layer or layers 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.

Where pervious paving is underlain with pervious soil or pervious storage material sufficient to hold the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, it is not considered impervious and can function as a self-treating area.

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. The thickness of the base layer is also affected by hydrologic sizing considerations. The following criteria should be considered:

SUBGRADE AND SITE REQUIREMENTS

- The soil sub-grade should be able to sustain anticipated traffic loading without excessive deformation.

The Clean Water Program gratefully acknowledges the contributions of Mr. David Smith, Technical Director of the Interlocking Concrete Pavement Institute, to this section of the C.3 Technical Guidance, including pavement sections, design details, and specifications.

- The subgrade should be ungraded in-situ material with a minimum infiltration rate of 0.5-inches per hour, or based on hydrologic analysis, an underdrain should be installed to remove detained flows within the pervious paving and base (see Figure 6.6-5), or Caltrans guidance for base layer sizing may be followed (see, “Base Layer”). To test the infiltration rate of underlying soils, use the ASTM D3385-09 Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer, or other test method approved by the local agency. Due to site variability and the potential for uncertainty in conducting tests, it is recommended that multiple tests be conducted for each area to be paved and a representative corrected infiltration rate be selected for design.
- In soils with less than 0.5-inch per hour infiltration rate, subject to approval by the local jurisdiction, one alternative approach to providing an underdrain, is to direct overflows from the surface of the pavement into bioretention areas and overflow drains. A second alternative approach, subject to approval by the local jurisdiction, is to increase the depth of subbase/base layer. The design should allow the stored water to infiltrate into the subgrade within 48 hours.
- Depth to seasonal high groundwater level should be at least 5 feet from the bottom of the base of the pervious paving system, unless a different separation is recommended by the geotechnical engineer.
- Pervious paving systems should not be used where site conditions do not allow infiltration.
- Grading of the soil subgrade below the pervious pavement should be relatively flat (not to exceed 2% slope) to promote infiltration across the entire area.
- A slope of 1% is recommended for pavement surface. Slopes of pervious pavement should not exceed 5%, or up to 16% with underdrains. Slopes exceeding 3% typically require berms or check dams placed laterally over the soil subbase to slow the flow of water and provide some infiltration. Alternatively, pervious pavement systems can be terraced to step down a steep slope, maintaining level bed bottoms separated by earthen berms.

BASE LAYER

- When subject to vehicular traffic, all open-graded aggregates should conform to the following or to similar specifications as directed by the municipality: crushed material, minimum 90% with at least 2 fractured faces conforming to Caltrans test method CT 205; have Los Angeles Rattler no greater than 40% loss at 500 revolutions per Caltrans test method CT 211; and a minimum Cleanness value of 75 per Caltrans test method CT 211. Sieve analysis should conform to Caltrans test method CT 202.
- Aggregate materials shall be clean virgin rock and shall avoid introducing to the pervious paving system debris, sediment, grease, oil, and other pollutants. The use of recycled concrete aggregate (RCA) is prohibited.
- If the subbase/base layer is sized to store and infiltrate at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, the area of pervious paving is

not considered an impervious surface and can function as a self-treating area, as described in Section 4. 1.

- If the subbase/base layer has sufficient capacity in the void space to store and infiltrate the C.3.d amount of runoff for both the area of pervious paving and the area that drains to it, the pervious paving area can function as a self-retaining area, described in Section 4.2.
- Pervious paving designed to function as a self-retaining may accept runoff from an area of impervious surface that has a surface area of up to two times the surface area of the pervious paving area.
- If an underdrain is used, position the perforated pipe a minimum of 2 inches above bottom elevation of base course. To be considered a self-treating area or self-retaining area, the underdrain should be positioned above the portion of the base layer that is sized to meet the C.3.d sizing criteria.
- Design calculations for the base should quantify the following:
  - Soil type/classification and soil permeability rate; if subject to vehicular traffic, k-values (psi/cubic inch) or R-values characterizing soil strength when saturated;
  - Fill type if used, installation, and compaction methods plus target densities;
  - Lifetime expected vehicular traffic loading (in 18,000 lb. equivalent single axle loads or Caltrans Traffic Index); the maximum recommended Traffic Index = 9.

PAVEMENT MATERIALS

- The pavement materials should not crack or suffer excessive rutting under anticipated traffic loads. This is controlled by designing pervious concrete and porous asphalt surfacing materials and layer thicknesses that minimize the horizontal tensile stress at their base. All pervious pavements benefit from using open-graded aggregate base materials with sufficient thicknesses and compaction that spread and minimize applied vertical stresses from vehicles.
- Pervious concrete and porous asphalt materials require narrow aggregate grading to create open voids in their surfaces. Materials choice is therefore a balance between stiffness in the surface layer and permeability. PICP requires similar types of aggregate (without cement or asphalt) placed in the joints, typically ASTM No. 8, 89, or 9 stone depending on the paver joint widths. Refer to industry association literature for grading recommendations for all surfaces.
- Paving units for PICP should conform to the dimensional tolerances, compressive strengths and absorption requirements in ASTM C936. Paving units subject to vehicular traffic should be at least 3 1/8 in. thick.

DESIGN AND INSTALLATION

- All designs should be reviewed and approved by a licensed civil or geotechnical engineer or as directed by the municipality.
- Design for pervious concrete should be reviewed by the concrete manufacturer or National Ready Mixed Concrete Association (NRMCA) (www.nrmca.org), or as directed, the municipality. Consult Portland Cement Association publication, *Hydrologic Design of Pervious Concrete* (2007) available from www.cement.org.
- Design for porous asphalt should be reviewed by the asphalt manufacturer, the National Asphalt Pavement Association (NAPA) (www.porousasphalt.net), or as directed by the

municipality. Consult NAPA publication, *Porous Asphalt for Stormwater Management* (2008) for additional information on design, construction, and maintenance.

- Design for PICP should be reviewed by the concrete paver manufacturer, the Interlocking Concrete Pavement Institute (ICPI) (www.icpi.org), or as directed by the municipality. Consult ICPI publication, *Permeable Interlocking Concrete Pavements* 4th Edition (2011) for additional information on design, construction and maintenance.
- Installation of pervious concrete, porous asphalt and PICP should be done by contractors who have constructed pervious pavement projects similar in size to that under consideration.
- For pervious concrete, only contractors with certification from NRMCA should be considered, and such contractors should have at least one foreman with this certification on the job site at all times. More information can be found at www.concreteparking.org.
- For PICP, it is recommended that only contractors holding a certificate of completion in the Interlocking Concrete Pavement Institute's PICP Installer Technician Course should be considered and such contractors should have at least one foreman with this certificate on the job site at all times. More information can be found at www.icpi.org.
- After installation, conduct an infiltration test using ASTM C1701 (for pervious concrete or porous asphalt) or ASTM C1781 (for PICP); record the test results to compare with results of future tests. All new pavements should have a minimum surface infiltration rate of 100 in./hr when tested in accordance with ASTM C1701 or C1781.
- Protect excavated area from excessive compaction due to construction traffic and protect the finished pavement from construction traffic.
- Post a sign at pervious pavement sites to alert maintenance personnel to:
  - Keep silt and debris from entering onto the pervious pavements.
  - Not seal the pavement, and
  - Clean surface with high performance vacuum equipment, not mechanical broom type.

MAINTENANCE

- Maintenance plan should be provided. Typical requirements are described in Chapter 8, and a maintenance plan template is provided in Appendix H. An essential requirement is periodic surface vacuuming to remove accumulated debris and sediment.

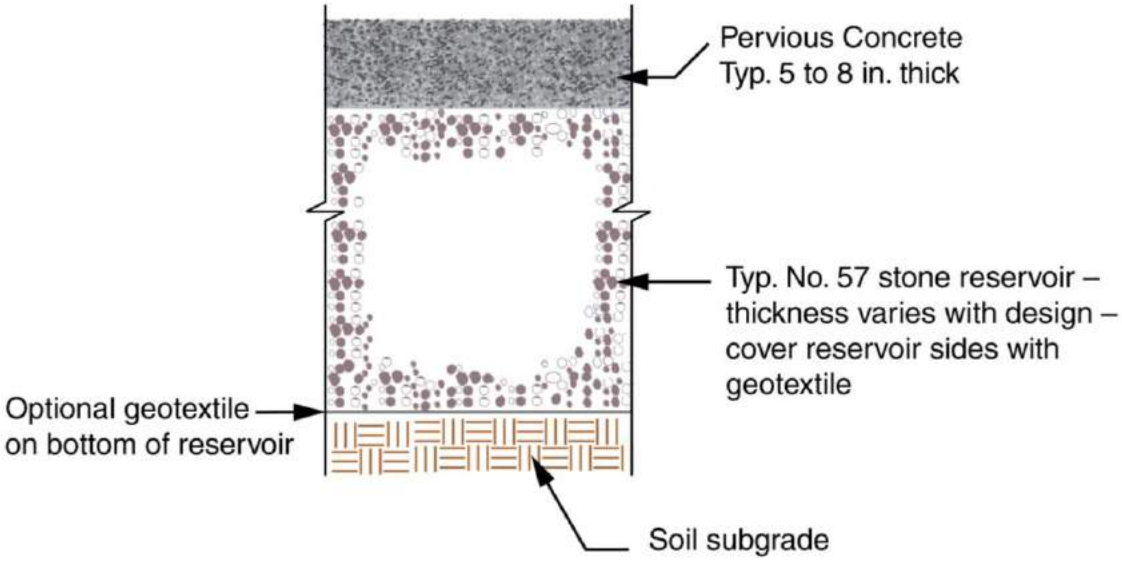


Figure 6.6-1. Typical Pervious Concrete Pavement

Note: Aggregate materials shall be clean virgin rock; recycled concrete aggregate (RCA) is prohibited.

Source: Interlocking Concrete Pavement Institute

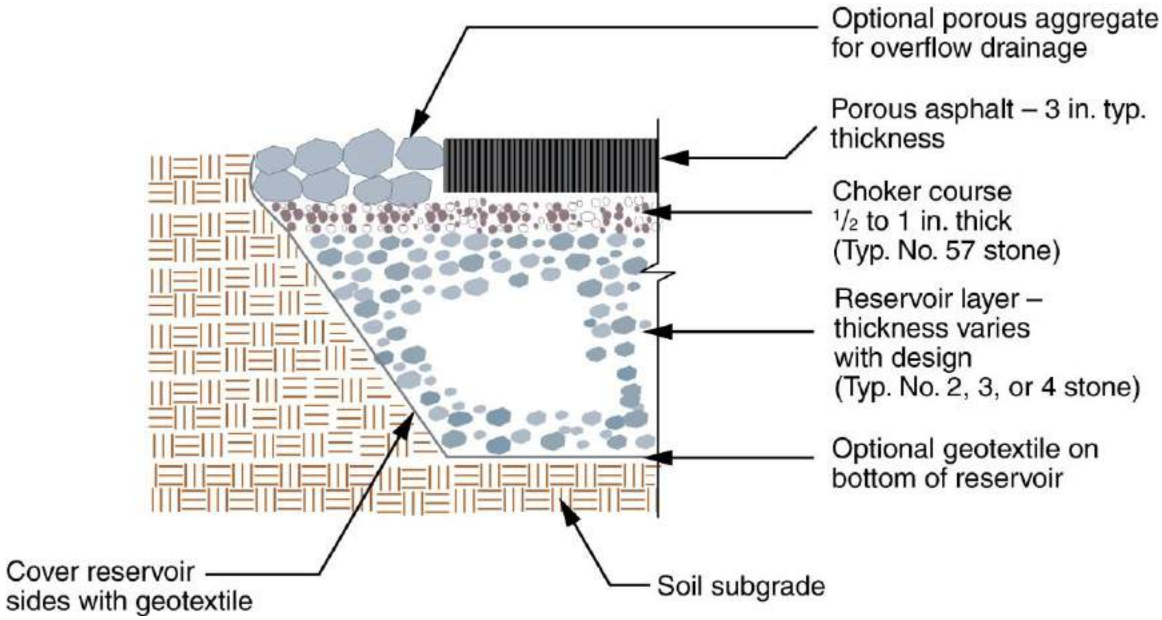


Figure 6.6-2. Typical Porous Asphalt Pavement

Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.Note: Aggregate materials shall be clean virgin rock; recycled concrete aggregate (RCA) is prohibited.

Source: Interlocking Concrete Pavement Institute

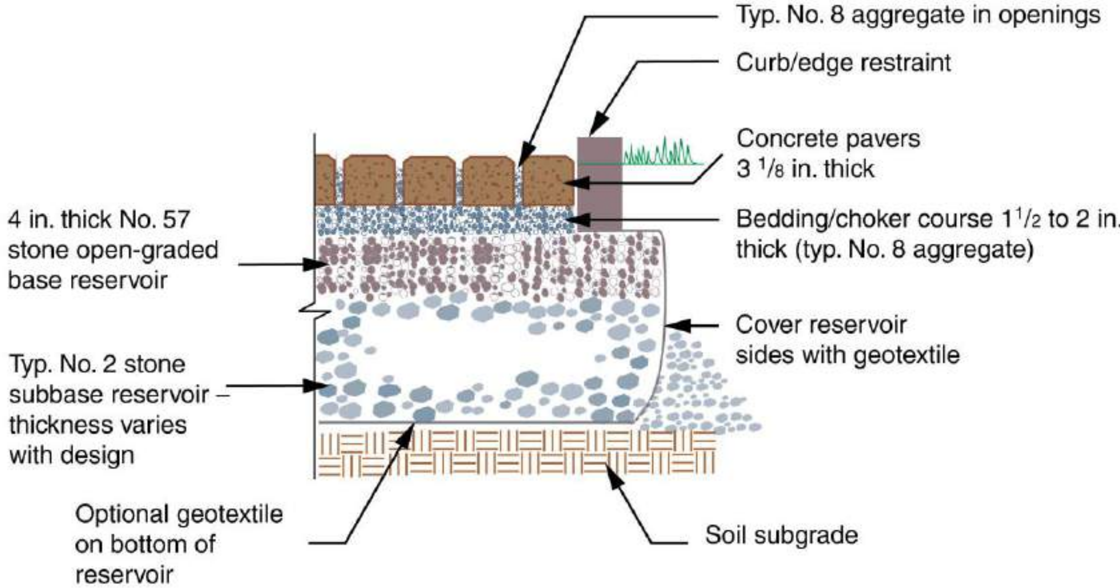


Figure 6.6-3. Typical Permeable Interlocking Concrete Pavement

Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.
ASTM No. 89 or 9 stone may be used in the paver openings.
Aggregate materials shall be clean virgin rock; recycled concrete aggregate (RCA) is prohibited.

Source: Interlocking Concrete Pavement Institute

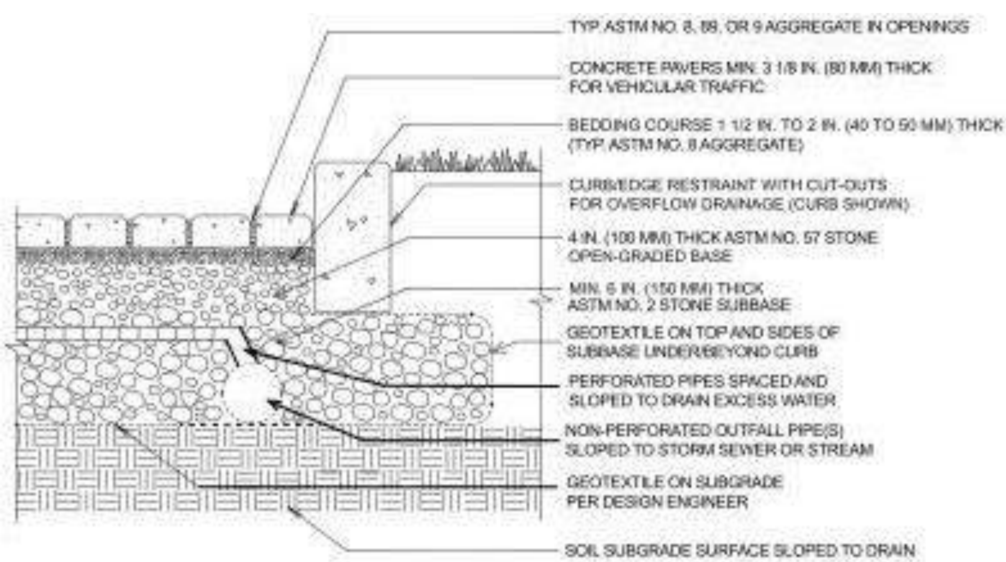


Figure 6.6-4. Underdrain Installation in Pervious Pavement.

Note: Perforated pipes can be raised above the soil subgrade to drain water from storm events that generate high flows.

Aggregate materials shall be clean virgin rock; recycled concrete aggregate (RCA) is prohibited.

Source: Interlocking Concrete Pavement Institute

6.7 Grid Pavements

Photo 6.7-1. Turf block fire access

Source: City of Pleasanton

Best uses

- Overflow parking areas
- Emergency access lanes
- Common areas
- Lawn/landscape buffers
- Pathways

Advantages

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

Limitations

- May clog without periodic cleaning
- Weeds
- Lightly-trafficked areas only
- Higher installation costs than conventional paving

Grid pavements consist of concrete or plastic grids used in areas that receive occasional light traffic (i.e., < 7,500 lifetime 18,000-lb equivalent single axle loads or a Caltrans Traffic Index < 5), typically overflow parking or fire access lanes. The surfaces of these systems can be planted with topsoil and grass in their openings and installed over a sand bedding layer that rests over a compacted, dense-graded aggregate base (see Figures 6.7-1 and 6.7-2). When planted with turf grass, they also assist in providing a cooler surface than conventional pavement. These systems are also known as turf block or grasscrete. Grid pavements can also be designed with aggregates in the openings.

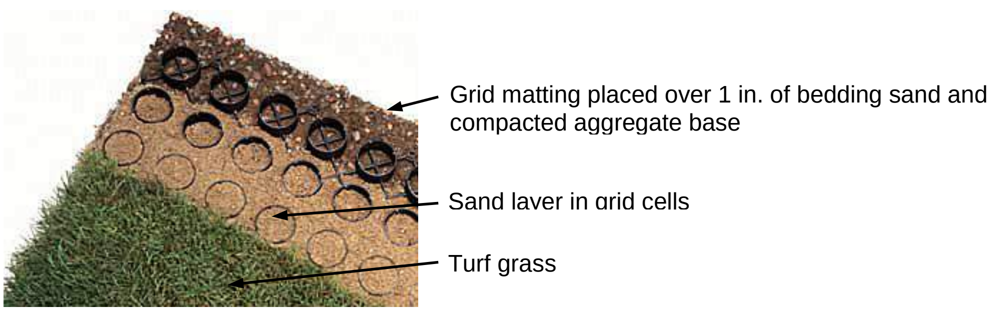


Figure 6.7-1. Plastic Grid Pavement for Occasional Vehicular Use or for Emergency Access Lanes

Note: Sand and turf grass can be replaced with ASTM No. 8 aggregate in cell openings.

(Source: Interlocking Concrete Pavement Institute)

The Clean Water Program gratefully acknowledges the contributions of Mr. David Smith, Technical Director of the Interlocking Concrete Pavement Institute, to this section of the C.3 Technical Guidance, including pavement sections, design details, and specifications.

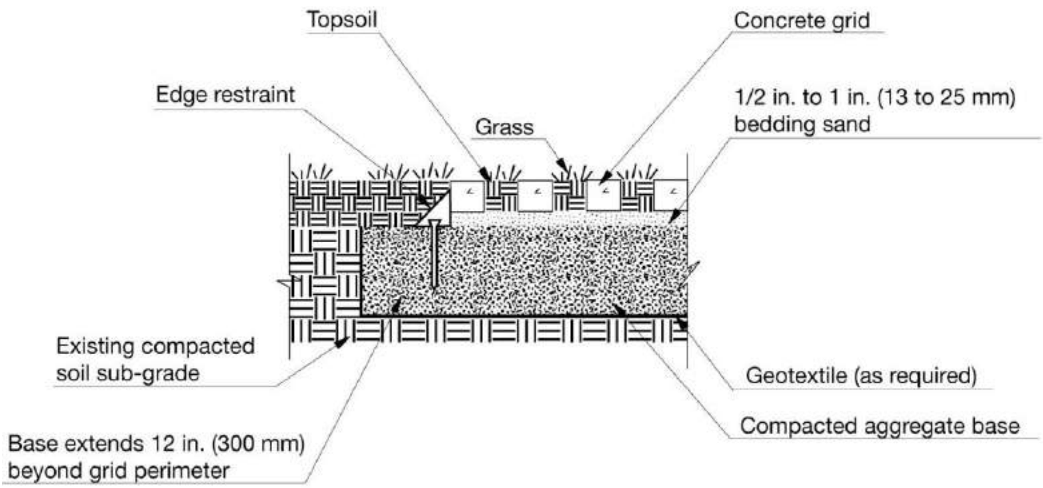


Figure 6.7-2. Concrete Grid Pavement for Occasional Vehicular Use or for Emergency Access Lanes

Note: Aggregate materials shall be clean virgin rock; recycled concrete aggregate (RCA) is prohibited.

(Source: Interlocking Concrete Pavement Institute)

Grid pavements can be installed over open-graded aggregate bases for additional water storage, infiltration, and outflow via an underdrain in low permeability soils if needed. Grid pavements are not considered an impervious area and can function as "self-treating areas" when supported by an aggregate base sufficient to hold the volume of rainfall runoff specified in the Municipal Stormwater Regional Permit Provision C.3.d. If a grid pavement is designed with a dense-graded base, instead of an open-graded base, this design is not suitable to accept runoff from adjacent areas.

Design and Sizing Guidelines

To provide satisfactory performance, the following criteria should be considered:

SUBGRADE AND SITE REQUIREMENTS

- The soil subgrade should be able to sustain anticipated traffic loads without excessive deformation while temporarily saturated.
- The soil subgrade should have sufficient infiltration rate to meet the requirements in this manual, or include an underdrain(s) to remove detained flows within the aggregate base. The surfacing and bedding materials are not used to store water. To test the infiltration rate of underlying soils, use the ASTM D3385-09 Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer, or other test method approved by the local agency. Due to site variability and the potential for uncertainty in conducting tests, it is recommended that multiple tests be conducted for each area to be paved and a representative corrected infiltration rate be selected for design.

- In soils with less than 0.5-inch per hour infiltration rate, subject to approval by the local jurisdiction, one alternative approach to providing an underdrain, is to direct overflows from the surface of the pavement into bioretention areas and overflow drains. A second alternative approach, subject to approval by the local jurisdiction, is to increase the depth of subbase/base layer. The design should allow the stored water to infiltrate into the subgrade within 48 hours.
- Depth to seasonal high groundwater level should be at least 5 feet from the bottom of the base of the grid pavement system, unless a different separation is recommended by the geotechnical engineer.
- Grid pavement systems should not be used where site conditions do not allow infiltration.
- Grading of the soil subgrade below the pervious pavement should be relatively flat (not to exceed 2% slope) to promote infiltration across the entire area.
- A slope of 1% is recommended for pavement surface. Slopes of grid pavements should not exceed 5%. Slopes exceeding 3% typically require berms or check dams placed laterally over the soil subgrade to slow the flow of water and provide some infiltration.

AGGREGATES

- When subject to vehicular traffic, all dense-graded aggregate bases should conform to Caltrans Class 2 or similar specifications as directed by the municipality. All open-graded aggregates should be crushed material, minimum 50% with one or more fractured faces conforming to Caltrans test method CT 205; have Los Angeles Rattler no greater than 45% loss at 500 revolutions per Caltrans test method CT 211; and a minimum Cleanness value of 75 per Caltrans test method CT 211.. Sieve analysis should conform to Caltrans test method CT 202.
- Aggregate materials shall be clean virgin rock and shall avoid introducing to the pervious paving system debris, sediment, grease, oil, and other pollutants. The use of recycled concrete aggregate (RCA) is prohibited.
- If the subbase/base layer is sized to hold at least the C.3.d volume of runoff, the area of pervious paving is not considered an impervious surface and can function as a self-treating area as described in Section 4.1.
- If an underdrain is used, position perforated pipe a minimum of 2 inches above the surface of the soil subgrade and provide non-perforated, upturned pipe for outflows. To be considered a self-treating area or self-retaining area, the outflow should be positioned above the portion of the base layer sized to meet the C.3.d sizing criteria.
- Design calculations for the base should describe and quantify the following:
    - Soil type/classification and soil permeability rate; for vehicular areas, k-values (psi/cubic inch) or R-values characterizing soil strength when saturated
    - Fill type if used, installation, and compaction methods plus target densities
    - Lifetime expected traffic loading in 18,000 lb. equiv. single axle loads or Caltrans Traffic Index; the maximum Traffic Index < 5.

GRID PAVEMENT MATERIALS

- Concrete grids should conform to the dimensional tolerances, compressive strength, and absorption requirements in ASTM C1319 and should be a minimum of 3 1/8 in. thick.
- Aggregates used for bedding and filling the grid openings should be No. 8 stone or similar sized crushed materials.
- If topsoil and grass are used in the grids, they should be placed over a 1 in. thick layer of bedding sand and over Caltrans Class 2 base compacted to a minimum 95% standard Proctor density. Do not use topsoil, grass, sand bedding and geotextile over an open-graded aggregate base as the surface has a low infiltration rate.
- Grid pavements should have edge restraints to render them stationary when subject to pedestrian or vehicular traffic.

DESIGN AND INSTALLATION RECOMMENDATIONS

- All designs should be reviewed and approved by a licensed civil or geotechnical engineer or as directed by the municipality.
- Design for plastic grid pavements should be done per the manufacturer's recommendation. Such designs should be reviewed by the manufacturer or as directed by the municipality.
- Design for concrete grid pavements should be reviewed by the concrete paver manufacturer, the Interlocking Concrete Pavement Institute (ICPI) (www.icpi.org), or as directed by the municipality.
- Consult ICPI *Tech Spec 8 Concrete Grid Pavements* available at www.icpi.org for additional design information and guide specifications.
- Installation of grid pavements should be done by contractors who have constructed grid pavement projects similar in size to that under consideration. Only contractors holding a certificate of completion in the Interlocking Concrete Pavement Institute's Commercial Paver Technician Course should be considered for concrete grid pavement construction, and such contractors should have at least one foreman with this certificate on the job site at all times. More information can be found at www.icpi.org.
- Protect excavated area from excessive compaction due to construction traffic and protect the finished pavement from construction traffic.
- Post a sign at grid pavement sites to alert maintenance personnel to keep silt and debris from entering onto the grid pavements.

MAINTENANCE

- A maintenance plan should be provided. Maintenance of grassed grid surfaces will require watering and mowing. Typical maintenance requirements are described in Chapter 8, and a maintenance plan template is provided in Appendix H.

6.8 Green Roofs

Photo 6.8-1. Extensive Green Roof in Emeryville

Best uses

- For innovative architecture
- Urban centers

Advantages

- Minimizes roof runoff
- Reduces "heat island" effect
- Absorbs sound
- Provides bird habitat
- Longer "lifespan" than conventional roofs

Limitations

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

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 (Photo 6.8-2), has experienced relatively few problems after nearly a decade in use. Native vegetation may be selected to provide habitat for endangered species of butterflies, as at the extensive green roof of the Academy of Sciences in San Francisco.

Design and Sizing Guidelines

- Green roofs are considered "self-treating areas" or "self-retaining areas" and may drain directly to the storm drain, if they meet the following requirements, specified in the MRP, as amended on November 28, 2011:
    - The green roof system planting media should be sufficiently deep to provide capacity within the pore space of the media to capture 80 percent of the average annual runoff.
    - The planting media should be sufficiently deep to support the long-term health of the vegetation selected for the green roof, as specified by the landscape architect or other knowledgeable professional.
- Extensive green roof systems contain 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.

- The components of intensive green roofs are generally the same as those used in extensive green roofs, with differences in depth and project-specific design application.
- Design and installation is typically completed by an established vendor.
- Follow manufacturer recommendations for slope, treatment width, and maintenance.
- 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 should be free of gullies or rills.
- Irrigation is typically required.

MAINTENANCE

- Inspection required at least semiannually. Confirm adequate irrigation for plant health.
- Fertilize and replenish growing media as specified by landscape designer and as needed for plant health. See Appendix B for alternatives to quick release fertilizers.

See www.greenroofs.com for information about and more examples of green roofs.

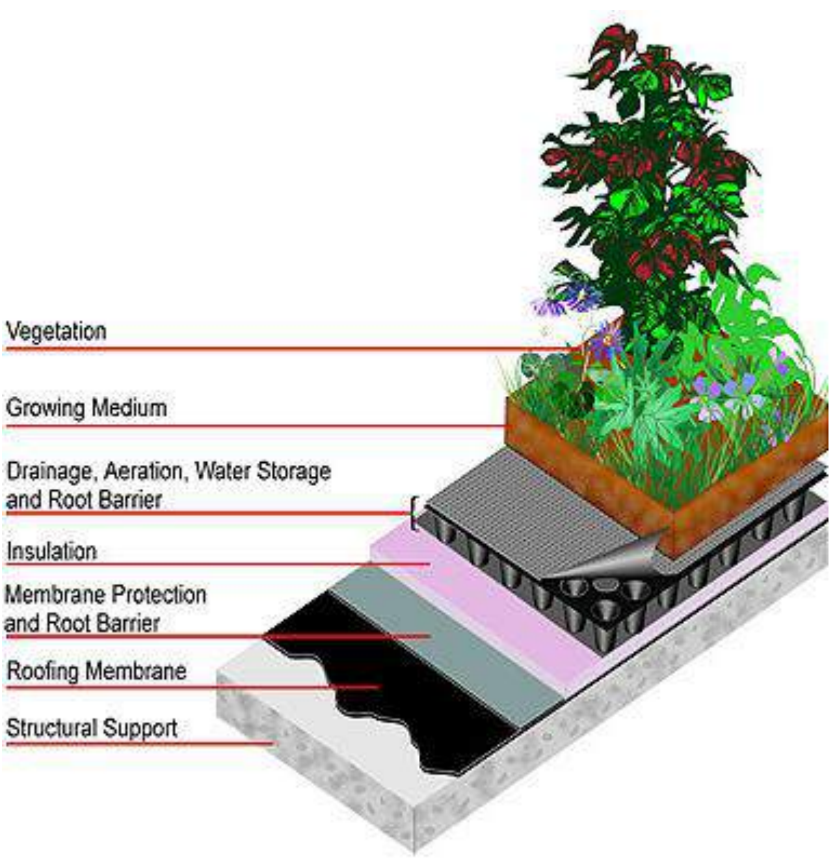


Figure 6.8-1. Green Roof Cross-section

Source: American Wick Drain Corp.

Photo 6.8-2. Extensive Green Roof at Gap Corporate Headquarters, San Bruno

Source: William McDonough & Partners

Photo 6.8-3. Plants selected to support endangered butterflies

Source: California Academy of Sciences

Photo 6.8-4. : Intensive Green Roof at Kaiser Center, Oakland

6.9 Rainwater Harvesting and Use

Photo 6.8-1. *Rainwater is collected and used for flushing toilets at Mills College, Oakland.*

Best Uses

- High density residential or office towers with high toilet flushing demand.
- Park or low density development with high irrigation demand.
- Industrial use with high non-potable water demand.

Advantages

- Helps obtain LEED or other credits for green building.

Limitations

- High installation and maintenance costs.
- Low return on investment.
- Municipal permitting requirements not standardized.

Rainwater harvesting systems area engineered to store a specified volume of water with no discharge until this volume is exceeded. Storage facilities that can be used to harvest rainwater include above-ground or below-ground cisterns, open storage reservoirs (e.g., ponds and lakes), and various underground storage devices (tanks, vaults, pipes, arch spans, and proprietary storage systems). Rooftop runoff is the stormwater most often collected in harvesting/use system, because it often contains lower pollutant loads than surface runoff, and it provides accessible locations for collection. Rainwater can also be stored under hardscape elements, such as paths and walkways, by using structural plastic storage units, such as RainTank, or other proprietary storage products. Water stored in this way can be used to supplement onsite irrigation needs, typically requiring pumps to connect to the irrigation system. Rain barrels are often used in residential installations, but typically collect only 55 to 120 gallons per barrel; whereas systems that are sized to meet Provision C.3 stormwater treatment requirements typically require thousands of gallons of storage.

Uses of Harvested Water

Uses of captured water may potentially include irrigation, indoor non-potable use such as toilet flushing, industrial processing, or other uses. The Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report prepared by the Bay Area Stormwater Management Agency's Association (BASMAA 2011) identified toilet flushing as the use that is most likely to generate sufficient demand to use the amount of runoff specified in Provision C.3.d. The demand for indoor toilet flushing is most likely to equal to the C.3.d amount of stormwater in high rise residential or office projects, and in schools. Irrigation demand may equal the C.3.d amount of runoff in projects with a very high percentage of landscaping.

System Components

Rainwater harvesting systems typically include several components: (1) methods to divert stormwater runoff to the storage device, (2) an overflow for when the storage device is full, 3) a distribution system to get the water to where it is intended to be used, and (4) filtration and treatment systems (see Treatment Requirements below).

LEAF SCREENS, FIRST-FLUSH DIVERTERS, AND ROOF WASHERS

These features may be installed to remove debris and dust from the captured rainwater before it goes to the tank. 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. Leaf screens remove larger debris, such as leaves, twigs, and blooms that fall on the roof. A first-flush diverter routes the first flow of water from the catchment surface away from the storage tank to remove accumulated smaller contaminants, such as dust, pollen, and bird and rodent droppings. A roof washer may be placed just ahead of the storage tank and filters small debris for systems using drip irrigation. Roof washers consist of a tank, usually between 30- and 50-gallon capacity, with leaf strainers and a filter.

CODES AND STANDARDS

The State of California adopted a new plumbing code on January 1, 2014 which includes Rainwater harvesting and graywater regulations. The new code (Chapter 17) allows rainwater to be harvested from roof tops for use in outdoor irrigation and some non-potable indoor uses. Rainwater collected from parking lots or other impervious surfaces at or below grade is considered graywater and subject to the water quality requirements for graywater in Chapter 16 of the code. Some small catchment systems (5,000 gallons or less) being used for non-spray irrigation do not require permits – see Chapter 17 for more details[1].

The Plumbing Code defines rainwater as “precipitation on any public or private parcel that has not entered an offsite storm drain system or channel, a flood control channel, or any other stream channel, and has not previously been put to beneficial use.”[2] The Rainwater Capture Act of 2013, which took effect January 1, 2013, specifically states that the use of rainwater collected from rooftops does not require a water right permit from the State Water Resources Control Board.

The ARCSA/ASPE Rainwater Catchment Design and Installation Standard[3] may also be used as a resource.

TREATMENT REQUIREMENTS

Rainwater catchment system treatment requirements in the code vary depending on the use. Small systems described above are not required to treat rainwater. Other systems may be required to remove turbidity, bacteria, particulates and/or debris. Uses of rainwater for car

[1] www.iapmo.org/Pages/2013CaliforniaPlumbingCode.aspx, click on Chapter 17

[2] www.iapmo.org/Pages/2013CaliforniaPlumbingCode.aspx, click on Chapter 2

[3] American Rainwater Catchment Systems Association (ARCSA) and American Society of Plumbing Engineers (ASPE), August 2009. Rainwater Catchment Design and Installation. See: www.harvesth2o.com/adobe_files/ARCSA_Rainwater%20Code.pdf.

washing, drip irrigation and small volume spray irrigation require filtration, while uses for large volume spray irrigation, toilet flushing, ornamental water features and cooling tower makeup water require filtration and disinfection. More details are provided in Plumbing Code Chapter 17, Table 1702.9.4.

Design and Sizing Guidelines

HYDRAULIC SIZING

- If a project applicant voluntarily chooses to design a rainwater harvesting system that will fully meet Provision C.3 stormwater requirements, there must be sufficient demand to use 80 percent of the average annual rainfall runoff, as specified in Provision C.3.d. Project designers may refer to the sizing curves included in Appendix F of the 2011 report, "Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report" (BASMAA 2011)[4] to size the cistern (or other storage device) to achieve the appropriate combination of drawdown time and cistern volume to harvest and use the C.3.d amount of runoff. These curves are included in Appendix N, Rainwater Harvesting.

DESIGN GUIDELINES FOR ALL SYSTEMS

- Equip water storage facilities covers with tight seals, to reduce mosquito-breeding risk. Follow mosquito control guidance in Appendix G.
- 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.
- Do not install rainwater storage devices in locations where geotechnical/stability concerns may prohibit the storage of large quantities of water. Above-ground cisterns should be located in a stable, flat area, and anchored for earthquake safety.
- To avoid excess hydraulic pressure on subsurface cisterns:
  1. The depth to seasonal high groundwater level should be at least 5 feet from the bottom of the cistern.
  2. A geotechnical engineer should be consulted for situations where the bottom of the cistern is less than 5 feet from the seasonal high groundwater level.
- Provide separate piping without direct connection to potable water piping. Dedicated piping should be color coded and labeled as harvested rainwater, not for consumption. Faucets supplied with non-potable rainwater should include signage identifying the water source as non-potable and not for consumption.
- The harvesting system must not be directly connected to the potable water system at any time.
- When make-up water is provided to the harvest/use system from the municipal system, prevent cross contamination by providing a backflow prevention assembly on the potable water supply line, an air gap, or both, to prevent harvested water from entering the potable supply. Contact local water system authorities to determine specific requirements.

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[4] This report is available on the Clean Water Program's website (www.cleanwaterprogram.org – click on "Resources", then "Development" and scroll to "Feasibility Infeasibility Criteria Report").

- The rainwater storage facility should be constructed using opaque, UV resistant materials, such as heavily tinted plastic, lined metal, concrete, or wood, or protected from sunlight by a structure or roof to prevent algae growth. Check with municipal staff for local building code requirements.
- Storage facilities should be provided with access for maintenance, and with a means of draining and cleaning.

DESIGN GUIDELINES FOR INDOOR USE

- Avoid harvesting water for indoor use from roofs with architectural copper, which may discolor porcelain.
- Provide filtration of rainwater harvested for indoor non-potable use, as required by the plumbing code and any municipality-specific requirements.

DESIGN GUIDELINES FOR IRRIGATION USE

- Water diverted by a first flush diverter may be routed to a landscaped area large enough to accommodate the volume, or a hydraulically-sized treatment measure.
- First flush diverters should be installed in such a way that they will be easily accessible for regular maintenance.
- Do not direct to food-producing gardens rainwater harvested from roofs with wood shingles or shakes (due to the leaching of compounds), asphalt shingles, tar, lead, or other materials that may adversely affect food for human consumption.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement should be provided and should state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. See Chapter 8 for guidance on maintenance requirements.

6.10 Media Filter

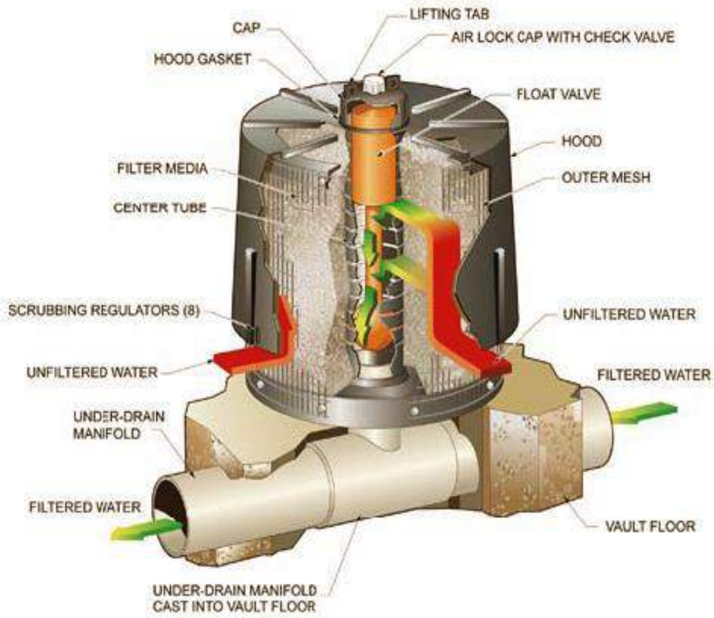

Figure 6.10-1. System C Filter Cartridge, Typically Used as Part of Array

Note: Proprietary products shown are for general information only and are not endorsed by the Clean Water Program. An equivalent filter may be used.

Source: CONTECH Stormwater Solutions, 2006.

Best Uses

- "Special Projects" per Appendix K
- As part of a treatment train (pre-treatment)

Advantages

- Less area required
- Customized media
- Customized sizing

Limitations

- Not considered LID
- No removal of trash without pre-treatment
- High installation and maintenance costs.
- Confined space entry may be required
- Media filtration is allowed only for qualifying "special projects"

Media filters are flow-through treatment systems that remove pollutants from runoff through screening and adsorptive media such as sand, peat, or manufactured media. Types of allowable non-vegetated[1] media filters include: 1) bed filters, such as Austin or Delaware sand filters; 2) proprietary modular cartridge filters; and 3) powered filtration systems.

Under current Municipal Regional Stormwater NPDES Permit (MRP) requirements, the use of media filters as a stand-alone treatment measure is no longer allowed, except at "Special Projects" that qualify for LID treatment reduction credits (see Appendix K). Media filters may also be used as part of a treatment train, for example, as pre-treatment for a subsurface infiltration system. Because Special Projects are typically dense urban infill projects where LID treatment is infeasible due to space constraints, this section focuses on proprietary cartridge filters, which are suitable for limited space and/or underground applications.

Cartridge filters use cartridges of a standard size that can be filled with various types of manufactured media, individually or in combination, including perlite (expanded volcanic ash), zeolite (natural mineral), granular activated carbon, and granular organic media (such as processed leaves). The media are designed to remove certain types of pollutants. The media

[1] Vegetated media filters using soil as the media are described in the bioretention, flow-through planter, and tree well filter sections of the C.3 Handbook.

cartridges are placed in vaults, manholes, or catch basins. In the unit shown in Figure 6.10-2, the water flows laterally (horizontally) into the cartridge to a center tube, then downward to an underdrain system. The number of cartridges required is a function of the water quality design flow rate and cartridge design operating rate (that is, the surface loading rate).

Design and Sizing Guidelines

- Select a media filter product certified by the Washington State Technical Assistance Protocol – Ecology (TAPE) program under the General Use Level Designation (GULD) for Basic Treatment[2]. A list of proprietary media filters currently holding this certification can be obtained from the Department of Ecology's website[3].
- The treatment measure should be sized based on the water quality design flow specified in MRP Provision C.3.d and the cartridge design operating rate for which the product received TAPE GULD certification.
- Consult the manufacturer to determine the proper type of media for the project site and pollutants of concern. Some use combinations of media to address a wide range of pollutants.
- Pretreatment to remove debris and coarse sediment upstream of the media filter, extending the life of the cartridges, is highly recommended. Pretreatment can be provided in a separate upstream unit and/or within the vault containing the cartridges.
- Consider filter head loss when selecting a media filter product. Your options may be limited if the site has limited available head or if you are trying to match up with existing storm drain invert elevations.
- Include provisions for bypassing high flows, either an internal bypass within the treatment measure or an external bypass using a piping configuration with a flow splitter (see Figure 6.10-2 for an example).
- Inform the contractor that if there is a product substitution prior to or during construction, he/she must obtain approval from the local jurisdiction for any changes in the selected treatment product or design. The substituted product must have TAPE GULD certification for Basic Treatment, and the design calculations must be revised if the design operating rate of the substituted product is different than the originally specified product.

Installation Requirements

- Consult the manufacturer to determine the installation requirements for a specific product.
- For vault-based media filters, base preparation will be required. Typically, the soil subbase will need to be compacted and a minimum 6-inch layer of crushed rock base material provided. See manufacturer's specifications.
- To avoid excess hydraulic pressure on subsurface treatment system structures:

[2] "General Use" is distinguished from pilot or conditional use designation, and "Basic Treatment" is distinguished from treatment effectiveness for phosphorus removal. Basic treatment is intended to achieve 80% removal of total suspended solids (TSS) for influent concentrations from 100 mg/l to 200 mg/l and achieve 20 mg/l TSS for less heavily loaded influents.

[3] See: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html

1. The depth to seasonal high groundwater level should be at least 5 feet from the bottom of the structure.
2. A geotechnical engineer should be consulted for situations where the bottom of the structure is less than 5 feet from the seasonal high groundwater level.

Maintenance Requirements

- A Maintenance Agreement should be provided.
- The Maintenance Agreement should state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan consistent with the manufacturer's recommendations and submit with the Maintenance Agreement. Maintenance plan templates are provided in Appendix H.

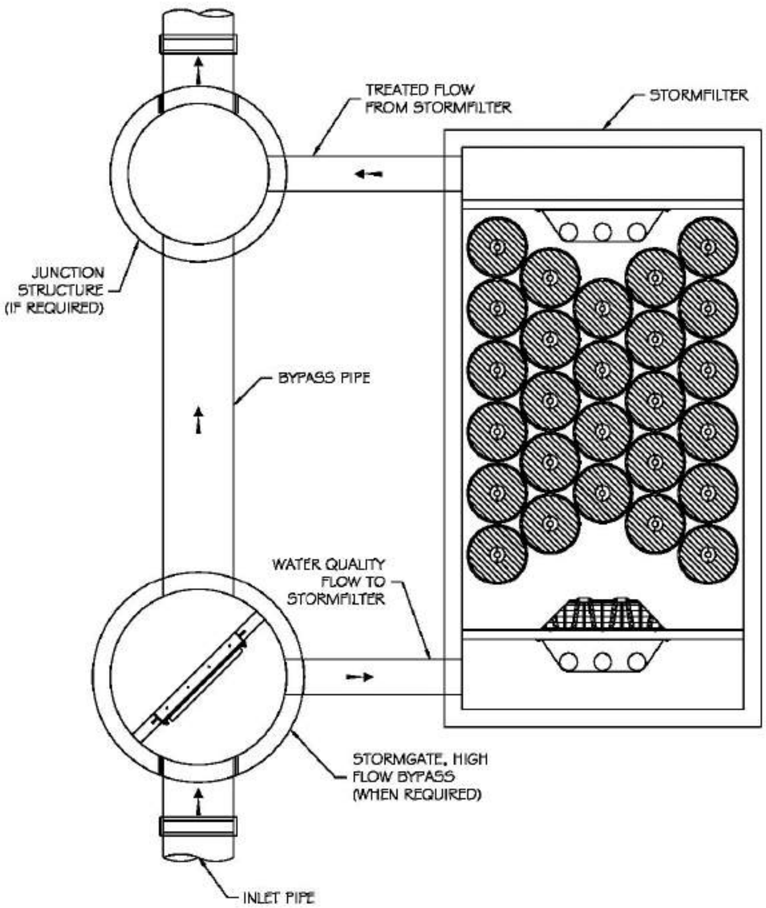

Figure 6.10-2. Plan View Schematic Detail, Typical System C Filter Array.

Note: The proprietary media filters shown are for general information only and are not endorsed by the Clean Water Program.)

Source: CONTECH Stormwater Solutions, 2006.

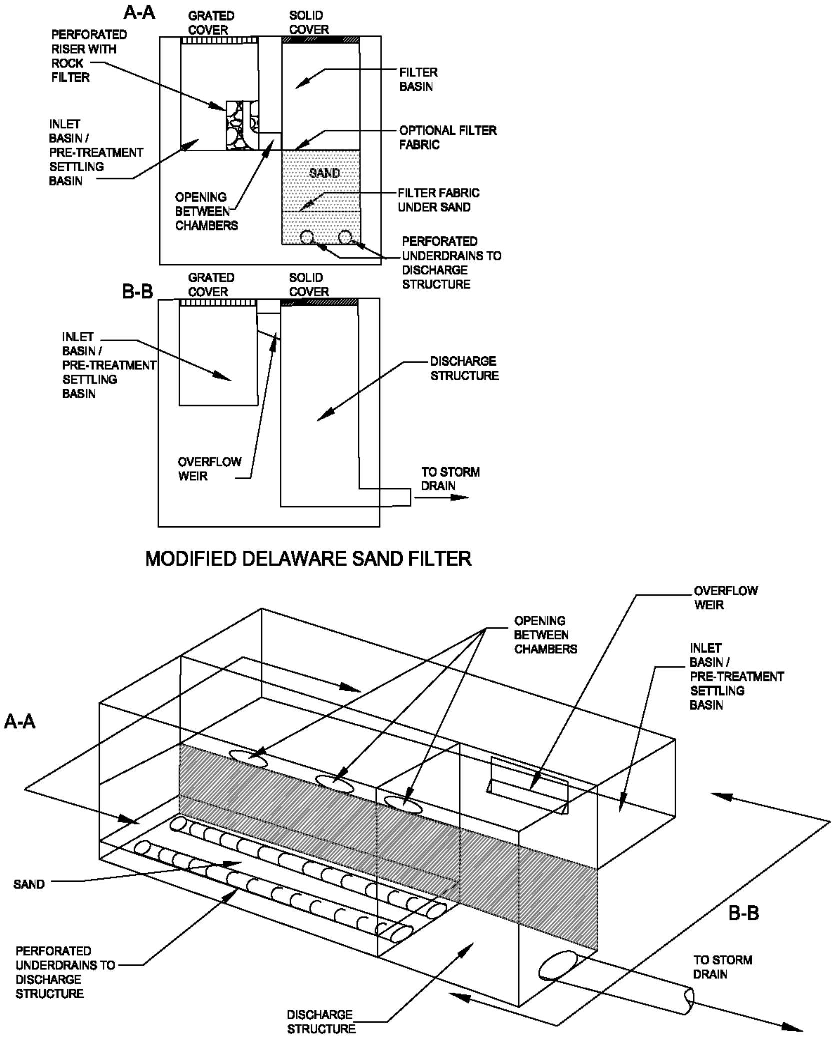

Figure 6.10-3. Cut Away Profile Views, System A Filter (Modified Delaware Sand Filter)

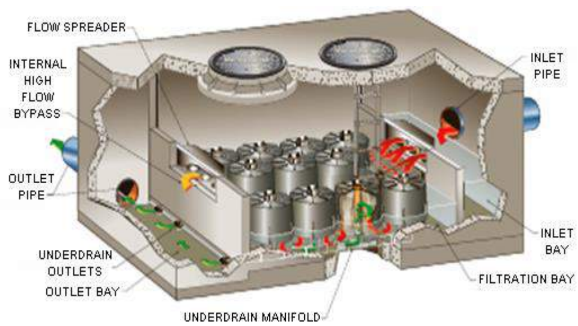

Figure 6.10-4. Cut Away View, Typical System C Filter Array.

(Note: Proprietary media filters shown are for general information only and are not endorsed by the Clean Water Program.)

Source: CONTECH, 2006.

6.11 Subsurface Infiltration System

Photo 6.11-1. *Subsurface retention/infiltration system installation under a parking lot.*

Source: Contech.

Best uses

l or commercial
ith large parking
mon areas
nage areas

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cated beneath
eatures
re modular,
exible design

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mended for
rating soils or
highly polluted runoff

- Requires pretreatment
- Potential for standing water and mosquito production

Subsurface infiltration systems, also known as ***infiltration galleries***, are underground vaults or pipes that store and infiltrate stormwater. See Appendix F for infiltration guidelines. Storage can take the form of large-diameter perforated metal or plastic pipe, or concrete arches, concrete vaults, plastic chambers or crates with open bottoms. These systems allow infiltration into surrounding soil while preserving the land surface above for parking lots, parks and playing fields. A number of vendors offer prefabricated, modular infiltration galleries in a variety of material types, shapes and sizes. Most of these options are strong enough for heavy vehicle loads and can be reinforced if needed.

Another type of subsurface infiltration system is an ***exfiltration basin or trench***, which consists of a perforated or slotted pipe laid in a bed of gravel. It is similar to an infiltration basin or trench with the exception that it can be placed below paved surfaces such as parking lots and streets. Stormwater runoff is temporarily stored in perforated pipe or coarse aggregate and allowed to infiltrate into the trench walls bottom for disposal and treatment.

Subsurface infiltration systems are appropriate for residential and commercial sites where soil conditions and groundwater depths allow for safe infiltration of stormwater into the ground and no risk of groundwater contamination exists. These systems are not appropriate for industrial sites, locations where chemical spills may occur, fill sites or steep slopes. Pretreatment of runoff to remove sediment and other pollutants is typically required to maintain the infiltration capacity of the facility, reduce the cost and frequency of maintenance, and protect groundwater quality.

A "subsurface fluid distribution system" is considered a Class V injection well that is regulated by EPA's Underground Injection Control Program[1]. These systems are "authorized by rule"

[1] See EPA Region 9's website: http://www.epa.gov/region09/water/groundwater/uic-classv.html

and do not require a permit if they do not endanger underground sources of drinking water and comply with federal UIC requirements (see Appendix F).

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK REQUIREMENTS

- In-situ/undisturbed soils should have a low silt and clay content and have infiltration rates greater than 0.5 inches per hour. Hydrologic soil groups C and D are generally not suitable. Soil testing should be performed to confirm infiltration rates, and an appropriate safety factor (minimum of 2) applied as directed by the municipality.
- A 10-foot separation between the bottom of the drain rock and seasonal high groundwater levels is required to avoid the risk of groundwater contamination.
- A setback of 18 feet from building foundations is recommended, or a 1:1 slope from the bottom of the foundation, unless a different setback is allowed by a geotechnical engineer or local standard, or a cutoff wall is provided.

TREATMENT MEASURE DIMENSIONS AND SIZING (INFILTRATION GALLERIES)

- The subsurface infiltration system should be sized to store and infiltrate the water quality design volume per MRP Provision C.3.d. The system may also be sized to store a larger volume for hydromodification management, if site conditions allow.
- Design the system to drain down (infiltrate) within 72 hours, in order to provide storage for runoff from back-to-back storms. To avoid mosquito production, the system should drain within 5 days.
- The maximum allowable effective depth of water (inches) stored in the system can be calculated by multiplying the drawdown time (hours) by the design infiltration rate of the native soils adjusted by the safety factor (in/hr). The required footprint of the system can then be calculated by dividing the storage volume by the effective depth. Consult with the manufacturer for sizing of various components to achieve storage and infiltration of the water quality design volume.
- One or more observation wells should be installed to monitor water levels (drain time) in the facility. The well should be a minimum 6-inch diameter perforated PVC pipe, which is anchored vertically to a foot plate at the bottom of the facility.
- Maintenance access to the underground galleries must be provided, as periodic cleaning may be necessary to maintain performance. Open systems such as large diameter pipe or concrete structures can more easily be inspected and entered for maintenance if necessary than low profile or crate-type systems. The access should be large enough to allow equipment to be lowered into each gallery.
- Provide a layer of aggregate between the subsurface storage component or galleries and native soils to prevent migration of native soils into the storage component.

TREATMENT MEASURE DIMENSIONS AND SIZING (EXFILTRATION TRENCHES)

- The exfiltration trench should be sized to store and infiltrate the water quality design volume per MRP Provision C.3.d. It is designed similar to an infiltration trench.
- 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

typically 1.5 to 2.5 inches in diameter, which provides a void space of approximately 35 percent. Trenches may be designed to provide temporary storage of storm water, but should drain within 72 hours, in order to provide storage for runoff from back-to-back storms. To avoid mosquito production, the system should drain within 5 days.

- The trench depth should maintain the required separation from seasonal high groundwater, and the depth should be less than the widest surface dimension, to avoid regulation as a Class V injection well.
- The invert of the trench should be flat (no slope).
- Place permeable filter fabric around the walls and bottom of the trench and top of the aggregate layer. The filter fabric should overlap each side of the trench in order to cover the top of the aggregate. The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate.
- A layer of filter fabric or sand should be placed at the bottom of the trench to keep the rock matrix from settling into the subgrade over time.
- An observation well should be installed to monitor water levels (drain time) in the trench. The well should be a minimum 6-inch diameter perforated PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure in the following ways:

- Through a pipe
- Through a drop inlet or catch basin
- Through roof leader or other conveyance from building roof

PRETREATMENT MEASURES

- The pretreatment measure(s) should be selected based on the expected pollutants on site and the infiltration system's susceptibility to clogging. Sediment removal is important for maintaining the long term infiltration capability of the system.
- Hydrodynamic separators or media filters are most commonly used for subsurface systems, and are allowed as part of a treatment train with the infiltration system. Landscaped-based treatment, such buffer strips, or bioretention may also be used upstream of subsurface systems if appropriate and if space allows.
- If a media filter is selected, refer to the media filter design in Section 6.10.

Construction Requirements

- 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. During project construction, runoff from unstabilized areas should be diverted away from the trench into a sedimentation control BMP until vegetation is established.
- Avoid spreading fines of the soils on bottom and side slopes while excavating. Loosen soils at the bottom of the excavation prior to constructing the infiltration trench.

- Avoid compaction of existing soils in the area of the infiltration. Protect from construction traffic.

Maintenance Requirements

- Provide a Maintenance Agreement (or other document or mechanism) that states the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Refer to Chapter 8 and Appendix H for specific maintenance requirements.

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Chapter

7

Hydromodification Management Measures

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

7.1 Why Require Hydromodification Management?

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.

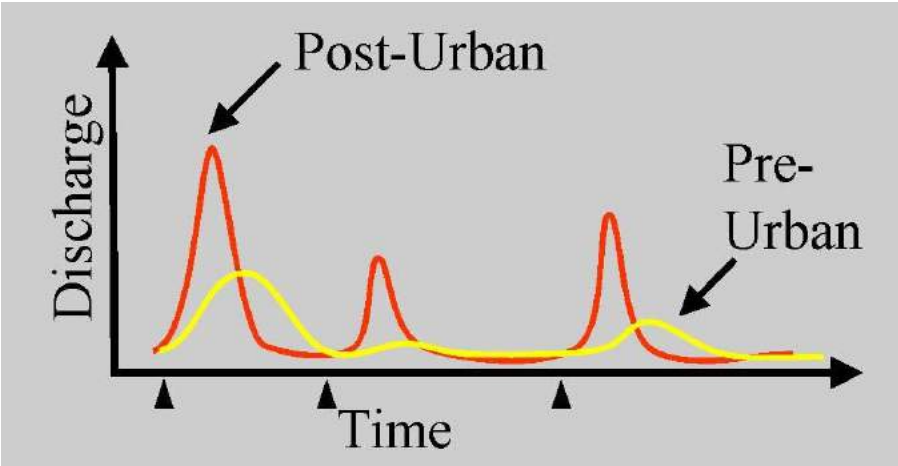

Figure 7-1. Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds

Source: NEMO-California Partnership, No Date

In watersheds with large amounts of impervious surface, the larger volumes and faster rates of flow, with extended durations of flows that cause erosion, 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.

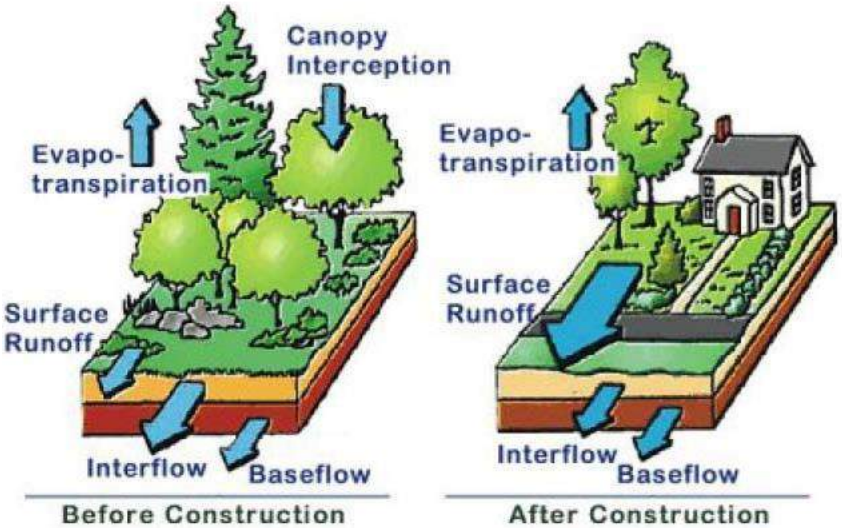

Figure 7-2. Effects of Urbanization on the Local Hydrologic Cycle

(Source: 2000 Maryland Stormwater Design Manual)

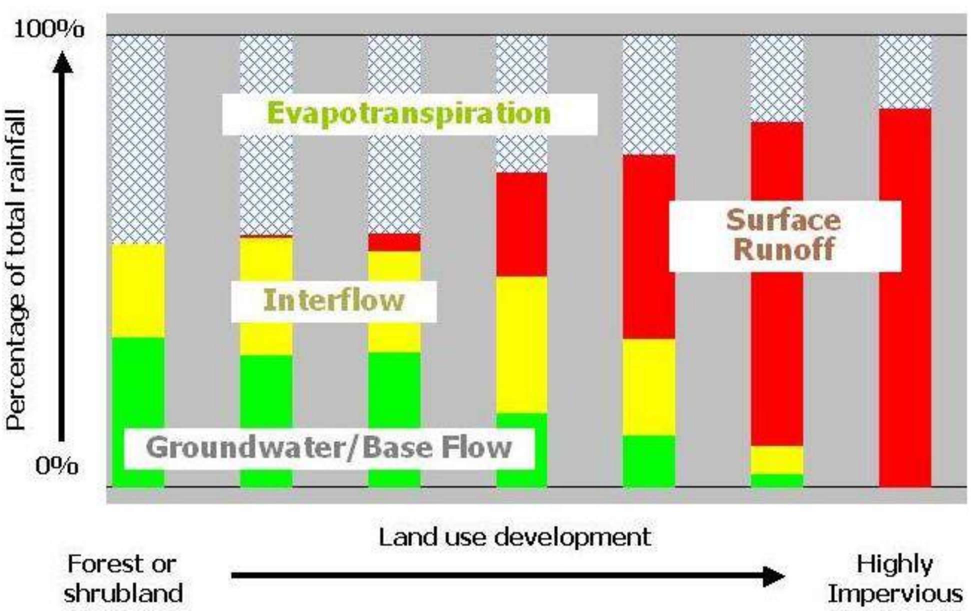

Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development.

(Chart used by permission of Clear Creek Solutions.)

Hydromodification management (HM) techniques focus on ***retaining, detaining or infiltrating runoff.***

Since 2007, hydromodification management (HM) techniques have been required in areas across the San Francisco Bay Area that are susceptible to hydromodification. These techniques focus on ***retaining, detaining or infiltrating runoff*** and matching post-project flows and durations to pre-project patterns for a specified range of smaller, more frequent rain events, to prevent increases in channel erosion downstream. Within Alameda County, a simple map-based approach is used to determine 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, are be required to incorporate one or more HM measures in the design in order to reduce erosive flows from a wide range of runoff conditions.

7.2 Which Projects Need to Implement HM?

Unless it is a single family home that is not part of a larger of development, your project will be required to comply with the HM requirements if it meets the following applicability criteria:

- The project ***creates and/or replaces one acre or more of impervious surface***,
- The project ***will increase impervious surface*** over pre-project conditions, AND
- The project is ***located in a susceptible area***, as shown on the default susceptibility map.

Appendix I shows a schematic view of a portion of the hydromodification susceptibility map. The full map may be downloaded from the Clean Water Program website (http://accwp.maps.arcgis.com/apps/webappviewer/index.html?id=11d7a1bfb90d46ce80f94defc03d012c) in an interactive format that enables zooming to a closer view of the project vicinity with local streets. The requirements do not apply to projects that drain directly to the bay or tidal channels nor to projects that drain into channel segments that have been hardened on three sides and/or are contained in culverts continuously downstream to their outfall in a tidal area. Note that project sites draining to earthen flood control channels are not automatically exempt from HM requirements.

- For guidance on whether it is necessary to implement controls, see the following description of the color coding used in the countywide map.
- **Solid pink areas** – Pink designates hilly areas with high slopes (greater than 25 percent). The HM Standard and all associated requirements apply in areas shown in solid pink on the map. In this area, the HM Standard does *not* apply if a project proponent demonstrates that all project runoff will flow through enclosed storm drains, existing concrete culverts, or fully hardened (with bed and banks continuously concrete-lined) channels to the tidal area shown in light gray.
- **Purple/red hatched areas** – These are upstream of areas where hydromodification impacts are of concern because of factors such as bank instability, sensitive habitat, or restoration projects. The HM Standard and all associated requirements apply in areas shown in purple/red (printer-dependent) hatch marking on the map. Projects in these areas may be subject to additional agency reviews related to hydrologic, habitat or other watershed-specific concerns.

- **Solid white areas** – Solid white designates the land area between the hills and the tidal zone. The HM Standard and all associated requirements apply to projects in solid white areas *unless* a project proponent demonstrates that all project runoff will flow through fully hardened channels. Short segments of engineered earthen channels (length less than 10 times the maximum width of trapezoidal cross-section) can be considered resistant to erosion if located downstream of a concrete channel of similar or greater length and comparable cross-sectional dimensions. Plans to restore a hardened channel may affect the HM Standard applicability in this area.
- **Solid gray areas** – Solid gray designates areas where streams or channels are tidally influenced or primarily depositional near their outfall in San Francisco Bay. The HM Standard does not apply to projects in this area. Plans to restore a hardened channel may affect the HM Standard applicability in this area.
- **Dark gray, *Eastern County* area** – Dark gray designates the portion of eastern Alameda County that lies outside the discharge area of this NPDES permit. This area is in the Central Valley Regional Water Quality Control Board's jurisdiction.

Please note that projects located in susceptible areas are encouraged to include hydrologic source control measures for HM if they are likely to cause hydrograph changes, ***even if they create and/or replace less than one acre of impervious surface.***

7.3 Hydromodification Management (HM) Measures

Provision C.3.g.iv identifies three types of hydromodification management (HM) measures: on-site controls, regional controls, and in-stream measures, as described below.

- ***Onsite HM controls*** consist of hydrologic source controls (site design measures), low impact development (LID) features and facilities, flow duration control structures, which collectively prevent increases in runoff flow and volume, to meet the HM Standard described in Section 7.4 at the point(s) where stormwater runoff discharges from the project site.
- ***On-site hydrologic source control measures***, which are generally distributed throughout a project site as site design 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 – which also helps reduce stormwater pollution.
- ***On-site LID features and facilities,*** which are generally included in order to meet stormwater treatment requirements described in Provisions C.3.c and C.3.d, also contribute to hydromodification management by infiltrating and detaining runoff.

Photo 7-1. Draining roof runoff to a landscaped area is an example of hydrologic source control.

- ***On-site structural HM measures*** manage excess runoff from the site after hydrologic source control measures are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes. Stormwater is temporarily detained, and then the runoff is gradually discharged to a natural channel at a rate calculated to avoid 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 to 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 for ***flow duration control for frequent, small runoff events*** (with average occurrence ranging from less than two-years to approximately ten-years). The structural HM measures are 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.

- ***Regional HM controls*** are flow duration control structures that collect stormwater runoff discharge from multiple projects (each of which shall incorporate hydrologic source control measures as well) and are designed such that the HM Standard described in Section 7.4 is met for all the projects at the point where the regional HM control discharges.

- ***In-stream measures*** are an option only where the stream, which receives runoff from the project, is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel. ***In-stream measures involve modifying the receiving stream channel slope and geometry*** so that the stream can convey the new flow regime without increasing the potential for erosion and aggradation. In-stream measures are intended to improve long-term channel stability and prevent erosion by reducing the erosive forces imposed on the channel boundary.

- In-stream measures, or a combination of in-stream and onsite controls, are designed to achieve the HM Standard described in Section 7.4 from the point where the project(s) discharge(s) to the stream to the mouth of the stream or to achieve an equivalent degree of flow control mitigation (based on amount of impervious surface mitigated) as part of an in-stream project located in the same watershed. ***Designing in-stream controls requires a hydrologic and geomorphic evaluation*** (including a longitudinal profile) of the stream system downstream and upstream of the project. Examples of in-stream measures 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. As with all in-stream activities, other regulatory permits must be obtained by the project proponent.

> 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.

7.4 Requirements for Hydromodification Management

7.4.1 Meeting the HM Standard

The HM Standard specified in Provision C.3.g.ii requires that storm water discharges from ***HM projects shall not cause an increase in the erosion potential of the receiving stream*** over the pre-project (existing) condition. HM controls shall be designed such that post-project stormwater discharge rates and durations match pre-project discharge rates and durations from 10 percent of the pre-project two-year peak flow up to the pre-project 10-year peak flow. HM controls designed using the Bay Area Hydrology Model (BAHM) and site-specific input data shall be considered to meet the HM Standard.

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. For projects subject to HM 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 Planning Steps 2 & 3 in Chapter 3).
- Where possible, ***maximize infiltration*** to further reduce detention requirements, using hydrologic source controls (site design measures) and LID features and facilities. 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. For some project locations, off-site options may be available to reduce or eliminate the need for onsite detention.

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.

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 Photo 7-1).

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

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.

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.

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

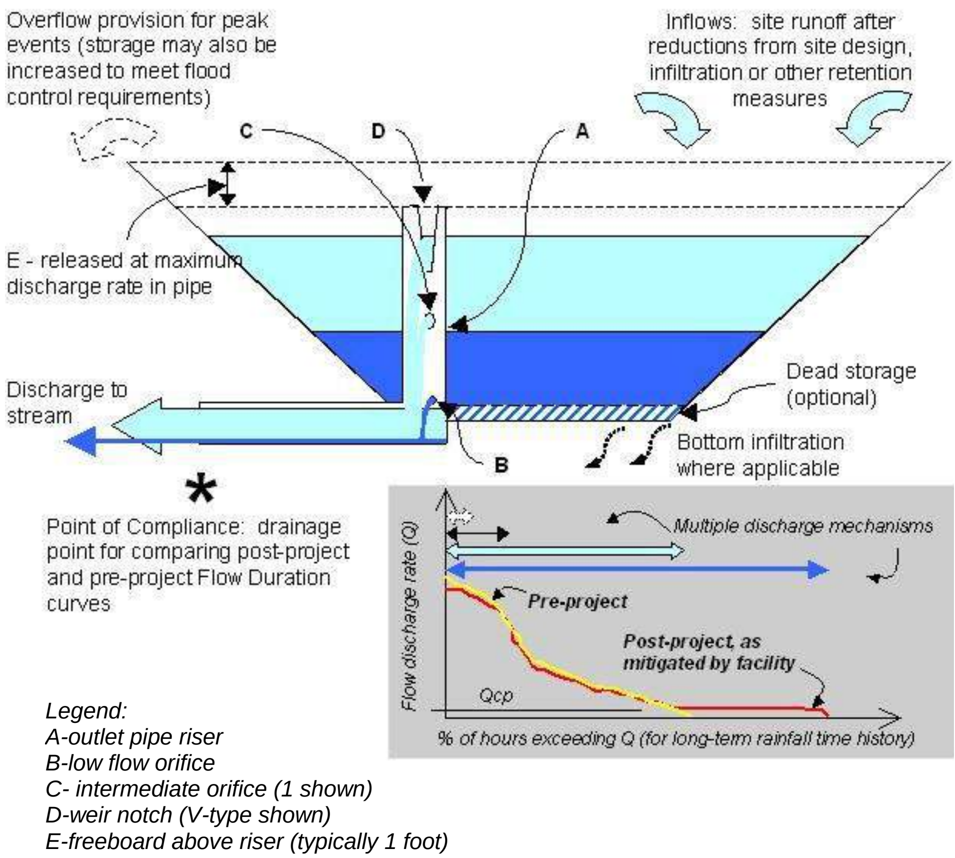

Figure 7-4. Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume.

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 Control (FDC) 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, the Clean Water Program collaborated 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 current version of the BAHM (BAHM 2013) is available for downloading at www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi, and it includes:

- 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.
- 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.

Please make sure to use the current version of the BAHM (BAHM 2013). Training courses on using the BAHM are offered periodically. For more information, please visit www.clearcreeksolutions.info/ftp/public/downloads/BAHM2013/bahm2013.msi.

7.5 HM Control Submittals for Review

Determine the potential applicability of the HM requirements to the proposed project, using the guidelines in Section 7.2, the applicability map shown in Appendix I (which can also be accessed at the following link: accwp.maps.arcgis.com/apps/webappviewer/index.html?id=11d7a1bfb90d46ce80f94defc03d012c), and the City-specific Stormwater Requirements Form (available from municipal staff). Then prepare an HM Control Plan as part of the project's Provision C.3. submittal.

Table 7-1 provides a model checklist of submittal requirements for the HM Control Plan. Information on site design and LID treatment measures should also be included, if they are part of the HM Control Plan, and any modeling analyses. Check with the local jurisdiction to determine the specific requirements for your project.

Table 7-1. HM Control Plan Checklist

Required?*		
Yes	**No**	**Information on Plan Sheets**
❑	❑	Soil types and depth to groundwater
❑	❑	Existing and proposed site drainage plan and grades
❑	❑	Drainage Management Area (DMA) boundaries
❑	❑	Amount of existing pervious and impervious areas (for total site and each DMA)
❑	❑	Amount of proposed impervious area (for total site and each DMA)
❑	❑	Amount of proposed pervious area (for total site and each DMA)
❑	❑	Proposed site design measures to minimize impervious surfaces and promote infiltration**
❑	❑	Proposed locations and sizes of stormwater treatment measures and HM measures
❑	❑	Stormwater treatment measure and HM measure details
		Information on Modeling Analysis and HM Facility Sizing
❑	❑	BAHM Report with input and output data and additional files as required by municipality
❑	❑	If different model is used, description of model, input and output data
❑	❑	Description of how site is represented in the model, what is proposed and why
❑	❑	Description of any changes to standard parameters (e.g. scaling factor, duration criteria)
❑	❑	Comparison of HM facility sizing per model results vs. details on plan
❑	❑	Description of any unique hydraulic conditions due to HM facility location
❑	❑	Description of orifice/weir sizing, outlet protection measures, and drawdown time
❑	❑	Preliminary maintenance plan for HM facility

** Municipal staff may check the boxes in the "Required" column to indicate which items are required for your project.*

*** Site design, treatment and HM measures that promote infiltration should be designed consistent with the recommendations of the project geotechnical engineer.*

7.6 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.

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 apply to stormwater treatment AND HM measures.

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 bioretention area, by contrast, may require little maintenance beyond the typical requirements for areas of landscaping.

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 72 hours*** 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 72 hours*** to effectively suppress mosquito production. The Clean Water Program 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 G.

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, including areas of pervious pavement, and the locations of hydromodification management (HM) controls, if any. The plan should specifically identify all pervious pavements systems that total 3000 $ft.^2$ or more (excluding private-use patios for single-family homes, townhomes, or condominiums). 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 H 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 Mosquito Abatement District staff may conduct ***O&M verification inspections*** to make sure that treatment and HM 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 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 H. ***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, including pervious paving, 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 site plan that shows the location of each stormwater treatment measure, including areas of pervious paving, and /structural HM measures. The site plan should specifically identify all pervious pavements systems that total 3,000 square feet or more (excluding private-use patios for single-family homes, townhomes, or condominiums). Letter-sized plans are preferred; legal-sized plans may be accepted.

- 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, which 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.

> Maintenance plan templates are provided, in Appendix H, for commonly-used stormwater treatment measures.

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

- Maintenance plan templates included in Appendix H. Electronic versions of the templates are available at www.cleanwaterprogram.org (Click on "Businesses," then "Development" and go to Appendix H of the C.3 Technical Guidance).
- A list of common maintenance concerns for the frequently used stormwater treatment measures, provided below.

When using a template to prepare your maintenance plan, please insert project-specific information where you find prompts such as the following: [[== insert name of property owner/responsible party ==]]. Each template includes sample inspection checklists. If your project includes different treatment/HM measures, you may also refer to the ***treatment measure-specific maintenance information*** presented in the following paragraphs.

Bioretention Areas[1] – Common Maintenance Concerns:

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

- Maintain vegetation and the irrigation system. Prune and weed, as needed, to keep the bioretention area neat and orderly in appearance.
- On a monthly basis, remove obstructions, debris, accumulated sediment and trash.
- On a biannual basis (pre- and post-wet season) evaluate the health of plants, remove and replace any dead or diseased vegetation, and till or replace soil (using biotreatment soil mix specified in Appendix K) as needed to maintain the design elevation of soil.
- Before and after the wet season, and monthly during the wet season, conduct inspections to assure proper functioning of bioretention area. Items to inspect include:
  - Inspect and, if needed, replace mulch before the wet season begins and 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.
  - Inspect bioretention area for ponded water. If ponded water does not drain within 72 hours, remove surface soils and replace with biotreatment soil. 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.
- On an ongoing basis, treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible, and replace any dead plants.

Photo 8-1. Bioretention Area in the City of Fremont

- 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.

[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

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.

- 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.

- On a biannual basis (pre- and post-wet season) evaluate the health of plants, remove and replace any dead or diseased vegetation, and till or replace soil (using biotreatment soil mix specified in Appendix K) as needed to maintain the design elevation of soil.

- Before and after the wet season, and monthly during the wet season, conduct inspections to assure proper functioning of flow-through planter. Items to inspect include:

  - Inspect planter box to ensure structural integrity of the box.

  - 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. Confirm that soil is not clogging and that the planter will drain within 72 hours after a storm event. Inspect and, if needed, replenish mulch.

  - Inspect downspouts from rooftops or sheet flow from paving to ensure that flow to the planter is unimpeded. Inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Remove any debris and repair any damaged or disconnected pipes. Check splash blocks or rocks and repair, replace or replenish as necessary.

- 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.

Photo 8-2. Flow through planter in the City of Emeryville

Tree Well Filters – Common Maintenance Concerns:

For proprietary tree well filters, consult product documents; some manufacturers require a maintenance agreement, under which the manufacturer conducts the maintenance. The following maintenance requirements are typical for non-proprietary tree well filters:

- On a biannual basis (pre- and post-wet season) evaluate the health of plants, remove and replace any dead or diseased vegetation, and till or replace soil (using biotreatment soil mix specified in Appendix K) as needed to maintain the design elevation of soil.
- Before and after the wet season, and monthly during the wet season, conduct inspections to assure proper functioning of tree well filter. Items to inspect include:
    - 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.
    - Check that the biotreatment soil 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 within 72 hours after rainfall. Till or replace the biotreatment soil as necessary.
    - 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.
    - 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.

Photo 8-3. Series of non-proprietary tree well filters installed along roadway, City of Fremont

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.

Photo 8-4. 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:

- Maintenance activities at the bottom of the basin shall NOT be performed with heavy equipment, which would compact the soil and limit infiltration.
- Harvest vegetation annually, during the summer.
- Trim vegetation at 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 you observe mosquito larvae, contact Alameda County Mosquito Abatement District, 510/783-7744. (In Albany, Alameda County Vector Control District, 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 basin at the middle and end of wet season (January and April), or as needed.

Photo 8-5. Extended Detention Basin, Palo Alto

Pervious Concrete and Asphalt – common maintenance concerns:

Standards for Ongoing Maintenance and Upkeep:

- On a monthly basis, remove any accumulated trash or debris from pervious paving surface. Also remove any trash or debris from downspouts to pervious paving facility or in outlets to storm drains.
- On a biannual basis (pre- and post-wet season) vacuum sweep and clean surface of pervious pavement. If power washing is used, avoid forcing fine sediments into the pervious pavement.
- Before and after the wet season, and monthly during the wet season, conduct inspections to assure proper functioning of pervious paving. Items to inspect include:
  - Check for standing water on the pavement surface.
  - Inspect pervious paving for any signs of hydraulic failure.
- Inspect outlets and remove accumulated trash/debris.
- Keep landscaped areas well maintained.

As needed maintenance:

- If any signs of clogging are noted, use high performance vacuum equipment. If pavement is determined to be clogged after vacuuming with high performance equipment, test sections test the infiltration rate using ASTM C1701 and compare against original test results after construction, if available. A minimum tested infiltration rate of 10 inches per hour indicates the system is approaching near-clogged condition.
- 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 after vacuuming, 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 abrasive or 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.

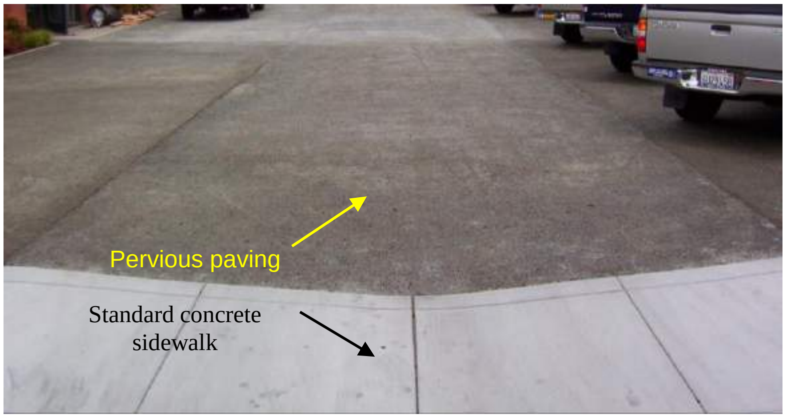

Photo 8-6. Parking Lot with Pervious Pavement, Emeryville

Turf Block and Permeable Joint Pavers – common maintenance concerns:

Standards for Ongoing Maintenance and Upkeep:

- Irrigate and mow turf block grass as required for selected turf species; no-mow and low-water species are advised.
- On a monthly basis, remove any accumulated trash or debris from pervious paving surface and/or between joints. Also remove any trash or debris from downspouts to pervious paving facility or in outlets to storm drains.
- On a biannual basis (pre- and post-wet season) Vacuum sweep the surface of the unplanted turf block and permeable joint pavers (for pervious joint pavers with sand in joints use minimum suction required to remove surface debris and minimize aggregate loss) and clean surface of pervious pavement, taking care not to move fine sediments into any permeable joints. If power washing is used, aim the spray at a minimum 45 degree angle in relation to the pavement surface, to avoid dislodging aggregate. Avoid forcing fine sediments into the pervious pavement.
- Before and after the wet season, and monthly during the wet season, conduct inspections to assure proper functioning of pervious paving. Items to inspect include:
    - Check for standing water on the pavement surface.
    - Inspect permeable joint pavers for any signs of hydraulic failure.
    - Inspect outlets and remove accumulated trash and debris.
- Keep landscaped areas well maintained.

As needed maintenance:

- If any signs of clogging are noted, use high performance vacuum equipment. If pavement is determined to be clogged after vacuuming with high performance equipment, test sections test the infiltration rate using ASTM C1781 and compare against original post-infiltration test results, if available. A minimum tested infiltration rate of 10 inches per hour indicates the system is approaching near-clogged condition.
- 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 permable joint materials, as necessary.

Photo 8-7. Turf block fire lane

Rainwater Harvesting And Use – Common Maintenance Concerns:
Routine maintenance:

- Conduct annual inspections of backflow prevention systems.
- If rainwater is provided for indoor use, conduct annual water quality testing.
- Clean gutters and first-flush devices at least annually, and as needed, to prevent clogging.
- Conduct regular inspection and replacement of treatment system components, such as filters and UV lights.
- If the system includes a roof washer, regularly inspect and clean the roof washer to avoid clogging.
- Regularly inspect for and repair leaks.
- Maintenance requirements specific to cisterns:
  - Flush cisterns annually to remove sediment.
  - For buried structures, vacuum removal of sediment is required.
  - Brush the inside surfaces and thoroughly disinfect twice per year.
- Maintenance requirements specific to rain barrels
  - Inspect rain barrels four times per year and after major storms
  - Remove debris from screens as needed.
  - Replace screens, spigots, downspouts, and rain leaders as needed.

Photo 8-8. Rainwater harvesting system, Mills College, Oakland

Media Filters – Common Maintenance Concerns:

Follow manufacturer requirements for maintenance. 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 72 hours.
- If the facility drain time exceeds 72 hours, 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).

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Chapter

9

Alternative Compliance

This chapter provides information on using Alternative Compliance options where LID treatment is required.

9.1 What is Alternative Compliance?

Provision C.3.e of the Municipal Regional Stormwater NPDES Permit (MRP) allows municipalities to grant "alternative compliance" to new development or redevelopment projects in lieu of requiring full onsite treatment of the Provision C.3.d amount of stormwater runoff and pollutant loads with low-impact development (LID) measures. ***Projects that receive alternative compliance must still provide LID treatment in full,*** but all of the treatment does not have to take place onsite. There are no special eligibility criteria for using alternative compliance. If your project is required to provide LID treatment, it may use alternative compliance to meet these requirements. There is no requirement to make LID impracticability or infeasibility findings in order to use alternative compliance. The MRP offers two options for using alternative compliance, described in Section 9.2, sets deadlines for constructing offsite alternative compliance projects (Section 9.3), and sets a timeline for the alternative compliance provision to take effect.

9.2 Categories of Alternative Compliance

A project may use either of the alternative compliance options listed below.

9.2.1 Option 1: Partial LID treatment at an off-site location

Projects may treat a portion of the required amount of stormwater runoff using LID on-site (or offsite at a "joint treatment facility" that is shared with an adjoining project), and then ***treat the remaining portion of runoff at an offsite project*** within the same watershed. Offsite LID treatment measures must provide an equivalent quantity of hydraulically-sized treatment of both stormwater runoff and pollutant loads and achieve a net environmental benefit.

JOINT TREATMENT FACILITY

A joint treatment facility ***treats the stormwater from more than one property*** at an offsite but nearby location.

OFFSITE EQUIVALENT TREATMENT PROJECT

An offsite equivalent treatment project provides off-site LID treatment for a surface area or volume and pollutant loading 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 LID treatment measures in a nearby parking lot, or other development where hydraulically-sized LID treatment measures were not previously installed.

9.2.2 Option 2: Payment of in-lieu fees

Projects may treat a portion of the required amount of stormwater runoff using LID on-site or offsite at a joint treatment facility and ***pay equivalent in-lieu fees to treat the remaining amount*** of stormwater runoff with LID treatment measures at a Regional Project.

IN-LIEU FEES

In-lieu fees provide the monetary amount necessary to provide both hydraulically-sized treatment (in accordance with Provision C.3.d) with LID treatment measures of an equivalent quantity of stormwater runoff and pollutant loading, ***and*** a proportional share of the operation and maintenance costs of the Regional Project.

REGIONAL PROJECT

A Regional Project is a regional or municipal stormwater treatment facility that discharges to the same watershed as the Regulated Project. The Regional Project must achieve a net environmental benefit.

9.3 Offsite or Regional Project Completion Deadlines

9.3.1 Timeline for construction of offsite project

Construction of the offsite LID treatment project must be completed within three years after the end of construction of the Regulated Project.

9.3.2 Timeline for construction of a Regional Project

The Regional Project must be completed within three years of the Regulated Project. This can be extended to five years only with Regional Water Board Executive Officer approval. In order for the Executive Officer to grant the extension of up to five years, the applicant must have demonstrated good-faith efforts to implement the regional project, such as by applying for the necessary permits and having the necessary funds encumbered for project completion.

9.4 When Does the Alternative Compliance Provision Take Effect?

The use of alternative compliance is optional, but if it is used, the projects must comply with the requirements for implementing alternative compliance included in the MRP, as reissued on November 19, 2015, ***beginning January 1, 2016***. The alternative compliance requirements in Provision C.3.e of the reissued MRP supersede any alternative compliance policies previously approved by the Regional Water Board Executive Officer.

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Appendix

A

Local Requirements

Each of the Countywide Program's 17 member agencies may have its own requirements that must be met in the C.3 stormwater submittals that are included with planning and building permit applications. Some of the agencies have made this information available on their websites, as listed below. Contact information for all member agencies is provided on the first page of the Technical Guidance, before the Table of Contents.

Emeryville

Emeryville's ***Stormwater Treatment Requirements*** are described at the following link: www.ci.emeryville.ca.us/index.aspx?nid=335

Stormwater Treatment Requirements information can also be accessed by going to www.ci.emeryville.ca.us, then clicking on "Departments", then "Public Works", then Environmental Services", then "Stormwater."

Fremont

Fremont's stormwater ***Development Submittal Requirements*** are described on Fremont's website at the following link: www.fremont.gov/stormwaterdevelopment.

The Development Submittal Requirements page can also be accessed by going to www.fremont.gov, then clicking on "Departments", then "Environmental Services", then "Stormwater Regulations", then "Development Submittal Requirements."

Pleasanton

Pleasanton's ***Stormwater Requirements*** are described on Pleasanton's website at the following link: www.cityofpleasantonca.gov/gov/depts/cd/engineering/stormwater.asp.

The information can also be accessed by going to www.cityofpleasantonca.gov, then clicking on "Government", then "Engineering", then "Stormwater Requirements".

Appendix

B

Plant List and Planting Guidance for Landscape-Based Stormwater Measures

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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.*

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.

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.

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.

Select California natives and/or drought tolerant plants. Planting appropriate, drought tolerant California natives or Mediterranean plants reduces water consumption for irrigations, and reduces mowing, fertilizing, and spraying. For the purposes of the plant list on the following pages, "drought tolerant" refers to plants that meet the following criteria:

- Are identified as drought tolerant as follows: California Native Plants for the Garden (Borstein, et al.).
- Are identified as requiring occasional or infrequent irrigation in Borstein, et al., or Plants and Landscapes for Summer Dry Climates (East Bay Municipal Utilities District [EBMUD]).
- Are identified as requiring no summer water in EBMUD.
- Are identified as requiring little or no water in the Sunset Western Garden Book.
- Are identified as requiring low or very low irrigation in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California (University of California Cooperative Extension).

Plants not listed in any of the above references will require that the design professional base selection upon successful experience with species on previous projects under similar horticultural conditions.

Site-specific Factors. Given Alameda County spans several Sunset climate zones, with variable humidity, heat, frost, and wind factors, as well as varying soil characteristics, plants need to be selected with an understanding of specific climate and microclimate conditions, and grouped in appropriate hydrozones.

Supplemental watering needs. Many plants listed as drought tolerant per the above references may require more supplemental watering in fast-draining, engineered soils.

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.

Invasive species. Under no circumstances shall any plants listed as invasive under www.cal-ipc.org/paf be specified.

Table B-1 Plant List for Stormwater Measures

		Bioretention Area - Including linear treatment measure	Flow-Through Planters	Tree Well Filters	Vegetated Buffer Strip	Infiltration Trench	Extended Detention Basin - biotreatment soil	Extended Detention Basin - non-biotreatment soil	Turf Block Pavers	Green Roof - extensive	Green Roof - Intensive	California Native	Drought Tolerant
Emergent Species													
Carex barbarae	Santa Barbara sedge				✓		✓	✓		✓	✓	✓	✓
Carex pansa	California meadow sedge			✓	✓		✓	✓	✓	✓	✓	✓	✓
Juncus patens	blue rush	✓	✓		✓	✓	✓	✓			✓	✓	
Limonium californicum	Marsh rosemary						✓	✓				✓	
Grass Species													
Aristida purpurea	Purple three-awn	✓	✓		✓						✓	✓	✓
Chondropetalum tectorum	cape rush	✓	✓		✓	✓	✓	✓			✓		
Deschampsia cespitosa [1]	tufted hairgrass	✓			✓	✓	✓	✓			✓	✓	✓
Deschampsia cespitosa ssp. holciformis	Pacific hairgrass	✓			✓	✓	✓	✓			✓	✓	
Festuca rubra [1]	red fescue		✓	✓	✓				✓		✓	✓	✓
Festuca rubra 'molate'	Molate fescue		✓	✓	✓				✓		✓	✓	✓
Hordeum brachyantherum [1]	meadow barley	✓			✓		✓	✓				✓	✓
Leymus triticoides	creeping wildrye	✓			✓	✓		✓			✓	✓	✓
Melica californica	California melic				✓							✓	✓
Melica imperfecta	coast range melic	✓	✓		✓							✓	✓
Muhlenbergia rigens	deergrass	✓	✓		✓	✓	✓	✓			✓	✓	✓
Nasella pulchra	purple needlegrass	✓		✓	✓	✓					✓	✓	✓
Nassella lepida	Foothill needlegrass			✓	✓	✓					✓	✓	✓
Herbaceous Species													
Achillea millefolium	common yarrow		✓	✓	✓					✓	✓	✓	✓
Anthemis nobilis (Chamaemelum nobile)	chamomile			✓					✓				✓
Armeria maritima	sea pink		✓	✓	✓					✓	✓	✓	✓
Clarkia spp.	Clarkia	✓			✓					✓	✓	✓	✓
Dietes	fortnight lily	✓			✓					✓	✓		✓
Epilobium densiflorum	dense spike-primrose	✓	✓		✓	✓						✓	✓

[1] *Denotes species with phytoremediation capabilities*

Table B-1 Plant List for Stormwater Measures

		Bioretention Area - Including linear treatment measure	Flow-Through Planters	Tree Well Filters	Vegetated Buffer Strip	Infiltration Trench	Extended Detention Basin - biotreatment soil	Extended Detention Basin - non-biotreatment soil	Turf Block Pavers	Green Roof - extensive	Green Roof - Intensive	California Native	Drought Tolerant
Herbaceous Species cont'd													
Eriogonum latifolium	coast buckwheat			✓	✓							✓	✓
Eriogonum fasciculatum	flattop buckwheat			✓	✓							✓	✓
Eschscholzia californica	California poppy	✓	✓		✓				✓	✓	✓	✓	✓
Kniphofia	Red hot poker	✓											✓
Layia platyglossa	tidy tips				✓					✓	✓	✓	✓
Linum usitatissimum [1]	flax	✓	✓										✓
Limonium californicum	marsh rosemary	✓	✓		✓	✓	✓	✓				✓	
Limonium perezii	sea lavender	✓	✓		✓	✓	✓	✓					✓
Linanthus spp.	Linanthus	✓			✓					✓	✓	✓	✓
Lotus scoparius (Acmispon glaber)	deerweed	✓			✓					✓	✓	✓	✓
Mimulus aurantiacus	common monkeyflower	✓	✓		✓						✓	✓	✓
Mimulus cardinalis	scarlet monkeyflower	✓	✓	✓	✓		✓	✓			✓	✓	
Monardella spp.	coyote mint	✓			✓							✓	✓
Myoporum parvifolium'Pink'	prostrate myoporum	✓	✓	✓	✓						✓		✓
Narcissus	daffodil	✓	✓		✓								✓
Nepeta spp.	catmint	✓		✓	✓						✓		✓
Penstemon spp.	bearded tongue	✓		✓	✓						✓	✓	✓
Sedum spp.	stonecrop				✓					✓	✓		✓
Sempervivum spp.	hen and chicks				✓					✓	✓		✓
Sisyrinchium bellum	blue-eyed grass	✓			✓			✓		✓	✓	✓	✓
Shrub Species													
Adenostoma fasciculatum	chamise				✓						✓	✓	✓
Arctostaphylos densiflora 'McMinn'	manzanita 'McMinn'	✓	✓		✓						✓	✓	✓
Arctostaphylos manzanita	common manzanita		✓		✓						✓	✓	✓
Arctostaphylos uva-ursi 'Emerald Carpet'	manzanita 'Emerald Carpet'	✓	✓	✓	✓						✓	✓	✓

[1] *Denotes species with phytoremediation capabilities*

Table B-1 Plant List for Stormwater Measures

		Bioretention Area - Including linear treatment measure	Flow-Through Planters	Tree Well Filters	Vegetated Buffer Strip	Infiltration Trench	Extended Detention Basin - biotreatment soil	Extended Detention Basin - non-biotreatment soil	Turf Block Pavers	Green Roof - extensive	Green Roof - Intensive	California Native	Drought Tolerant
Shrub Species cont'd													
Baccharis pilularis 'Twin Peaks'	Baccharis pilularis 'Twin Peaks'	✓	✓	✓	✓						✓	✓	✓
Buddleia spp. (<u>excluding</u> Buddleja davidii, which is invasive)	butterfly bush	✓			✓								✓
Calycanthus occidentalis	Spicebush	✓	✓		✓	✓						✓	✓
Carpenteria californica	bush anemone	✓	✓		✓							✓	✓
Ceanothus hearstiorum	ceanothus	✓			✓						✓	✓	✓
Ceanothus spp.	ceanothus	✓			✓						✓	✓	✓
Cercocarpus betuloides	mountain mahogany				✓							✓	✓
Cistus spp.	rockrose				✓								✓
Corylus cornuta v. californica	California hazelnut	✓			✓							✓	✓
Garrya elliptica	coast silk tassle		✓		✓						✓	✓	✓
Heteromeles arbutifolia	toyon	✓	✓		✓						✓	✓	✓
Lavandula spp.	lavender		✓	✓	✓						✓		✓
Lepechina calycina	pitcher sage				✓							✓	✓
Lupinus albifrons	bush lupine				✓							✓	✓
Mahonia aquifolium (Berberis aquifolium)	Oregon grape	✓	✓		✓						✓	✓	✓
Mahonia repens (Berberis aquifolium var repens)	creeping Oregon grape	✓	✓	✓	✓						✓	✓	✓
Myrica californica	Pacific wax myrtle				✓						✓	✓	✓
Nandina	Heavenly bamboo	✓	✓	✓	✓								✓
Physocarpus capitatus	Pacific ninebark	✓		✓	✓		✓	✓			✓	✓	
Pittosporum tobira	mock orange		✓		✓								✓
Prunus ilicifolia	holleyleaf cherry				✓	✓						✓	✓
Rhamnus californica (Frangula californica)	coffeeberry	✓	✓		✓						✓	✓	✓
Rhus integrifolia	lemonade berry				✓							✓	✓

[1] *Denotes species with phytoremediation capabilities*

Table B-1 Plant List for Stormwater Measures

		Bioretention Area - Including linear treatment measure	Flow-Through Planters	Tree Well Filters	Vegetated Buffer Strip	Infiltration Trench	Extended Detention Basin - biotreatment soil	Extended Detention Basin - non-biotreatment soil	Turf Block Pavers	Green Roof - extensive	Green Roof - Intensive	California Native	Drought Tolerant
Shrub Species cont'd													
Ribes aureum	golden currant	✓	✓		✓	✓						✓	✓
Ribes malvaceum	chaparral currant				✓							✓	✓
Ribes sanguineum	red-flowering currant				✓							✓	✓
Rosa californica	California wild rose	✓	✓		✓	✓						✓	✓
Rubus parviflorus	thimbleberry	✓	✓		✓	✓						✓	
Rubus spectabilis	salmonberry	✓	✓		✓	✓						✓	
Rubus ursinus	California blackberry	✓			✓							✓	✓
Salvia brandegeei	black sage				✓							✓	✓
Salvia clevelandii	Cleveland sage				✓							✓	✓
Salvia leucophylla	purple sage				✓							✓	✓
Salvia melifera	black sage				✓							✓	✓
Salvia sonomensis	creeping sage				✓							✓	✓
Sambucus mexicana	elderberry	✓	✓		✓							✓	✓
Santolina spp.	santolina	✓	✓		✓								✓
Symphoricarpos albus	snowberry		✓		✓							✓	✓
Stachys spp.	lambs ear	✓		✓	✓					✓	✓		✓
Styrax officinalis redivivus	California snowdrop	✓			✓							✓	✓
Trichostema spp.	wooly blue curls	✓			✓						✓	✓	✓
Vaccinium ovatum	evergreen huckleberry	✓	✓		✓							✓	
Zauschneria californica (Epilobium c.)	California fuchsia			✓	✓						✓	✓	✓
Tree Species													
Aesculus californica	buckeye	✓			✓							✓	✓
Arbutus unedo	strawberry tree	✓			✓								✓
Carpinus betulus	European hornbeam	✓	✓	✓									✓
Celtis occidentalis	Common hackberry	✓	✓	✓									✓

[1] *Denotes species with phytoremediation capabilities*

Table B-1 Plant List for Stormwater Measures

		Bioretention Area - Including linear treatment measure	Flow-Through Planters	Tree Well Filters	Vegetated Buffer Strip	Infiltration Trench	Extended Detention Basin - biotreatment soil	Extended Detention Basin - non-biotreatment soil	Turf Block Pavers	Green Roof - extensive	Green Roof - Intensive	California Native	Drought Tolerant
Tree Species cont'd													
Cercis occidentalis	redbud	✓			✓							✓	✓
Crataegus (<u>excluding</u> *Crataegus monoyna*, *which is invasive)*	Hawthorn	✓		✓	✓								✓
Lagerstroemia spp.	crape myrtle	✓		✓	✓								✓
Laurus 'Saratoga'	Saratoga laurel	✓		✓	✓								✓
Koelreuteria paniculata	goldenrain tree	✓		✓	✓								✓
Nyssa sylvatica	sour gum	✓		✓	✓								✓
Platanus acerifolia 'Columbia'	London Plane Tree	✓	✓	✓									
Platanus racemosa	California sycamore	✓	✓	✓								✓	✓
Pistacia chinensis 'Keith Davey	Chinese pistache	✓		✓	✓								✓
Quercus agrifolia	California live oak	✓			✓							✓	✓

[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. For suitable plantings, please refer to Table B-1.

Bioretention Area (including linear treatment measures)

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.

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.

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.

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.

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.

Extended Detention Basin

Extended detention basins are intended to capture and detain water for much longer periods (up to 5 days) 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 basins are intended to capture and move large quantities of water, trees should not be planted in the basins, and shrubs are typically not specified for extended detention basins. Subject to approval by the municipality, trees and shrubs may be included on the outer perimeter (top of bank), provided 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. Extended detention basins typically have typically not been constructed with special soil, and beginning December 1, 2011, basins designed without biotreatment soil (having a long-term infiltration rate of 5 to 10 inches per hour) may not be used as stand-alone treatment measures, although they could be used as part of a treatment train, along with biotreatment measures (more information in Section 6.6).

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.

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 in Table B-1 is only a sample of plants that could be suitable for an intensive green roof. Please note that shrub species may be used only if the substrate has a minimum depth of 12 inches; a minimum dept of 36 inches is required for planting trees.

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 in Table B-1, pre-vegetated mats can be utilized on extensive green roofs. Information can be found at: www.thehenryford.org/rouge/leedlivingroof.aspx.

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 Rescape California, also known as the Bay-Friendly Landscaping Coalition (available at www.rescapeca.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 non-dyed mulch to build healthy soils and increase the water holding capacity of the soil. Mulch should be organic, non-dyed, and should resist floating, as described in Section B5, under the heading, "Erosion Control."

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 supplier should provide the certified germination percentage.

Water Level Management and Irrigation for Plant Establishment

All newly planted material needs 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. Also, grouping plants with similar water needs can help reduce irrigation demand. The specific approach will vary for irrigated and non-irrigated conditions, and for each stormwater application. In most cases, stormwater applications 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 is 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 compost mulch, or other organic, non-dyed mulch material that will resist floating with surface runoff (such as pea gravel, rock, cobble, or large float-resistant wood mulches), will also help control weed growth. “Micro-bark” or “gorilla hair” mulches are not recommended.

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 and maintain a 3-inch layer of “arbor”, “aged” or “composted” mulch on any exposed soil areas between plantings. Washed and clean pea gravel, rock, cobble, or other mulches that resist floating may also be used. Bark and “gorilla hair” mulches are not recommended. Only non-dyed mulch should be used in stormwater treatment facilities.
- Minimize the use of blowers in planting beds and on turf;
- Store leaf litter as additional much in planting beds as appropriate.

Irrigation Systems

Bioretention facilities, flow-through planters, and other stormwater treatment facilities that use biotreatment soil may need to receive more frequent irrigation than other landscaped areas, due to the sand content of biotreatment soil. Provide separate irrigation control for bioretention areas, flow-through planters, and other stormwater treatment measures that use biotreatment soil. Specify weather-based irrigation controllers, sometimes called “smart” irrigation controllers, which use soil moisture sensors to signal the irrigation controller. Drip emitters should be used instead of spray irrigation. 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 drip emitters and valves, and any sprinkler and bubbler heads, for proper coverage. Contractor shall monitor the irrigation system while operating to identify and correct problems with water runoff or standing water.

In the event that a weather-based irrigation controller is not used, monitor soil moisture within plant root zones using a soil probe or shovel and adjust irrigation schedules accordingly , and schedule irrigation 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 Rescape California (also known as the Bay-Friendly Landscaping Coalition) at www.rescapeca.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. Maintain an adequate layer of organic, non-dyed, floating-resistant mulch, as described above, under the heading, "Erosion Control." 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 IPM

This section provides a summary of Bay-Friendly landscaping and integrated pest management (IPM) techniques, based on Alameda County's Bay Friendly Landscaping Guidelines prepared by Rescape California, also known as the Bay-Friendly Landscaping Coalition (available at www.rescapeca.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 provided by the California Invasive Plant Council at www.cal-ipc.org. 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 during 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, non-dyed, floating-resistant mulch, as described in Section B.5 -- 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 composted mulch (or other organic, non-dyed mulch that resists floating) 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 organic, non-dyed, floating-resistant 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, integrated 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 the Clean Water Program’s Source Control Model

List. 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 to first prevent, and then control, but not eliminate, 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 an adequate layer of organic, non-dyed, floating-resistant mulch on the soil surface at all times, and keeping it away from root crowns, as described above, under the heading, "Erosion Control.";
- 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 causing 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
www.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
www.ebcnps.org (click on "Native Here Nursery")

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

References

A. Rescape California (also known as the Bay-Friendly Landscaping Coalition) www.rescapeca.org

1. Bay-Friendly Landscape Guidelines
2. A Landscaper's Guide to Grasscycling
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B. A Guide to Estimating Irrigation of Water Needs of Landscape Plantings, California Dept of Water Resources, cdec.water.ca.gov

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, www.ipm.ucdavis.edu

G. A Field Guide to Compost Use, The Composting Council, Alexandria, VA. www.composting council.org/index.cfm

H. City of Santa Rosa. 2005. Appendix A. Landscaping and Vegetation for Storm Water Best Management Practices in New Development and Redevelopment in the Santa Rosa Area.

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

J. California Stormwater Quality Association (CASQA). Stormwater BMP Handbook: New Development and Redevelopment. January 2003.

K. Bornstein, Carol, David Fross and Bart O'Brien, California Native Plants for the Garden

L. East Bay Municipal Utility District (EBMUD), Plants and Landscapes for Summer Dry Climates

M. University of California Cooperative Extension, Guide to Estimating Irrigation Water Needs of Landscape Plantings in CA

Appendix

C

Example Scenarios and Spreadsheet Tools for Sizing Stormwater Treatment Measures

1. Parking Lot Example
2. Podium Type Building Example
3. Spreadsheet Tools for Sizing Stormwater Treatment Measures
   - 3.1 Worksheet for Calculating the Water Quality Design Volume (80 percent capture method)
   - 3.2 Worksheet for Calculating the Combination Flow and Volume Method

C.1 Parking Lot Example

Introduction

This example shows a proposed parking lot in Alameda County with bioretention areas. LID feasibility/infeasibility criteria (Appendix J) shall be used to determine whether bioretention areas may be used and methods to design bioretention areas to maximize infiltration and evapotranspiration. This example demonstrates the use of the 4 percent standard for sizing bioretention areas.

Typical Parking Lot

Summary of Stormwater Controls

Site Design Measures

- Landscaped areas within one drainage management area is designed to function as a self-treating area, so that it bypasses the bioretention area, as described in Section 4.1 of this manual. A second landscaped area drains to the bioretention area.

Source Controls

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

Treatment Measures

- Bioretention areas

The example parking lot site description:

The project site is 1.2 acres with 1% slope from edge of lot to street.
The site has one ingress/egress point.

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 to bioretention areas along the perimeter of the site. Parking lot slopes are approximately 1%.

Bioretention areas are sized following the four percent standard described in Section 5.1.

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

Typical Bioretention Area

Procedure for sizing treatment measures using the 4 percent standard:

A1. Based on the topography of the site and configuration of buildings, divide the site into drainage management areas (DMAs), each of which will drain to an LID treatment measure. Implement Steps 2 through 5 for each DMA.

A2. To minimize the amount of landscaping or pervious pavement that will contribute runoff to the LID treatment measures, it was possible to design landscaping in Drainage Management Area B as a "self-treating area" (as described in Section 4.1), so that runoff from that landscaped area bypasses the treatment measure.

A3. List the area of impervious surfaces that drain to each treatment measure; include the area of pervious surface (landscaping) in Area A and multiply the pervious area by a factor of 0.1.

A4. For Area A, add the product obtained in Step A3 to the area of impervious surface, to obtain the area of "effective impervious surface."

A5. Multiply the impervious surface (or effective impervious surface in applicable DMAs) by a factor of 0.04. This is the required surface area of the LID treatment measure.

Steps 2 through 5 are shown in Table A-1.

Table A-1: Bioretention Sizing for Parking Lot Example (4% standard sizing approach)

DMA	Impervious Area (sf)	Pervious Area (sf)[1]	Pervious Area x 0.1	Effective Impervious Area (EIA) (sf)	EIA * 0.04 (sf)
A	6,788	7,868	786.8	7,575	303
B	24,491	0	0	24,491	980
Totals	31,279	7,868	786.8	32,066	1,283

[1] Include only the pervious area that drains to the treatment measure, not self-treating areas.

C.2 Podium Type Building Example

Introduction

This example is to show a proposed podium type building in Alameda County, with flow-through planters. LID feasibility/infeasibility criteria (Appendix J) need to be used to determine whether the use of flow-through planters will be allowed. Flow-through planters in this example are sized using the combination flow and volume sizing approach.

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 space 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 landscaping and 15,000 square feet of conventional roof.

Off site sidewalks and driveways will be graded toward street.

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 treatment soil with a surface loading rate of 5 inch/hour. A 12-inch layer of drain rock will be placed around the perforated underdrain to allow for dewatering of the flow through the planter.

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

The flow through planters shall have splash blocks at rain water leader discharge points to protect against erosion.

Design flow criterion: rainfall intensity – 0.2 in./hr.

Design volume criterion: capture 80% of the average annual runoff

The mean annual precipitation (MAP) at the site is 16 inches. Because this value is less than 16.4 inches, the applicable rain gauge is the San Jose Airport gauge (MAP = 14.4 inches)

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

Source Control
Parking and trash shall be under the building and covered.

City of Portland 2004 *Stormwater Manual*

Typical Flow Through Planter

Procedure for sizing using combined flow and volume method:

B1. List areas to each treatment measure. (“A” in Q = CIA)

Impervious Patio Surfaces	9,000 square feet
Patio Landscaping	500 square feet
Roof Surfaces	15,000 square feet
Landscape	500 square feet

B2. The approach assumes that all of the design rainfall becomes runoff, and thus it is appropriate for use where the drainage area to the bioretention area is mostly impervious. Convert landscape area to effective impervious area by multiplying by 0.1. (Note: In this example, the landscaped area is designed to flow through the planter. For an example where self-treating areas bypass the bioretention area, see the preceding parking lot example.)

Patio Impervious Surfaces		9,000 square feet
Roof Impervious Surfaces		15,000 square feet
Landscape	1,000*0.1 =	100 square feet
Effective Impervious Area		**24,100 square feet**

B3. Determine the Unit Basin Storage Volumes for 80 Percent Capture using 48-hour drawdown. using Table 5.2 of Chapter 5 based on 100 percent impervious area (runoff coefficient of 1.0). The unit basin storage volume at the San Jose Airport gauge for a coefficient of 1.0 is **0.56 inches**. Adjust this volume based on the mean annual precipitation at the site (16 inches).

Adjusted unit basin storage volume = 0.56" * (16"/14.4") = 0.62".

B4. Calculate the Water Quality Design Volume. The water quality design volume is the area from Step B2 times the adjusted unit basin storage volume. (24,100 square feet * 0.62 inches * 1/12 feet per inch = **1,245 cubic feet**.)

B5. Use a constant surface loading rate of **5 inches per hour** through the soil as required by the Permit for use with treatment soils.

B6. Assume that the rain event that generates the required capture volume of runoff determined in Step B4 occurs at a constant intensity of 0.2 inches/hour from the start of the storm (i.e., assume a rectangular hydrograph). Calculate the duration of the rain event by dividing the unit basin storage volume by the intensity. In other words, determine the amount of time required for the unit basin storage volume to be achieved at a rate of 0.2 inches/hour. For this example, the unit basin storage volume is 0.62 inches, the rain event duration is 0.62 inches ÷ 0.2 inches/hour = **3.1 hours**.

B7. Compute Required Depth of Storage for a given treatment area. (Maximum Allowable Depth = 12 inches)

Start by calculating the bioretention area using the 4% standard sizing factor. For the effective impervious area calculated in Step B2 (24,100 square feet), the required bioretention surface area would be (0.04*24,100) = **964 square feet**. Then assume a bioretention area size that is 25% smaller than that calculated using the 4% standard. Using the example, 964 – (0.25 × 964) = **723 square feet**. Calculate the volume of runoff that filters through the treatment soil at a surface loading rate of 5 inches per hour (the design surface loading rate for bioretention facilities), for the duration of the rain event calculated in Step B6. For this example, for a bioretention treatment area of 723 square feet, with a surface loading rate of 5 inches per hour for a duration of 3.1 hours, the volume of treated runoff = 723 square feet × 5 inches/hour × (1 foot/12 inches) × 3.1 hours = **934 cubic feet**.

B8. The difference between the volume of runoff from Step B4 and the volume that flows through the planter for the storm duration from B7 is (1,245 cubic feet – 934 cubic feet) = **311 cubic feet**. If this volume is stored over a surface area of 723 square feet, the average ponding depth would be 311 cubic feet ÷ 723 square feet = **0.43 feet or 5.2 inches**.

B9. Check to see if the average ponding depth is between 6 and 12 inches, which is the recommended allowance for ponding in a bioretention facility or flow-through planter. If the ponding depth is less than 6 inches, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps B7 and B8 with a smaller treatment area). If the ponding depth is greater than 12 inches, a larger surface treatment area will be required. In this example, the ponding depth of 5.2 inches is less than the recommended range of 6 to 12 inches. A repetition of steps B7 and B8 with a bioretention area that is 30 percent smaller than the bioretention area calculated in Step B2 is provided below.

B.10 Repeat Step B7 with a bioretention area 30% smaller than the bioretention area in Step B2: 964 sq.ft. – (0.30 x 964) = 674 sq.ft. Calculate the volume treated during the rain event duration: 674 sq.ft. x 5 in/hr x 1 ft/12 in x 3.1 hours = **871 cubic feet**.

Repeat Step B9 for the smaller bioretention area to calculate the volume remaining in the ponded area: 1245 cu.ft. – 871 cu.ft. = 374 cubic feet. Calculate the average ponding depth: 374 cu.ft. ÷ 674 sq.ft. = **0.55 feet or 6.6 inches**.

Note: See worksheets on the following pages:

3.1 Worksheet for Calculating the Water Quality Design Volume (80 percent capture method)
3.2 Worksheet for Calculating the Combination Flow and Volume Method

The worksheets are available for download at www.cleanwaterprogram.org, included in Appendix C of the online C.3 Technical Guidance.

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Worksheet for Calculating the Water Quality Design Volume (80 percent capture method)

Instructions: After completing Section 1, make a copy of this Excel file for each Drainage Management Area within the project. Enter information specific to the project and DMA in the cells shaded in yellow. Cells shaded in light blue contain formulas and values that will be automatically calculated.

1.0 Project Information

The calculations presented here are based on the 80% capture method of sizing **volume-based treatment measures** provided in the Clean Water Program Alameda County C.3 Technical Guidance, v. 4.0. The steps presented below are explained in Chapter 5, Section 5.1 of the guidance manual, applicable portions of which are included in this file, in the tab called "Guidance from Chapter 5".

1-1 Project Name:

1-2 City application ID:

1-3 Site Address or APN:

1-4 Tract or Parcel Map No:

1-5 Site Mean Annual Precip. (MAP)[1] **Inches**

Refer to the Mean Annual Precipitation Map in Appendix D of the C.3 Technical Guidance to determine the MAP, in inches, for the site. Click here for map

1-6 Applicable Rain Gauge[2]

Enter "Oakland Airport" if the site MAP is 16.4 inches or greater. Enter "San Jose" if the site MAP is less than 16.4 inches.

MAP adjustment factor is automatically calculated as:

(The "Site Mean Annual Precipitation (MAP)" is divided by the MAP for the applicable rain gauge, showin in Table 5.2, below.)

2.0 Calculate Percentage of Impervious Surface for Drainage Management Area (DMA)

2-1 Name of DMA:

For items 2-2 and 2-3, enter the areas in square feet for each type of surface within the DMA.

	Type of Surface	Area of surface type within DMA (Sq. Ft)	Adjust Pervious Surface	Effective Impervious Area
2-2	Impervious surface		**1.0**	
2-3	Pervious service		**0.1**	
	Total DMA Area (square feet) =			

2-4 ***Total Effective Impervious Area (EIA)*** **Square feet**

3.0 Calculate Unit Basin Storage Volume in Inches

Table 5-2: Unit Basin Storage Volumes (in inches) for 80 Percent Capture Using 48-Hour Drawdowns		
		Unit Basin Storage Volume (in) for Applicable Runoff Coefficients
Applicable Rain Gauge	**Mean Annual Precipitation (in)**	**Coefficient of 1.00**
Oakland Airport	18.35	0.67
San Jose	14.4	0.56

3-1 ***Unit basin storage volume from Table 5.2:*** **Inches**

(The coefficient for this method is 1.00, due to the conversion of any landscaping to effective impervious area)

3-2 ***Adjusted unit basin storage volume:*** **Inches**

(The unit basin storage volume is adjusted by applying the MAP adjustment factor.)

3-3 ***Required Capture Volume (in cubic feet):*** **Cubic feet**

(The adjusted unit basin sizing volume [inches] is multiplied by the size of the DMA and converted to feet)

3-4 ***To size an infiltration trench, enter the surface area available:*** **Square feet**

3-5 ***Required depth of infiltration trench, given the surface area available (in 3-4):*** **Feet**

(Assumes 35% void space in rectangular trench with vertical sides.)
(Note: Infiltration trench depths are typically between 3 and 8 feet.)

Worksheet for Calculating the Combination Flow and Volume Method

Instructions: After completing Section 1, make a copy of this Excel file for each Drainage Management Area within the project. Enter information specific to the project and DMA in the cells shaded in yellow. Cells shaded in light blue contain formulas and values that will be automatically calculated.

1.0 Project Information

The calculations presented here are based on the **combination flow and volume hydraulic sizing method** provided in the Clean Water Program Alameda County C.3 Technical Guidance, Version 4.0. The steps presented below are explained in Chapter 5, Section 5.1 of the guidance manual, applicable portions of which are included in this file, in the tab called "Guidance from Chapter 5".

1-1 Project Name:

1-2 City application ID:

1-3 Site Address or APN:

1-4 Tract or Parcel Map No:

1-5 Site Mean Annual Precip. (MAP)[1] **Inches**

Refer to the Mean Annual Precipitation Map in Appendix D of the C.3 Technical Guidance to determine the MAP, in inches, for the site. Click here for map

1-6 Applicable Rain Gauge[2]

Enter "Oakland Airport" if the site MAP is 16.4 inches or greater. Enter "San Jose" if the site MAP is less than 16.4 inches.

MAP adjustment factor is automatically calculated as:

(The "Site Mean Annual Precipitation (MAP)" is divided by the MAP for the applicable rain gauge, showin in Table 5.2, below.)

2.0 Calculate Percentage of Impervious Surface for Drainage Management Area (DMA)

2-1 Name of DMA:

For items 2-2 and 2-3, enter the areas in square feet for each type of surface within the DMA.

	Type of Surface	Area of surface type within DMA (Sq. Ft)	Adjust Pervious Surface	Effective Impervious Area
2-2	Impervious surface		**1.0**	
2-3	Pervious service		**0.1**	
	Total DMA Area (square feet) =			

2-4 ***Total Effective Impervious Area (EIA)*** **Square feet**

3.0 Calculate Unit Basin Storage Volume in Inches

Table 5-2: Unit Basin Storage Volumes (in inches) for 80 Percent Capture Using 48-Hour Drawdowns

		Unit Basin Storage Volume (in) for Applicable Runoff Coefficients
Applicable Rain Gauge	**Mean Annual Precipitation (in)**	**Coefficient of 1.00**
Oakland Airport	18.35	0.67
San Jose	14.4	0.56

3-1 ***Unit basin storage volume from Table 5.2:*** **Inches**

(The coefficient for this method is 1.00, due to the conversion of any landscaping to effective impervious area)

3-2 ***Adjusted unit basin storage volume:*** **Inches**

(The unit basin storage volume is adjusted by applying the MAP adjustment factor.)

3-3 ***Required Capture Volume (in cubic feet):*** **Cubic feet**

(The adjusted unit basin sizing volume [inches] is multiplied by the size of the DMA and converted to feet)

4.0 Calculate the Duration of the Rain Event

4-1 Rainfall intensity **0.2 Inches per hour**

4-2 Divide Item 3-2 by Item 4-1 **Hours of Rain Event Duration**

5.0 Preliminary Estimate of Surface Area of Treatment Measure

5-1 4% of DMA impervious surface **Square feet**

5-2 Area 25% smaller than item 5-1 **Square feet**

5-3 Volume of treated runoff for area in Item 5-2 **Cubic feet** (Item 5-2 * 5 inches per hour * 1/12 * Item 4-2)

6.0 Initial Adjustment of Depth of Surface Ponding Area

6-1 Subtract Item 5-3 from Item 3-3 **Cubic feet** (Amount of runoff to be stored in ponding area)

6-2 Divide Item 6-1 by Item 5-2 **Feet** (Depth of stored runoff in surface ponding area)

6-3 Convert Item 6-2 from ft to inches **Inches** (Depth of stored runoff in surface ponding area)

6-4 If ponding depth in Item 6-3 meets your target depth, skip to Item 8-1. If not, continue to Step 7-1.

7.0 Optimize Size of Treatment Measure

7-1 Enter an area larger or smaller than Item 5-2 **Sq.ft.** (enter larger area if you need less ponding depth; smaller for more depth.)

7-2 Volume of treated runoff for area in Item 7-1 **Cubic feet** (Item 7-1 * 5 inches per hour * 1/12 * Item 4-2)

7-3 Subtract Item 7-2 from Item 3-3 **Cubic feet** (Amount of runoff to be stored in ponding area)

7-4 Divide Item 7-3 by Item 7-1 **Feet** (Depth of stored runoff in surface ponding area)

7-5 Convert Item 7-4 from feet to inches **Inches** (Depth of stored runoff in surface ponding area)

7-6 If the ponding depth in Item 7-5 meets target, stop here. If not, repeat Steps 7-1 through 7-5 until you obtain target depth

8.0 Surface Area of Treatment Measure for DMA

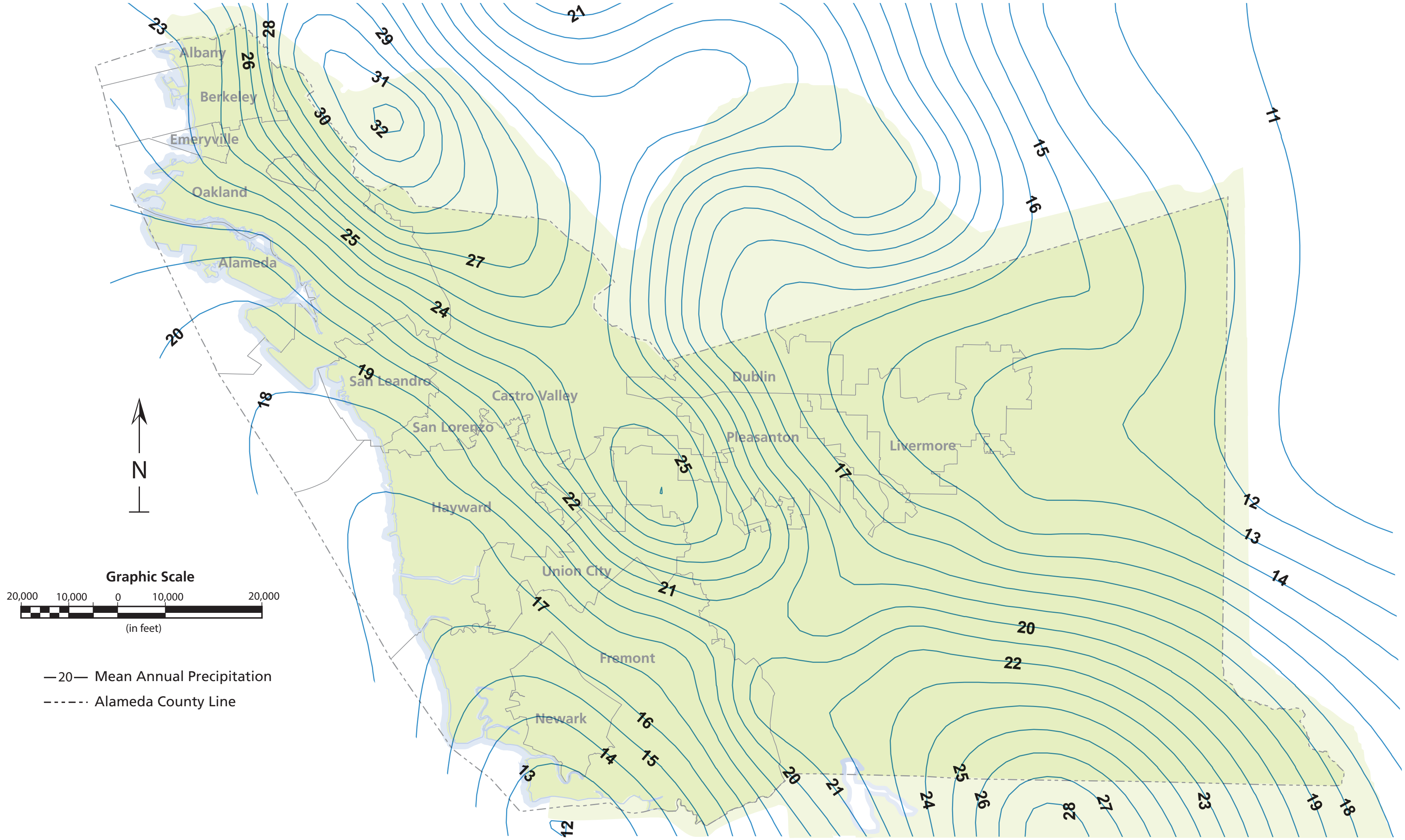
8-1 Final surface area of treatment* **Square feet** (Either Item 5-2 or final amount in Item 7-1)

**Note: Check with the local jurisdiction as to its policy regarding the minimum biotreatment surface area allowed.*

Appendix

D

Mean Annual Precipitation Map: Alameda County



This map is Attachment 6 of the Alameda County Hydrology & Hydraulics Manual and may be downloaded as a GIS file from the Alameda County Flood Control District website.

(District 2011)

Alameda County Flood Control & Water Conservation District

Mean Annual Precipitation

Appendix

E

Applicability of Non-Low Impact Development Treatment Measures

As described in Section 5.2, since December 1, 2011, no underground vault systems have been allowed to be used as stand-alone stormwater treatment measures to meet the requirements of Provisions C.3.c and C.3.d of the MRP, except in certain types of "Special Projects," in which media filters may be allowed. Special Projects criteria are included in Appendix J. 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. A discussion of media filters precedes the attached letter.

As described below, some of these devices can be extremely effective in removing trash and other gross solid pollutants, as well as sediment and oil. While not adequate to meet the MEP standard alone, their use may be worth considering if used as part of a treatment train.

E.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, the Clean Water Program'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. Long-term use of inlet filters can be problematic due to their need for frequent maintenance; however they may be used effectively as construction BMPs.

E.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, Clean Water Program 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.

E.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.

In 2005 the Contra Costa Clean Water Program conducted 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

---

[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 (included in this appendix).

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

identified as pollutants of concern in the Contra Costa Countywide NPDES municipal stormwater permit[3]. The technical memorandum 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. Effective December 1, 2011, the stand-alone use of hydrodynamic separators is no longer allowed to meet stormwater treatment requirements.

Hydrodynamic separators can be very effective at removing trash and gross solids from runoff, and may be included as part of a treatment train in order to remove large solids before the stormwater is routed to a treatment measure that is more effective at removing fine particulates.

E.4 Media Filters

A technical description of media filters is provided in Section 6.10. Effective December 1, 2011, the stand-alone use of media filters to meet stormwater treatment requirements is no longer allowed, except for use in Special Projects, as described in Appendix J. While media filters have been demonstrated to remove suspended solids more effectively that the manufactured treatment systems described above, concerns remain about the maintenance of these systems. Media filters have more intensive maintenance requirements than low impact development treatment measures, and, since they are located underground, tend to be "out of sight, out of mind," and often do not receive the maintenance required to function properly. When used in Special Projects, it will be important for municipal staff to conduct regular maintenance verification inspections to verify that these systems are maintained properly and operating as designed.

E.5 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.

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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

F

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.

F.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 F-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 buffer strips.

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.

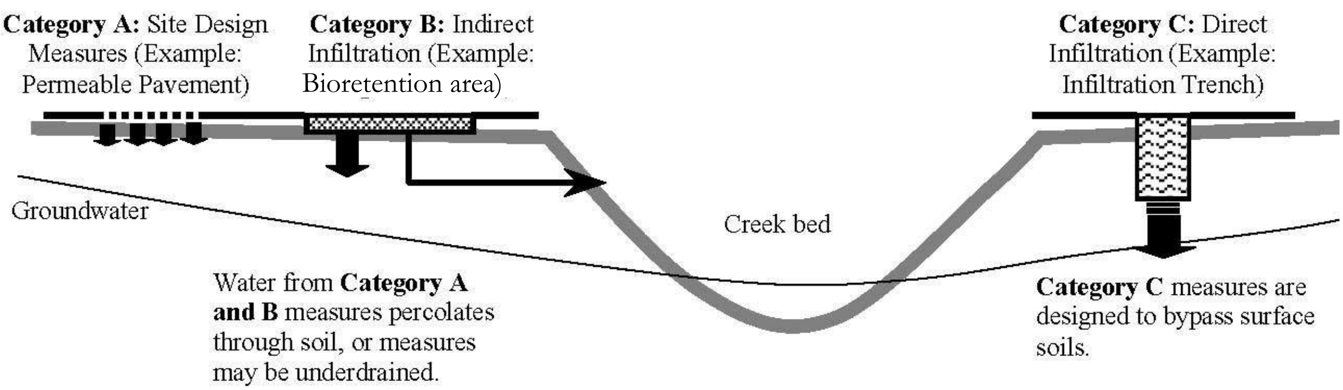


Figure F-1: Stormwater Infiltration Methods (Source: Contra Costa County Clean Water Program, 2005)

Table F-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 F-1
Infiltration Methods in Commonly-Used Stormwater Controls

Stormwater Control	**Description**	**Guidance in Section**
Category A: Site Design Measures		
Disconnected Downspouts	Instead of connecting directly to storm drains, roof runoff is directed away from the building to nearby landscaped areas.	N/A
Site Grading	Using gentler slopes and concave areas to reduce runoff and encourage infiltration.	N/A
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 street.	N/A
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

Table F-1 Infiltration Methods in Commonly-Used Stormwater Controls		
Stormwater Control	**Description**	**Guidance in Section**
Category B: Indirect Infiltration (continued)		
Pervious Pavements	Special mixes of concrete and asphalt. Require a base course of crushed aggregate and installation by experienced crews.	6.6
Turf Block	A load-bearing, durable surface of impermeable blocks separated by spaces and joints in which soil is planted with turf.	6.7
Unit Pavers	Traditional bricks or other pavers on sand or fine crushed aggregate.	6.7
Cisterns	Above- or below-ground storage vessels, sometimes with a manually operated valve, provide infiltration if runoff is stored for post-storm discharge to landscaping.	6.9
	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.		

F.2 Factors Affecting Feasibility of Infiltration

The Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report) submitted to the Regional Water Board by BASMAA on April 29, 2011 identified the following factors affecting the feasibility of infiltration. These factors are grouped according to whether they apply to "infiltration measures," which provide indirect infiltration, or "infiltration devices," which provide direct infiltration. The MRP defines "infiltration device" as any structure that is deeper than wide and designed to infiltrate stormwater into the subsurface and, as designed, bypass the natural groundwater protection afforded by surface soil. The MRP lists the following as examples of infiltration devices: dry wells, injection wells, infiltration trenches, and French drains.

F.2.1 Factors Affecting Feasibility of Both Indirect and Direct Infiltration

The permeability of the underlying soil is a key factor in determining the feasibility of either direct or indirect infiltration. Additionally there are various factors that may preclude the use of both infiltration measures (indirect infiltration) and infiltration devices (direct infiltration). These include the following:

- Development sites where pollutant mobilization in the soil or groundwater is a documented concern;
- Locations with potential geotechnical hazards;

- Conflicts with the location of existing or proposed underground utilities or easements.

F.2.2 Factors Affecting Feasibility of Direct Infiltration

Factors that specifically preclude the use of infiltration devices (direct infiltration) include the following:

- Locations where policies of local water districts or other applicable agencies preclude infiltration.
- Locations within 100 feet of a groundwater well used for drinking water;
- Appropriate pollution prevention and source control measures, including a minimum of two feet of suitable soil to achieve a maximum of 5 inches/hour infiltration rate;
- Adequate maintenance is provided to maximize pollutant removal capabilities;
- Vertical distance from the base of any infiltration device to the seasonal high groundwater mark is at least 10 feet (or greater if the site has highly porous soils or there are other concerns for groundwater protection);
- Unless stormwater is first treated by a method other than infiltration, infiltration devices are not approved as a treatment measure for stormwater runoff from areas of industrial areas, areas of high vehicular traffic or land uses that pose a high threat to water quality;
- Infiltration devices are not placed in the vicinity of known contaminated sites; and
- Infiltration devices are located a minimum of 100 feet horizontally away from any known water supply wells, septic systems, and underground storage tanks (or greater if the site has highly porous soils or there are other concerns for groundwater protection).

F.3 Dealing with Common Site Constraints

The following tips are intended to help manage constraints to infiltration that are common in Alameda County.

- Where conditions (such as steep slopes or high groundwater table) do not preclude infiltration, the design of bioretention areas should ***maximize infiltration to the underlying soil***, as shown in Section 6.1.
- 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.
- Green roofs, cisterns, flow-through planters, and other stormwater controls that are isolated from underlying soils are also appropriate for areas with ***steep slopes, 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) structural soils, grading

landscaping to a concave form, designing taller buildings with smaller footprints, and concentrating development on less sensitive portions of the site.

F.4 Infiltration Devices and Class V Injection Well Requirements

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] 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/uic/forms/underground-injection-wells-registration. 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.

[1] USEPA Office of Ground Water and Drinking Water, "When Are Storm Water Discharges Regulated as Class V Wells?," June 2003.

United States Environmental Protection Agency

WHEN ARE STORM WATER DISCHARGES REGULATED AS CLASS V WELLS?

Audience: This fact sheet is for storm water managers that implement the National Pollutant Discharge Elimination System (NPDES) program.

Purpose: To increase awareness that storm water drainage wells are regulated as Class V injection wells and to ensure that NPDES regulators understand the minimum federal requirements under the Safe Drinking Water Act (SDWA) for the Underground Injection Control (UIC) program.

ARE STORM WATER DRAINAGE WELLS REGULATED BY THE UIC PROGRAM?

Yes. These wells are regulated by EPA and primacy states through the UIC program as Class V injection wells with requirements to protect underground sources of drinking water (USDWs). A USDW is defined as an aquifer that contains less than 10,000 mg/L total dissolved solids and is capable of supplying water to a public drinking water system.

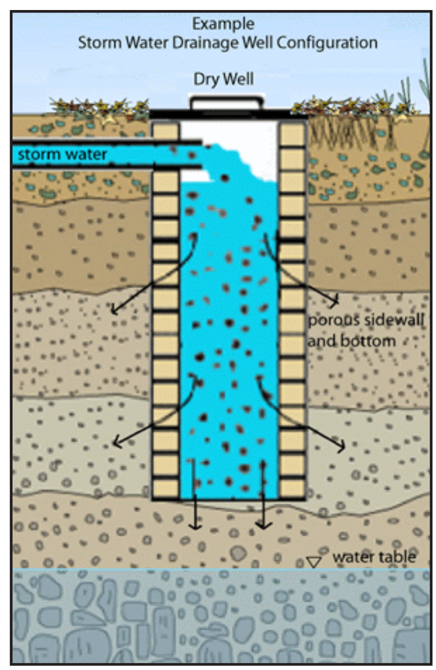
Class V storm water drainage wells are typically shallow disposal wells designed to place rain water or melted snow below the land surface. By definition, a Class V injection well is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system.

Storm water management strategies that include subsurface drainage must comply with UIC program regulations.

WHY ARE STORM WATER DRAINAGE WELLS A CONCERN?

State and federal UIC program representatives are concerned that there may be a dramatic increase in the use of Class V wells as an NPDES Best Management Practice (BMP) to dispose of storm water. Infiltration through storm water drainage wells has the potential to adversely impact USDWs. The runoff that enters storm water drainage wells may be contaminated with sediments, nutrients, metals, salts, fertilizers, pesticides, and microorganisms.

WHAT ARE SOME EXAMPLES OF STORM WATER DRAINAGE WELLS?



The broad definition of Class V wells covers a variety of storm water injection well configurations, including:

- Dry wells
- Bored wells
- Infiltration galleries

The underground injection well definition applies to any subsurface drainfields that release fluids underground. These can include French drains, tile drains, infiltration sumps, and percolation areas with vertical drainage. Improved sinkholes designed for storm water management are also considered Class V storm water drainage wells. These wells are natural karst depressions or open fractures that have been intentionally altered to accept and drain storm water runoff. The pictures on the back page illustrate an example of a Class V injection well that is subject to UIC requirements.

WHAT INFILTRATION SYSTEMS ARE NOT STORM WATER DRAINAGE WELLS?

Two types of infiltration systems are not considered storm water drainage wells:

- **Infiltration trenches** are excavated trenches filled with stone (no piping or drain tile) to create an underground reservoir. They are usually wider than they are deep.

- **Surface impoundments or ditches** are excavated ponds, lagoons, and ditches (lined or unlined, without piping or drain tile) with an opened surface. They are used to hold storm water. These devices **would be** considered Class V injection wells, however, if they include subsurface fluid distribution systems.

Picture and schematic drawing of parking lot infiltration (Source: Louisiana Department of Transportation)

Storm water drainage well designs can be as varied as the engineers who design them. A fluid distribution system that discharges underground through piping is typically the defining characteristic. If you are unsure about the classification of your infiltration system, contact your UIC program representative for clarification.

HOW ARE STORM WATER DRAINAGE WELLS REGULATED?

Under the minimum federal requirements, storm water drainage wells are "authorized by rule" (40 CFR 144). This means that storm water drainage wells do not require a permit if **they do not** endanger USDWs **and they comply with** federal UIC program requirements. The prohibition on endangerment means the introduction of any storm water contaminant must not result in a violation of drinking water standards or otherwise endanger human health. Primacy states may have more stringent requirements.

Federal program requirements include:

- Submitting basic inventory information about the storm water drainage wells to the state or EPA. (Contact your UIC program to learn what inventory information must be submitted and when.) In some cases, the information may be required prior to constructing the well.

- Constructing, operating, and closing the drainage well in a manner that does not endanger USDWs.

- Meeting any additional prohibitions or requirements (including permitting or closure requirements) specified by a primacy state or EPA region.

HOW CAN I HELP PREVENT NEGATIVE IMPACTS FROM STORM WATER DRAINAGE WELLS?

As an NPDES storm water manager, you can help to ensure that current and future storm water systems using Class V wells meet regulatory requirements under the UIC program. You can also help identify storm water drainage systems that may affect USDWs, and recommend BMPs to protect USDWs. BMPs for storm water drainage wells may address well siting, design, and operation, as well as education and outreach to prevent misuse.

FOR MORE INFORMATION...

EPA's Office of Ground Water and Drinking Water Web Site:
http://www.epa.gov/safewater

UIC Program Contacts:
http://www.epa.gov/safewater/uic/primacy.html

EPA's NPDES Web Site:
http://www.epa.gov/NPDES/Stormwater

Safe Drinking Water Hotline:
1-800-426-4791

Office of Ground Water and Drinking Water (4606M)

EPA 816-F-03-001

June 2003

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Appendix

G

Mosquito Control Guidelines

This appendix presents the guidance for designing and maintaining stormwater treatment measures to control mosquitoes from the Clean Water Program'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.

G.1 Design Guidance for Mosquito Control

The following design considerations were adapted from guidance prepared by the California

Department of Public Health[1,2], 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.

[1] Metzger, Marco, Vector-Borne Disease Section, California Department of Health Services. "Managing Mosquitoes in Stormwater Treatment Devices," 2004.

[2] California Department of Public Health. "Checklist for Minimizing Vector Production in Stormwater Management Structures," 2010.

- In flat areas, where standing water may occur for more than 72 hours under existing conditions, grade 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 72 hours 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.

- When a new stormwater treatment measure is being installed, select 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. Design and construct pipes for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe. Construct storm drains 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 72 hours, sometimes due to their outdated designs, and possibly due to improper construction and maintenance. To ensure that public health and safety are protected, implement one of the following suggestions for any structure that holds water for over 72 hours:

    - Select or design an alternative (or modified) device that provides adequate pollutant removal and complete drainage in 72 hours. This is the most reliable and cost-effective choice.

    - Contact Alameda County Mosquito Abatement District (ACMAD); in the City of Albany, contact the Alameda County Vector Control Services District (ACVCSD) to determine whether local mosquito species and local factors may preclude rapid mosquito emergence, thus safely allowing water residence times to exceed 72 hours. 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”).
- Provide signage with details on design, ownership, and contact information.
- 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.
- Provide ACMAD with all keys or gate codes needed for access (in the City of Albany, provide the necessary keys and gate codes to the ACVCSD).

Dry System Design Principles for Mosquito Control

- Structures should be designed so they do not hold standing water for more than 72 hours.
- Avoid locating the base of the system below the local groundwater level.
- 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. Design and construct pipes for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe.

- Properly design inlets and other structures to prevent scour depressions.

Sumps, Wet Vaults, and Catch Basin Design Principles for Mosquito Control

- Completely seal structures that retain water permanently or longer than 72 hours 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 mosquito 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, contact ACMAD for consultation (in Albany, contact the ACVCSD). 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, which feed on immature mosquitoes and can aid significantly in mosquito control.

- If large predatory fish are present (e.g., perch and bass), 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 mosquito abatement 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 may be stocked with native surface feeding fish known to feed 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.

G.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 mosquito control are described here, maintenance guidelines for individual treatment measures are often site-specific. Therefore, consult with ACMAD regarding the site-specific design of stormwater treatment measures (in Albany, consult with ACVCSD).

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 72 hours to effectively suppress mosquito 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. Underdrains and filtration media should be inspected periodically and cleaned out or replaced as needed.
- Conduct inspection and 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 72 hours, 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. Contact ACMAD for inspection (in Albany, contact ACVCSD).

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 ACMAD access to underground measures that may have standing water (in Albany, provide access to ACVCSD).

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.

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Appendix H

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
- How to Use the Maintenance Plan Templates
- Maintenance Plan for Bioretention[1] Area
- Maintenance Plan for Flow-through Planter
- Maintenance Plan for Tree Well Filter
- Maintenance Plan for Infiltration Trench
- Maintenance Plan for Extended Detention Basin
- Maintenance Plan for Pervious Paving
- Maintenance Plan for Media Filter

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.

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[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

Stormwater Treatment Measures Operation and Maintenance Inspection Report [[==Insert Name of Municipality==]], California

This report and attached Inspection and Maintenance Checklists document the inspection and maintenance conducted for the identified stormwater treatment measure(s) and flow duration controls (FDCs) 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 __________ annually.

IV. Stormwater Treatment Measure and Flow Duration Control Information:

The following Stormwater Treatment Measures and Flow Duration Controls are located on the property identified above and are subject to the Maintenance Agreement:

Identifying Number of Facility	Type of Stormwater Treatment Measure or Flow Duration Control	Location of Facility 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.

The sediment was removed and disposed as follows: ____

____

VII. Inspector Information:

The inspections documented in the attached inspection checklists were conducted by the following inspector(s):

Inspector Name and Title	Inspector's Employer and Address

VIII. Statement of STM and FDC Condition

Based on the inspections documented in the attached checklists, are the facilities identified in this report present, functional and being maintained as required by the Maintenance Plan? (Check yes or no.)

____YES ____NO

If "NO", describe problem, proposed solution and schedule of correction:

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:______________________________

Attachments to the
Stormwater Treatment Measure
Operation and Maintenance
Inspection Report:

Inspection Checklists

Using the Maintenance Plan Templates for Stormwater Treatment Measures

The New Development Subcommittee (NDS) of the Clean Water Program has prepared templates that project applicants may use to prepare maintenance plans for the following stormwater treatment measures:

- Bioretention[1] areas,
- Flow-through planters,
- Tree well filters,
- Infiltration trenches,
- Extended detention basins,
- Pervious paving, and
- Media filters.

These are treatment measures for which technical guidance has been provided in Chapter 6 of the Clean Water Program's C.3 Stormwater Technical Guidance, which may be downloaded from www.cleanwaterprogram.org (click on "Businesses," then "Development" and go to Appendix H of the C.3 Technical Guidance to download the maintenance plan templates). In some cases, a treatment measure may be sized to function as both a treatment and hydromodification management (HM) measure, as described in Chapter 7 of the Clean Water Program's C.3 Technical Guidance. If your project includes treatment and/or HM measures that are not listed above, but have been approved by the municipality, you may customize one of the maintenance plan templates with information specific to your treatment/HM measure(s).

Microsoft Word documents of the maintenance plan templates may be downloaded from the above link to the Clean Water Program's New Development webpage. When using a template to prepare your maintenance plan, please insert project-specific information where you find prompts such as the following: [[== insert name of property owner/responsible party ==]]. You will need to attach to your maintenance plan a legible, letter-size (8.5-by-11-inch) site plan showing the location(s) of the treatment/HM measure(s). Also, be sure to contact the municipality to learn about any requirements specific to the local jurisdiction. Agency contact information is provided inside the front cover of the C.3 Technical Guidance.

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[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1 of the C.3 Technical Guidance, may also be called a "bioinfiltration area"

Bioretention Area[1] Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date ==]]

Project Address and Cross Streets ________________________________

Assessor's Parcel No.:________________________________

Property Owner:________________________ Phone No.: ________________

Designated Contact: ________________________ Phone No.: ________________

Mailing Address: ________________________________

The property contains [[== insert number ==]] bioretention area(s), located as described below and as shown in the attached site plan[2].

- **Bioretention Area No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other bioretention areas, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to bioretention area failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Bioretention Areas

No.	Maintenance Task	Frequency of Task
1	▪ Remove obstructions, debris, accumulated sediment and trash from bioretention area and dispose of properly. ▪ Maintain vegetation and the irrigation system. Prune and weed to keep bioretention area neat and orderly in appearance.	Monthly
2	▪ Remove and replace all dead and diseased vegetation (replace plants in kind, or per Alameda Countywide Clean Water Program C.3 Technical Guidance Appendix B plant list). ▪ Till or replace soil (using biotreatment soil mix specified in C.3 Technical Guidance Appendix K) as necessary to maintain the design elevation of soil.	Before wet season (August or September), and After wet season (May)
3	▪ Inspect bioretention area using the attached inspection checklist.	Before wet season (inspect in August make all corrections by September 30), and After wet season (May), and Monthly during wet season (October through April)

II. Prohibitions

The use of pesticides and quick release fertilizers is strongly discouraged. For the purposes of stormwater treatment measure maintenance and function, it is anticipated that non-chemical controls (i.e., biological, physical, and cultural controls) will be adequate to address any pest problems. Proper and timely maintenance, as described in this plan, should serve to reduce the potential for pest establishment.

To avoid the need for pesticides or quick release fertilizers, follow the principles of integrated pest management (IPM):

[1] Bioretention areas include linear treatment measures designed for water to filter through biotreatment soils. A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

[2] Attached site plan must match the site plan exhibit to Maintenance Agreement.

1. Employ non-chemical controls (biological, physical and cultural controls) before using chemicals to treat a pest problem.
2. Prune plants properly and at the appropriate time of year.
3. Provide adequate irrigation for landscape plants. Do not over water.
4. Limit fertilizer use unless soil testing indicates a deficiency. Slow-release or organic fertilizer is strongly preferred. Check with municipality for specific requirements and prohibitions.
5. Pest control should avoid harming non-target organisms, or negatively affecting air and water quality and public health. Apply chemical controls only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, apply the least toxic and the least persistent pesticide that will provide adequate pest control. Do not apply pesticides on a prescheduled basis.
6. Sweep up spilled fertilizer and pesticides. Do not wash away or bury such spills.
7. Do not over apply pesticide. Spray only where the infestation exists. Follow the manufacturer's instructions for mixing and applying materials.
8. Only licensed, trained pesticide applicators shall apply pesticides.
9. Apply pesticides at the appropriate time to maximize their effectiveness and minimize the likelihood of discharging pesticides into runoff. With the exception of pre-emergent pesticides, avoid application if rain is expected.
10. Unwanted/unused pesticides shall be disposed as hazardous waste.

Standing water shall not remain in the treatment measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

IV. Inspections

The attached Bioretention Area Inspection and Maintenance Checklist shall be used to conduct inspections, identify needed maintenance, and record maintenance that is conducted. The, schedule of inspections is as follows:

- Before the wet season (in August so that corrections can be made by September 30);
- Monthly during the wet season (October through April);
- After the wet season (May).

Bioretention Area
Inspection and Maintenance Checklist

Property Address:____

Property Owner:____________________ Treatment Measure No.:________________

Date of Inspection:____________________ Inspector:________________________

Type of Inspection:
- ☐ Monthly
- ☐ Pre-Wet Season
- ☐ After heavy runoff
- ☐ End of Wet Season
- ☐ Other:____________________

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)	Corrective Action/Results Expected When Maintenance Is Performed
1. Standing Water	When water stands in the bioretention area between storms and does not drain within 72 hours after rainfall; water may not flow evenly through facility.			▪ Remove top 2 to 4 inches of sediment at inlets to the facility. Add biotreatment soil (C.3 Technical Guidance Appendix K) to design elevation of soil (top of mulch is typically 6 inches below the overflow outlet). Rake, till, or amend with soil mix until infiltration rate is restored. Use ASTM D3385-09 to test infiltration rate. ▪ Install a flow spreader or regrade to distribute flow evenly.
2. Trash/Debris Accumulation	Trash and debris accumulated in the bioretention area.			▪ Trash and debris removed from bioretention area and disposed of properly.
3. Sediment	Evidence of sedimentation in bioretention area.			▪ Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels or ruts have formed around inlets, there are areas of bare soil, and/or other evidence of erosion.			▪ Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased and/or overgrown.			▪ Replant in-kind or substitute from C.3 Technical Guidance Appendix B plant list. ▪ Manually weed and prune to ensure inlets and outlets convey water into/out of the facility. Remove plant debris.
6. Mulch	Mulch is missing or patchy in appearance. Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth.			▪ Replenish mulch; use aged or composted mulch. ▪ All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. ▪ Mulch is even in appearance, at a depth of 3 inches.
7. Irrigation	Irrigation system is not working properly.			▪ Repair as needed and confirm irrigation system works properly.
8. Soil shrinkage	The soil surface is more than 6" below overflow drain).			▪ Add biotreatment soil mix (specified in C.3 Technical Guidance Appendix K), so that soil is at proper depth (top of mulch is typically 6 inches below the overflow outlet).
9. Downspouts and Inlets to Planters	Flow to the facility is impeded, or downspouts are clogged or pipes are damaged. Splash blocks and rocks in need of repair/replenishment.			▪ Repair or replace broken downspouts and curb cuts as needed, so that flow is conveyed efficiently to the planter. ▪ Repair, replace or replenish splash blocks/cobbles, to protect soil from erosive flows at downspouts and inlets.
10. Overflow Pipe or Outlet to Storm Drain	Excess flows are not conveyed safely to storm drain. Piping is damaged or disconnected. Mulch/debris clogs outlet to storm drain (check inside the drain).			▪ Repair the overflow pipe or remove material clogging the overflow outlet, so that excess flow is conveyed efficiently to storm drain. ▪ Remove any mulch, debris or obstruction that is blocking the drain, including any material inside the drain.

Flow-Through Planter Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets ______________________________

Assessor's Parcel No.:______________________________

Property Owner:______________________ Phone No.: ____________________

Designated Contact: ____________________ Phone No.: ____________________

Mailing Address: ______________________________

The property contains [[== insert number ==]] Flow-Through Planter(s), located as described below and as shown in the attached site plan[1].

- **Flow-Through Planter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other Flow-Through Planters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objectives are to ensure that water flows unimpeded into the flow-through planter and landscaping remains attractive in appearance. Table 1 shows the routine maintenance activities, and the frequency at which they will be conducted.

Table 1
Routine Maintenance Activities for Flow-Through Planters

No.	Maintenance Task	Frequency of Task
1	▪ Prune and weed excess vegetation to maintain conveyance/infiltration capacity. ▪ Remove litter, debris, and accumulated sediment; dispose of it properly.	Monthly
2	▪ Till or replace soil (using biotreatment soil mix specified in Appendix K) as necessary to maintain the design elevation of soil. ▪ Remove and replace all dead and diseased vegetation (replace plants in kind, or per Appendix B plant list).	Before wet season (August or September); After wet season (May)
3	▪ Inspect flow-through planter using the attached inspection checklist.	Before wet season (inspect in August make all corrections by September 30), and After wet season (May), and Monthly during wet season (October through April)

II. Prohibitions

The use of pesticides and quick release fertilizers is strongly discouraged. For the purposes of stormwater treatment measure maintenance and function, it is anticipated that non-chemical controls (i.e., biological, physical, and cultural controls) will be adequate to address any pest problems. Proper and timely maintenance, as described in this plan, should serve to reduce the potential for pest establishment.

To avoid the need for pesticides or quick release fertilizers, follow the principles of integrated pest management (IPM):

1. Employ non-chemical controls (biological, physical and cultural controls) before using chemicals to treat a pest problem.
2. Prune plants properly and at the appropriate time of year.

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

3. Provide adequate irrigation for landscape plants. Do not over water.
4. Limit fertilizer use unless soil testing indicates a deficiency. Slow-release or organic fertilizer is strongly preferred. Check with municipality for specific requirements and prohibitions.
5. Pest control should avoid harming non-target organisms, or negatively affecting air and water quality and public health. Apply chemical controls only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, apply the least toxic and the least persistent pesticide that will provide adequate pest control. Do not apply pesticides on a prescheduled basis.
6. Sweep up spilled fertilizer and pesticides. Do not wash away or bury such spills.
7. Do not over apply pesticide. Spray only where the infestation exists. Follow the manufacturer's instructions for mixing and applying materials.
8. Only licensed, trained pesticide applicators shall apply pesticides.
9. Apply pesticides at the appropriate time to maximize their effectiveness and minimize the likelihood of discharging pesticides into runoff. With the exception of pre-emergent pesticides, avoid application if rain is expected.
10. Unwanted/unused pesticides shall be disposed as hazardous waste.

Standing water shall not remain in the treatment measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

IV. Inspections

The attached Flow-Through Planter Inspection and Maintenance Checklist shall be used to conduct inspections, identify needed maintenance, and record maintenance that is conducted. The schedule of inspections is as follows:

- Before the wet season (in August so that corrections can be made by September 30);
- Monthly during the wet season (October through April);
- After the wet season (May).

Flow-Through Planter
Inspection and Maintenance Checklist

Property Address:____

Property Owner:_________________________ Treatment Measure No.:__________________

Date of Inspection:_______________________ Inspector:______________________________

Type of Inspection: ☐ Pre-wet season ☐ Monthly during wet season ☐ Post-wet season ☐ Other:_________________

Items to Review	**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)	**Corrective Action/Results Expected When Maintenance Is Performed**
1. Vegetation	▪ Vegetation is dead, diseased and/or overgrown.			▪ Replant in-kind or substitute from Appendix B plant list. ▪ Manually weed and prune to ensure inlets and outlets convey water into/out of the facility. Remove plant debris.
2. Irrigation	▪ Irrigation system is not working properly.			▪ Repair as needed and confirm irrigation system works properly.
3. Soil	▪ Soil too deep (i.e., the soil surface is more than 6 inches below the overflow drain). ▪ Channels or ruts have formed around inlets, and/or other evidence of erosion.			▪ Add biotreatment soil mix (specified in Appendix K), so that soil is at proper depth (top of mulch is typically 6 inches below the overflow outlet). ▪ Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
4. Mulch	▪ Mulch is missing or patchy in appearance. ▪ Areas of bare earth are exposed, or mulch is less than 3 in deep.			▪ Replenish mulch; use aged or composted mulch. ▪ All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. ▪ Mulch is even in appearance, at a depth of 3 inches.
5. Sediment, Trash & Debris	▪ Sediment, trash and debris accumulated in the planter.			▪ Sediment, trash and debris removed from flow-through planter and disposed of properly.
6. Confirm Proper Drainage	▪ The planter does not drain within 72 hours after rainfall.			▪ Remove top 2 to 4 inches of sediment at all inlets to the planter. Add biotreatment soil mix (Appendix K) to restore the design elevation of soil (top of mulch is typically 6 inches below the overflow outlet). Rake, till, or amend with soil mix until infiltration rate is restored.
7. Downspouts and Inlets	▪ Flow to planter is impeded. ▪ Downspouts are clogged or pipes are damaged. ▪ Splash blocks and rocks in need of repair/replacement.			▪ Repair or replace broken downspouts and curb cuts as needed, so that flow is conveyed efficiently to the planter. ▪ Repair, replace or replenish splash blocks and rocks, to protect soil from erosive flows at all downspouts and inlets.
8. Overflow Pipe or Outlet to Storm Drain	▪ Does not safely convey excess flows to storm drain. ▪ Piping damaged or disconnected. ▪ Mulch/debris clogs outlet to storm drain (check inside drain).			▪ Repair the overflow pipe or remove material clogging the overflow outlet, so that excess flow is conveyed efficiently to the storm drain. ▪ Remove any mulch, debris or obstruction that is blocking the drain, including any material inside the drain.
9. Structural Soundness	▪ Planter is cracked, leaking or falling apart.			▪ Extend and secure liner to planter walls above the high water mark. If abutting a building, the planter must be water tight to protect building foundation from moisture damage. ▪ Repair cracks and leaks, so that planter is structurally sound.
10. No Dumping Signage	▪ Drain inlet "No dumping, flows to Bay" sign is damaged or missing			▪ Install new sign (standard metal plaque).

Tree Well Filter Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets ____

Assessor's Parcel No.:____

Property Owner:______________________________ Phone No.: ____________________________

Designated Contact: __________________________ Phone No.: ____________________________

Mailing Address: ____

The property contains [[== insert number ==]] tree well filter(s), located as described below and as shown in the attached site plan[1].

- **Tree Well Filter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other tree well filters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to tree well filter failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Tree Well Filters

No.	Maintenance Task	Frequency of Task
1	▪ Prune and weed excess vegetation to maintain conveyance/infiltration capacity. ▪ Remove litter, debris, and accumulated sediment; dispose of it properly.	Monthly
2	▪ Till or replace soil (using biotreatment soil mix specified in Appendix K) as necessary to maintain the design elevation of soil. ▪ Remove and replace all dead and diseased vegetation (replace plants in kind, or per Appendix B plant list).	Before wet season (August or September); After wet season (May)
3	▪ Inspect tree well filter using the attached inspection checklist.	Before wet season (inspect in August, make all corrections by September 30), and After wet season (May), and Monthly during wet season (October through April)

II. Prohibitions

The use of pesticides and quick release fertilizers is strongly discouraged. For the purposes of stormwater treatment measure maintenance and function, it is anticipated that non-chemical controls (i.e., biological, physical, and cultural controls) will be adequate to address any pest problems. Proper and timely maintenance, as described in this plan, should serve to reduce the potential for pest establishment.

To avoid the need for pesticides and quick release fertilizers, follow the principles of integrated pest management (IPM):

1. Employ non-chemical controls (biological, physical and cultural controls) before using chemicals to treat a pest problem.

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

2. Prune plants properly and at the appropriate time of year.
3. Provide adequate irrigation for landscape plants. Do not over water.
4. Limit fertilizer use unless soil testing indicates a deficiency. Slow-release or organic fertilizer is strongly preferred. Check with municipality for specific requirements and prohibitions.
5. Pest control should avoid harming non-target organisms, or negatively affecting air and water quality and public health. Apply chemical controls only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, apply the least toxic and the least persistent pesticide that will provide adequate pest control. Do not apply pesticides on a prescheduled basis.
6. Sweep up spilled fertilizer and pesticides. Do not wash away or bury such spills.
7. Do not over apply pesticide. Spray only where the infestation exists. Follow the manufacturer’s instructions for mixing and applying materials.
8. Only licensed, trained pesticide applicators shall apply pesticides.
9. Apply pesticides at the appropriate time to maximize their effectiveness and minimize the likelihood of discharging pesticides into runoff. With the exception of pre-emergent pesticides, avoid application if rain is expected.
10. Unwanted/unused pesticides shall be disposed as hazardous waste.

Standing water shall not remain in the treatment measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

IV. Inspections

The attached Tree Well Filter Inspection and Maintenance Checklist shall be used to conduct inspections, identify needed maintenance, and record maintenance that is conducted. The schedule of inspections is as follows:

- Before the wet season (in August so that corrections can be made by September 30);
- Monthly during the wet season (October through April);
- After the wet season (May).

Tree Well Filter
Inspection and Maintenance Checklist

Property Address:____

Property Owner:__________________________ Treatment Measure No.:__________________

Date of Inspection:________________________ Inspector:________________________________

Type of Inspection: ☐ Pre-wet season ☐ Monthly during wet season ☐ Post-wet season ☐ Other:_________________

Items to Review	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)	Corrective Action / Results Expected When Maintenance Is Performed
1. Vegetation	▪ Vegetation is dead, diseased and/or overgrown.			▪ Replant in-kind or substitute from Appendix B plant list. ▪ Manually remove weeds and prune to ensure inlets freely convey stormwater into the tree well filter. Remove all plant debris.
2. Irrigation	▪ Irrigation system is not working properly.			▪ Repair as needed and confirm irrigation system works properly.
3. Soil/Planting Mix	▪ Soil/planting mix too deep (i.e., the soil surface is more than 6 inches below overflow drain). ▪ Channels or ruts have formed around inlets, and/or other evidence of erosion.			▪ Add biotreatment soil mix (specified in Appendix K) so that soil is at proper depth (top of mulch is typically 6 inches below the overflow outlet). ▪ Obstructions and sediment removed so that water flows freely into the tree well filter. Obstructions and sediment are disposed of properly.
4. Mulch	▪ Mulch is missing or patchy in appearance. ▪ Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth.			▪ Replenish mulch; use aged or composted mulch. ▪ All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. ▪ Mulch is even in appearance, at a depth of 3 inches.
5. Sediment, Trash and Debris	▪ Sediment, trash and debris accumulated in the tree well filter.			▪ Sediment, trash and debris removed from tree well filter and disposed of properly.
6. Confirm Proper Drainage	▪ The tree well filter does not drain within 72 hours after rainfall.			▪ Remove top 2 to 4 inches of sediment at all inlets to the tree well filter. Add biotreatment soil mix (Appendix K) to restore the design elevation of soil (top of mulch is typically 6 inches below the overflow outlet). Rake, till, or amend with soil mix until infiltration rate is restored.
7. Overflow Pipe	▪ Does not safely convey excess flows to storm drain. ▪ Piping damaged or disconnected. ▪ Mulch/debris clogs outlet to storm drain (check inside drain).			▪ Repair the overflow pipe or remove material clogging the overflow outlet, so that excess flow is conveyed efficiently to storm drain.

Infiltration Trench Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date ==]]

Project Address and Cross Streets ____

Assessor's Parcel No.:____

Property Owner:_________________________ Phone No.: ______________________

Designated Contact: ______________________ Phone No.: ______________________

Mailing Address: ____

The property contains [[== insert number ==]] infiltration trench(es), located as described below and as shown in the attached site plan.

- **Infiltration Trench No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other infiltration trenches, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to trench failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Infiltration Trenches

No.	Maintenance Task	Frequency of Task
1	Remove obstructions, debris and trash from infiltration trench and dispose of properly.	Monthly, or as needed after storm events
2	Inspect trench to ensure that it drains between storms, and within 72 hours after rainfall. Check observation well 2-3 days after storm to confirm drainage.	Monthly during wet season, or as needed after storm events
3	Inspect filter fabric for sediment deposits by removing a small section of the top layer.	Annually
4	Monitor observation well to confirm that trench has drained during dry season.	Annually, during dry season
5	Mow and trim vegetation around the trench to maintain a neat and orderly appearance.	As needed
6	Remove any trash, grass clippings and other debris from the trench perimeter and dispose of properly.	As needed
7	Check for erosion at inflow or overflow structures.	As needed
8	Confirm that cap of observation well is sealed.	At every inspection
9	Inspect infiltration trench using the attached inspection checklist.	Monthly, or after large storm events, and after removal of accumulated debris or material

II. Prohibitions

Trees and other large vegetation shall be prevented from growing adjacent to the trench to prevent damage.

Standing water shall not remain in the treatment measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

IV. Inspections

The attached Infiltration Trench Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Infiltration Trench
Inspection and Maintenance Checklist

Property Address:____

Property Owner:________________________ Treatment Measure No.:__________________

Date of Inspection:_______________________ Inspector:______________________________

Type of Inspection:
- ☐ Monthly
- ☐ Pre-Wet Season
- ☐ After heavy runoff
- ☐ End of Wet Season
- ☐ Other:_________________________

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**
1. Standing Water	When water stands in the infiltration trench between storms and does not drain within 72 hours after rainfall.			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 infiltration trench, removed clogging at check dams, or added underdrains.
2. Trash and Debris Accumulation	Trash and debris accumulated in the infiltration trench.			Trash and debris removed from infiltration trench and disposed of properly.
3. Sediment	Evidence of sedimentation in trench. Less than 50% storage volume remaining in sediment traps, forebays or pretreatment swales.			Material removed and disposed of properly so that there is no clogging or blockage.
4. Inlet/Outlet	Inlet/outlet areas clogged with sediment or debris, and/or eroded.			Material removed and disposed of properly so that there is no clogging or blockage in the inlet and outlet areas.
5. Overflow Spillway	Clogged with sediment or debris, and/or eroded.			Material removed and disposed of properly so that there is no clogging or blockage, and trench is restored to design condition.
6. Filter Fabric	Annual inspection, by removing a small section of the top layer, shows sediment accumulation that may lead to trench failure.			Replace filter fabric, as needed, to restore infiltration trench to design condition.
7. Observation Well	Routine monitoring of observation well indicates that trench is not draining within specified time or observation well cap is missing.			Restore trench to design conditions. Observation well cap is sealed.
8. Miscellaneous	Any condition not covered above that needs attention in order for the infiltration trench to function as designed.			Meet the design specifications.

Extended Detention Basin Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date ==]]

Project Address and Cross Streets ____

Assessor's Parcel No.:____

Property Owner:______________________________ Phone No.: ____________________

Designated Contact: ___________________________ Phone No.: ____________________

Mailing Address: ____

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 ==]].
- [[== Add descriptions of other extended detention basins, if applicable. ==]]
- [[== Identify Extended Detention Basin(s) designed for Hydromodification Management (HM).]]

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 and dispose of properly.	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 and dispose of sediment properly.	As needed
6	Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of basin volume and dispose of sediment properly.	Every 10 years, or as needed [[to maintain 2 in. clearance below low-flow orifice for HM design]]
7	Remove accumulated trash and debris from the extended detention basin at the middle and end of the wet season and dispose of trash and debris properly.	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

The use of pesticides and quick release fertilizers is strongly discouraged. For the purposes of stormwater treatment measure maintenance and function, it is anticipated that non-chemical controls (i.e., biological, physical, and cultural controls) will be adequate to address any pest problems. Proper and timely maintenance, as described in this plan, should serve to reduce the potential for pest establishment.

To avoid the need for pesticides or quick release fertilizers, follow the principles of integrated pest management (IPM):

1. Employ non-chemical controls (biological, physical and cultural controls) before using chemicals to treat a pest problem.
2. Prune plants properly and at the appropriate time of year.
3. Provide adequate irrigation for landscape plants. Do not over water.
4. Limit fertilizer use unless soil testing indicates a deficiency. Slow-release or organic fertilizer is strongly preferred. Check with municipality for specific requirements and prohibitions.
5. Pest control should avoid harming non-target organisms, or negatively affecting air and water quality and public health. Apply chemical controls only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, apply the least toxic and the least persistent pesticide that will provide adequate pest control. Do not apply pesticides on a prescheduled basis.
6. Sweep up spilled fertilizer and pesticides. Do not wash away or bury such spills.
7. Do not over apply pesticide. Spray only where the infestation exists. Follow the manufacturer’s instructions for mixing and applying materials.
8. Only licensed, trained pesticide applicators shall apply pesticides.
9. Apply pesticides at the appropriate time to maximize their effectiveness and minimize the likelihood of discharging pesticides into runoff. With the exception of pre-emergent pesticides, avoid application if rain is expected.
10. Unwanted/unused pesticides shall be disposed as hazardous waste.

Standing water shall not remain in the treatment and/or hydromodification management measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502

IV. 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:______________________ Inspector:______________________________

Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:______________________

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 and disposed of properly.
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.
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).

 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
Drainage time	Standing water remains in basin more than 72 hours.			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 and dispose of properly.
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. Sediment disposed of properly.
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.
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.

 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
Debris Barriers (e.g., Trash Racks)				
Trash and Debris	Trash or debris is plugging openings in the barrier.			Trash or debris is removed and disposed of properly.
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.
Flow Duration Control Outlet (if included in design to meet Hydromodification Management Standard) [[==refer to any attachments with additional provisions==]]				
Risers, orifices and screens	Any debris or clogging			Restore unobstructed flow through discharge structure; to meet original design; dispose of debris properly.
Miscellaneous				
Miscellaneous	Any condition not covered above that needs attention to restore extended detention basin to design conditions.			Meets the design specifications.

Pervious Paving Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date ==]]

Project Address and Cross Streets ____

Assessor's Parcel No.:____

Property Owner:__________________________ Phone No.: ___________________

Designated Contact: ______________________ Phone No.: ___________________

Mailing Address: ____

The term "pervious paving" encompasses a range of paved stormwater treatment practices, including pervious concrete or porous asphalt, as well as paving stones with permeable joints ("permeable joint pavers"), paving stones or pavers that are permeable themselves, and turf blocks. These different types of pervious paving facilities all accomplish a similar function by allowing infiltration of stormwater.

The property contains [[== insert number ==]] areas of pervious paving, located as described below and as shown in the attached site plan[1].

- **Pervious Paving Facility No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other pervious paving facilities, if applicable. ==]]

I. Routine Maintenance Activities

Routine maintenance activities for pervious paving facilities, and the frequency at which they will be conducted, are shown in Table 1. Note that there is some variation in maintenance requirements depending on the type of pavement. For example, vacuum sweeping is generally required for pervious pavement, but is prohibited for permeable joint pavers that use sand in the joints between pavers.

In addition to, or in support of, any routine maintenance activities identified here, pervious paving products should be maintained in accordance with any manufacturer's instructions. Where applicable, manufacturer's instructions/maintenance guidelines for pervious paving products should be included as an attachment to this plan.

Table 1
Routine Maintenance Activities for Pervious Paving

No.	Maintenance Task	Frequency of Task
1	▪ Remove any accumulated trash or debris from pervious paving surface and/or between joints. Also remove any trash or debris from downspouts to pervious paving facility or in outlets to storm drains.	Monthly
2	▪ Irrigate and mow turf block grass as required for selected turf species; no-mow and low-water species are advised.	Irrigate turf block as specified by landscape architect. Mow turf block as needed to maintain grass at the upper end of the range of height specified by manufacturer or landscape architect.

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

Table 1 Routine Maintenance Activities for Pervious Paving		
No.	**Maintenance Task**	**Frequency of Task**
3	▪ Vacuum sweep (for permeable joint pavers with sand in joints use minimum suction required to remove surface debris and minimize aggregate loss). ▪ Clean surface of pervious paving, taking care not to move fine sediments into any permeable joints. If power washing is used, aim the spray at a minimum 45 degree angle in relation to the pavement surface, to avoid dislodging aggregate.	Twice annually (in September before wet season, and in May, after wet season)
4	▪ Inspect pervious paving using the attached inspection checklist.	Before wet season (inspect in August, make all corrections by September 30); After wet season (May); Monthly during wet season (October through April)

II. Prohibitions of Pesticides and Quick-release Fertilizer

The use of pesticides and quick release fertilizers is strongly discouraged. For the purposes of stormwater treatment measure maintenance and function, it is anticipated that non-chemical controls (i.e., biological, physical, and cultural controls) will be adequate to address any pest problems. Proper and timely maintenance, as described in this plan, should serve to reduce the potential for pest establishment.

1. To avoid the need for pesticides or quick release fertilizers, follow the principles of integrated pest management (IPM):
2. Employ non-chemical controls (biological, physical and cultural controls) before using chemicals to treat a pest problem.
3. Prune plants properly and at the appropriate time of year.
4. Provide adequate irrigation for landscape plants. Do not over water.
5. Limit fertilizer use unless soil testing indicates a deficiency. Slow-release or organic fertilizer is strongly preferred. Check with municipality for specific requirements and prohibitions.
6. Pest control should avoid harming non-target organisms, or negatively affecting air and water quality and public health. Apply chemical controls only when monitoring indicates that preventative and non-chemical methods are not keeping pests below acceptable levels. When pesticides are required, apply the least toxic and the least persistent pesticide that will provide adequate pest control. Do not apply pesticides on a prescheduled basis.
7. Sweep up spilled fertilizer and pesticides. Do not wash away or bury such spills.
8. Do not over apply pesticide. Spray only where the infestation exists. Follow the manufacturer's instructions for mixing and applying materials.
9. Only licensed, trained pesticide applicators shall apply pesticides.
10. Apply pesticides at the appropriate time to maximize their effectiveness and minimize the likelihood of discharging pesticides into runoff. With the exception of pre-emergent pesticides, avoid application if rain is expected.
11. Unwanted/unused pesticides shall be disposed as hazardous waste.

III. Pollution Prevention

Do not apply, transfer, or store chemicals or fine-grained material on pervious pavement. Contact the local stormwater agency [[== insert phone number ==]] for immediate assistance responding to spills of hazardous materials. Record the time/date, weather, and site conditions if site activities contaminate stormwater. Record the date/time and description of corrective action taken.

IV. Mosquito Abatement

Mosquitoes can potentially pose a threat to public health by serving as vectors for disease. To prevent mosquito generation, standing water shall not remain in any treatment measure for more than 72 hours. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

V. Inspections

The attached Pervious Paving Inspection and Maintenance Checklist shall be used to conduct inspections at the frequency indicated in Table 1 (or as needed), identify needed maintenance, and record maintenance that is conducted.

Pervious Paving
Inspection and Maintenance Checklist

Property Address:____

Property Owner:__________________________ Treatment Measure No.:__________________

Date of Inspection:________________________ Inspector:_______________________________

Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________________

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)	Recommended Action / Results Expected When Maintenance Is Performed
1. Drainage	▪ Ponds covering more than 10 percent of the paved area remain present for more than one hour after a rainstorm.			▪ Vacuum/clean permeable surface/joints of any debris that may be obstructing flow. ▪ Use industrial pressure washer to restore permeability. ▪ For permeable joint pavers, replace permeable joint materials. ▪ If above methods do not restore infiltration rates, reconstruction or replacement of the surface and/or subsurface layers may be required.
2. Downspouts (if any)	▪ Flow to the facility is impeded ▪ Downspouts are clogged or pipes are damaged			▪ Remove any sediment or debris blocking flows. ▪ Repair or replace broken downspouts as needed, so that flow is conveyed efficiently to the pervious paving surface area.
3. Outlet to Storm Drain (if any)	▪ Does not safely convey excess flows to storm drain ▪ Piping damaged or disconnected ▪ Sediment/debris clogs outlet to storm drain (check inside drain)			▪ Repair the overflow pipe or remove material clogging the overflow outlet, so that excess flow is conveyed efficiently to storm drain. ▪ Remove any debris or obstruction that is blocking the drain, including any material inside the drain.
4. Structural Integrity	▪ Pervious paving structure is cracked, broken, concrete spalling or raveling; missing paver blocks or grid ▪ Aggregate loss in permeable joint pavers			▪ ***Porous concrete or asphalt*** - Fill with patching mixes; large cracks and settlement may require cutting and replacing the pavement section. ***Pavers/turf block:*** Repair or replace broken structural components as needed, per manufacturer's instructions. ▪ Replenish permeable joint material as specified by manufacturer or in design plans
4. Pavement Settling	▪ Portions of the paved area are one inch (1"), or more, lower than the general surface of the pavement			▪ Remove pavers and bedding stone[2] in the affected area. Level the exposed base course[3] and compact. Replace bedding stone and reinstate pavers and jointing aggregate.
5. Vegetation	▪ Root systems of adjacent trees encroach on subsurface structural components or cause pavement lift ▪ Weeds in joints of permeable joint pavement			▪ Consult with arborist to assess safety of pruning off problem roots; consider installing a mechanical barrier. ▪ Manually remove weeds. Do not use herbicides. Mow, torch, or, if vegetation is specified in joints, inoculate with preferred vegetation.

[2] The bedding stone is the shallow layer of stone (or, in some cases, sand) on which the pavers are placed. The bedding stone is located above the base course.

[3] The base course is the layer of stone below the bedding stone. The stone size used for the base course is typically larger than the bedding stone.

Media Filter Maintenance Plan for
[[== Insert Project Name ==]]

[[== Insert Date =]]

Project Address and Cross Streets ______________________________

Assessor's Parcel No.:______________________________

Property Owner:______________________ Phone No.: ______________

Designated Contact: ___________________ Phone No.: ______________

Mailing Address: ______________________________

The property contains [[== insert number ==]] media filter(s), located as described below and as shown in the attached site plan[1].

- **Media Filter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other media filters, if applicable. ==]]

I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduces pollutant removal efficiency and may lead to Media Filter failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

Table 1
Routine Maintenance Activities for Media Filters

No.	Maintenance Task	Frequency of Task
1	Inspect for standing water, sediment, trash and debris.	Monthly during rainy season
2	Remove sediment, trash and debris from sedimentation basin, riser pipe and filter bed. Dispose of sediment, trash and debris properly.	As needed
3	Ensure that media filter drains completely within 72 hours.	After major storm events and as needed.
4	For media filters with a filter bed, inspect media depth to ensure proper drainage.	Monthly during rainy season, or as needed after storm events
5	For manufactured media filter, follow manufacturer's guidelines for maintenance and cartridge replacement.	As per manufacturer's specifications.
6	Inspect Media Filter using the attached inspection checklist.	Monthly, or after large storm events, and after removal of accumulated debris or material

II. Prohibitions

Trees and other large vegetation shall be prevented from growing adjacent to the media filter to prevent damage.

Standing water shall not remain in the treatment measures for more than 72 hours, to prevent mosquito generation. Should any mosquito issues arise, contact the Alameda County Mosquito Abatement District (ACMAD), as needed for assistance. In Albany, contact the Alameda County Vector Control Services District (ACVCSD). Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the ACMAD or ACVCSD, and then only by a licensed professional or contractor. Contact information for ACMAD and ACVCSD is provided below.

[1] Attached site plan must match the site plan exhibit to Maintenance Agreement.

III. Vector Control Contacts

Alameda County Mosquito Abatement District
23187 Connecticut St.
Hayward, CA 94545
Phone: (510) 783-7747

Alameda County Vector Control Services District
1131 Harbor Bay Parkway, Ste. 166
Alameda, CA 94502
Phone: (510) 567-6800

III. Inspections

The attached Media Filter Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

Media Filter
Inspection and Maintenance Checklist

Property Address:____

Property Owner:_______________________ Treatment Measure No.:________________

Date of Inspection:_____________________ Inspector:__________________________

Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:____________________

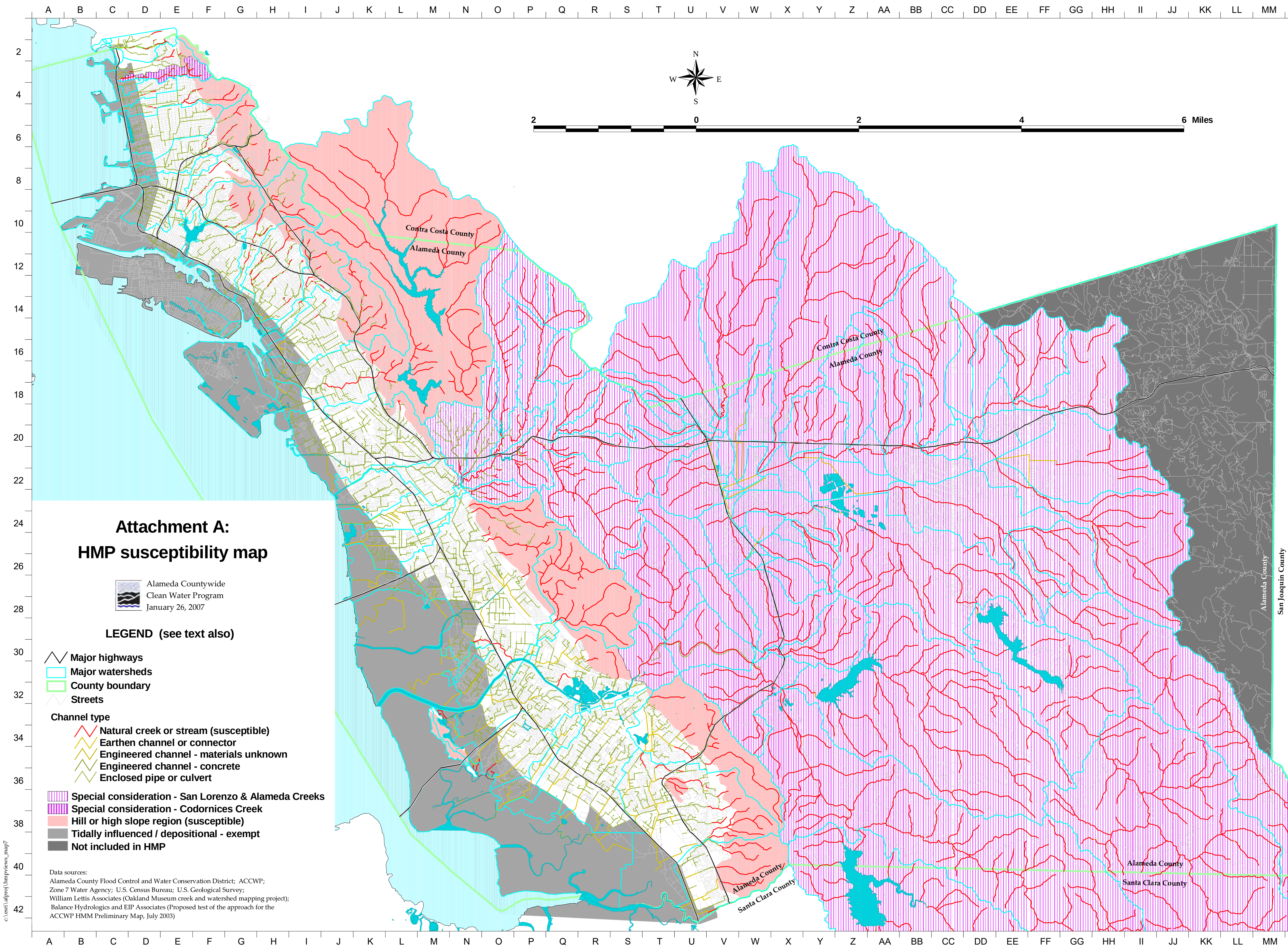
Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done)	Results Expected When Maintenance Is Performed
1. Sediment, trash and debris accumulation	Sediment, trash and debris accumulated in the sedimentation basin, riser pipe and filter bed. Filter does not drain as specified.			Sediment, trash and debris removed from sedimentation basin, riser pipe and filter bed and disposed of properly. Filter drains per design specifications.
2. Standing water	Media filter does not drain within 72 hours after rainfall.			Clogs removed from sedimentation basin, riser pipe and filter bed. Filter drains per design specifications.
3. Mosquitoes	Evidence of mosquito larvae in media filter.			Clogs removed from sedimentation basin, riser pipe and filter bed. Filter drains per design specifications.
4. Filter bed	Overall media depth 300 millimeters (12 inches) or less.			Media depth restored to 450 millimeters (18 inches).
5. Miscellaneous	Any condition not covered above that needs attention in order for the media filter to function as designed.			Meet the design specifications.

Appendix

I

Hydromodification Management Susceptibility Map

This map in this appendix shows a portion of the Hydromodification Management Susceptibility Map included in the Municipal Regional Stormwater NPDES Permit (MRP). This map is available for download in a format that enables zooming to a closer view of the project vicinity with local streets on the Clean Water Program's website (accwp.maps.arcgis.com/apps/webappviewer/index.html?id=11d7a1bfb90d46ce80f94defc03d012c).


Attachment A:
HMP susceptibility map
Alameda Countywide
Clean Water Program
January 26, 2007
LEGEND (see text also)
Major highways
Major watersheds
County boundary
Streets
Channel type
Natural creek or stream (susceptible)
Earthen channel or connector
Engineered channel - materials unknown
Engineered channel - concrete
Enclosed pipe or culvert
Special consideration - San Lorenzo & Alameda Creeks
Special consideration - Codornices Creek
Hill or high slope region (susceptible)
Tidally influenced / depositional - exempt
Not included in HMP
Data sources:
Alameda County Flood Control and Water Conservation District; ACCWP;
Zone 7 Water Agency; U.S. Census Bureau; U.S. Geological Survey;
William Lettis Associates (Oakland Museum creek and watershed mapping project);
Balance Hydrologics and EIP Associates (Proposed test of the approach for the
ACCWP HMM Preliminary Map, July 2003)
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Alameda County
San Joaquin County
Alameda County
Santa Clara County
Alameda County
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Appendix

J

Special Projects

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J.2: Category A: Small Infill Projects
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J6: LID Infeasibility Requirement for Special Projects
J7: Select Non-LID Treatment Measures Certified by a Government Agency
Attachment: Template for Narrative Discussion of LID Feasibility or Infeasibility

J.1 Introduction

On November 19, 2015, the San Francisco Bay Regional Water Quality Control Board (Water Board) re-issued the MRP, revising search and aspects of Provision C.3.e.ii, which allows LID treatment reduction credits for three categories of smart growth, high density and transit oriented development project, described below. Projects that receive LID treatment reduction credits are allowed to use specific types of non-LID treatment, if the use of LID treatment is first evaluated and determined to be infeasible. As described in Section J.6, documentation must be provided to discuss the feasibility and infeasibility of using 100 percent LID treatment onsite and offsite.

The types of non-LID treatment that may be used are:

- High flow-rate media filters, and
- High flow-rate tree well filters (also called high flow-rate tree box filters).

The three categories of Special Projects are:

- Category A: Small Infill Projects (< ½ acre of impervious surface)
- Category B: Larger Infill Projects (< 2 acres of impervious surface)
- Category C: Transit-Oriented Development

Any Regulated Project that meets all the criteria for more than one Special Project Category (such as a Regulated Project that may be characterized as a Category B or C Special Project) may only use the LID Treatment Reduction Credit allowed under one of the categories. For example, a Regulated Project that may be characterized as a Category B or C Special Project may use the LID Treatment Reduction Credit allowed under Category B or Category C, but not the sum of both.

J.2 Category A: Small Infill Projects

The defining criteria and LID treatment reduction credits for Category A projects are described below.

CRITERIA FOR CATEGORY A (SMALL INFILL) SPECIAL PROJECTS

To be considered a Category A Special Project, a Provision C.3 Regulated Project must meet all of the following criteria:

1. Be built as part of the municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design.
2. Be located in the municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian oriented commercial district, or historic preservation site and/or district.
3. Create and/or replace one half acre or less of impervious surface area.
4. Include no surface parking, except for incidental surface parking. Incidental surface parking is allowed only for emergency vehicle access, Americans with Disabilities Act (ADA) accessibility, and passenger and freight loading zones.
5. Have at least 85% coverage for the entire project site by permanent structures. The remaining 15% portion of the site is to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping, and stormwater treatment.

LID TREATMENT REDUCTION FOR CATEGORY A (SMALL INFILL) SPECIAL PROJECTS

Any Category A Special Project may qualify for 100% LID Treatment Reduction Credit, which would allow the Category A Special Project to treat up to 100% of the amount of stormwater runoff specified by Provision C.3.d with either one or a combination of the two types of non-LID treatment systems identified in Section J.1. Prior to receiving the LID treatment reduction credits, the applicant must demonstrate, to the satisfaction of municipal staff, that LID treatment is infeasible, as described in Section J.6.

J.3 Category B: Larger Infill Projects

The defining criteria and LID treatment reduction credits for Category B projects are described below.

CRITERIA FOR CATEGORY B (LARGER INFILL) SPECIAL PROJECTS

To be considered a Category B Special Project, a Provision C.3 Regulated Project must meet all of the following criteria:

1. Be built as part of the municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design.
2. Be located in a permittee's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian oriented commercial district, or historic preservation site and/or district.
3. Create and/or replace greater than one-half acre but no more than 2 acres of impervious surface area.
4. Include no surface parking, except for incidental surface parking. Incidental surface parking is allowed only for emergency vehicle access, ADA accessibility, and passenger and freight loading zones.
5. Have at least 85% coverage for the entire project site by permanent structures. The remaining 15% portion of the site is to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections, public uses, landscaping, and stormwater treatment.

LID TREATMENT REDUCTION FOR CATEGORY B (LARGER INFILL) SPECIAL PROJECTS

For Category B Special Projects, the maximum LID treatment reduction credit allowed varies depending upon the density achieved by the project in accordance with the criteria shown in Table J-1. Density is expressed in Floor Area Ratios (FARs) for commercial projects, and in Dwelling Units per Acre (DU/Ac) for residential development projects. Density of mixed-use projects can be expressed in either FARs or DU/Ac. The credits are expressed in percentages of the amount of stormwater runoff specified by Provision C.3.d for the Project's drainage area. The Special Project may treat the percentage of the C.3.d amount of runoff that corresponds to the project's density using either one or a combination of the two types of non-LID treatment systems listed in Section J.1. To be eligible to receive the LID treatment reduction credits, the applicant must demonstrate, to the satisfaction of municipal staff, that LID treatment is infeasible, as described in Section J.6. Any remaining amount of stormwater runoff must be treated with LID treatment measures.

Table J-1
Category B LID Treatment Reduction Credits, Based on the Density of Development

% of the C.3.d Amount of Runoff that May Receive Non-LID Treatment	Land Use Type	Density Required to Obtain the LID Treatment Reduction Credit
50%	Commercial	Floor Area Ratio 2:1
50%	Residential	50 dwelling units/acre
50%	Mixed Use	Floor Area Ratio 2:1 or 50 dwelling units/acre
75%	Commercial	Floor Area Ratio 3:1
75%	Residential	75 dwelling units/acre
75%	Mixed Use	Floor Area Ratio 3:1 or 75 dwelling units/acre
100%	Commercial	Floor Area Ratio 4:1
100%	Residential	100 dwelling units/acre
100%	Mixed Use	Floor Area Ratio 4:1 or 100 dwelling units/acre

J.4 Category C: Transit-Oriented Development

The defining criteria and LID treatment reduction credits for Category C projects are described below.

CRITERIA FOR CATEGORY C (TRANSIT ORIENTED DEVELOPMENT) SPECIAL PROJECTS

To be considered a Category C Special Project, a Provision C.3 Regulated Project must meet all of the following criteria:

1. Be characterized as a non auto-related land use project. That is, Category C specifically excludes any Regulated Project that is a stand-alone surface parking lot; car dealership; auto and truck rental facility with onsite surface storage; fast-food restaurant, bank or pharmacy with drive-through lanes; gas station, car wash, auto repair and service facility; or other auto-related project unrelated to the concept of Transit-Oriented Development.
2. If a commercial development project, achieve at least an FAR of 2:1.
3. If a residential development project, achieve at least a density of 25 DU/Ac.
4. If a mixed-use development project, achieve at least an FAR of 2:1 or a density of 25 DU/Ac.

LID TREATMENT REDUCTION FOR CATEGORY C (TRANSIT-ORIENTED DEVELOPMENT)

For Category C Special Projects, the total maximum LID treatment reduction credit allowed is the sum of three different types of credits for which the Category C Special Project qualifies. These credits are categorized as follows:

- Location Credits,
- Density Credits, and
- Minimized Surface Parking Credits.

The Special Project may use either one or a combination of the two types of non-LID treatment systems listed in Section J.1 to treat the total percentage of the C.3.d amount of stormwater runoff that results from adding together the Location, Density and Minimized Surface Parking credits that the project is eligible for. In addition, to be eligible to receive the LID treatment reduction credits, the applicant must demonstrate, to the satisfaction of municipal staff, that LID treatment is infeasible, as described in Section J.6. Any remaining amount of stormwater runoff must be treated with LID treatment measures.

Location Credits (Transit-Oriented Development)

Location credits are based on the project site's proximity to a transit hub[1], or its location within a planned Priority Development Area (PDA)[2]. Only one Location Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Location Credits. In order to qualify for a Location Credit, at least 50 percent or more of a Category C Special Project's site must be located within the ¼ or ½ mile radius of an existing or planned transit hub, or 100 percent of the site must be located within a PDA. The Location Credits, presented in Table J-2, are expressed in percentages of the amount of stormwater runoff specified by Provision C.3.d for the project's drainage area.

Table J-2
Location Credits for Category C, Transit Oriented Development
(Only one Location Credit may be used.)

% of the C.3.d Amount of Runoff that May Receive Non-LID	Project Site Location
50%	50% or more of the site is located within a ¼ mile radius of an existing or planned transit hub
25%	50% or more of the site is located within a ½ mile radius of an existing or planned transit hub
25%	100% of the site is located within a PDA

[1] Transit hub is defined as a rail, light rail, or commuter rail station, ferry terminal, or bus transfer station served by three or more bus routes (i.e., a bus stop with no supporting services does not qualify). A planned transit hub is a station on the MTC's Regional Transit Expansion Program list, per MTC's Resolution 3434 (revised April 2006), which is a regional priority funding plan for future transit stations in the San Francisco Bay Area.

[2] A planned Priority Development Area (PDA) is an infill development area formally designated by the Association of Bay Area Government's / Metropolitan Transportation Commission's FOCUS regional planning program. FOCUS is a regional incentive-based development and conservation strategy for the Bay Area.

Density Credits (Transit-Oriented Development)

To qualify for any Density Credits, a Category C Special Project must first qualify for one of the Location Credits listed above. The Density Credits are based on the density achieved by the project in accordance with the criteria shown in Table J-4. Density is expressed in Floor Area Ratios (FARs) for commercial development projects and in Dwelling Units per Acre (DU/Ac) for residential development projects. Density of mixed-use projects may be expressed in either FARs or DU/Ac. The credits are expressed in percentages of the amount of stormwater runoff specified in Provision C.3.d. Commercial and mixed-use Category C projects do not qualify for Density Credits based on DU/Ac, and residential Category C Projects do not qualify for Density Credits based on FAR. Only one Density Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Density Credits.

Table J-3
Density Credits for Category C, Transit Oriented Development
(Only one Density Credit may be used.)

% of the C.3.d Amount of Runoff that May Receive Non-LID Treatment	Land Use Type	Density Required to Obtain the Density Credit
10%	Commercial	Floor Area Ratio 2:1
10%	Residential	30 dwelling units/acre
10%	Mixed Use	Floor Area Ratio 2:1 or 30 dwelling units/acre
20%	Commercial	Floor Area Ratio 4:1
20%	Residential	60 dwelling units/acre
20%	Mixed Use	Floor Area Ratio 4:1 or 60 dwelling units/acre
30%	Commercial or Mixed Use	Floor Area Ratio 6:1
30%	Residential	100 dwelling units/acre
30%	Mixed Use	Floor Area Ratio 6:1 or 100 dwelling units/acre

Minimized Surface Parking Credits (Transit-Oriented Development)

To qualify for any Minimized Surface Parking Credits, a Category C Special Project must first qualify for one of the Location Credits listed above. The LID treatment reduction credit is based on the amount of post-project impervious surface area that is dedicated to at-grade surface parking, in accordance with the criteria shown in Table J-3. The credits are expressed in percentages of the amount of stormwater runoff specified in Provision C.3.d. The at-grade surface parking must be treated with LID treatment measures. Only one Minimized Surface Parking Credit may be used by an individual Category C Special Project, even if the project qualifies for multiple Minimized Surface Parking Credits.

Table J-4
Minimized Surface Parking Credits for Category C, Transit Oriented Development
(Only one Minimized Surface Parking Credit may be used.)

% of the C.3.d Amount of Runoff that May Receive Non-LID	Percentage of the Total Post-Project Impervious Surface Dedicated to At-Grade, Surface Parking
10%	10% or less
20%	0% (except for emergency vehicle access, ADA accessibility and passenger and freight loading zones)

J.5 Calculating the LID Treatment Reduction Credit (Special Projects Worksheet)

The Countywide Program has prepared a Special Projects Worksheet, which municipal staff may ask you to complete to document that your project meets the criteria for Special Project Categories A, B, and/or C and to calculate the total allowable LID treatment reduction credit for which the project is eligible. Some municipalities may have developed their own forms; contact municipal staff for the appropriate Special Projects Worksheet. To download an electronic version of the worksheet, visit the Program's website www.cleanwaterprogram.org and click on "Resources," then "Development."

If the project meets all the criteria for more than one Special Project Category, it may use only the LID treatment reduction credit allowed under one of the categories. However, the worksheet may be used to compute the credit allowed under each category in order to determine which category would allow the most credit.

J.6 LID Infeasibility Requirement for Special Projects

In order to be considered a Special Project, in addition to documenting that all applicable criteria for one of the above-described Special Project categories have been met, the applicant must provide a narrative discussion of the feasibility or infeasibility of using 100 percent LID treatment onsite, offsite, or at a Regional Project. The narrative discussion is required to address the following:

1. The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with LID treatment measures onsite;
2. The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with LID treatment measures offsite or paying in-lieu fees to treat 100% of the Provision C.3.d runoff with LID treatment measures at an offsite or Regional Project; and
3. The infeasibility of treating 100% of the amount of runoff identified in Provision C.3.d for the Regulated Project's drainage area with some combination of LID treatment measures onsite, offsite, and/or paying in-lieu fees towards at an offsite or Regional Project.

The discussion is required to contain enough technical and/or economic detail to document the basis of any infeasibility that is determined. The Template for Narrative Discussion of LID Feasibility or Infeasibility, included as an attachment to Appendix J, can be used to document the basis of infeasibility.

J.6.1 On-site LID Treatment

The narrative discussion should describe how the routing of stormwater runoff has been optimized to route as much runoff as possible to LID treatment measures. A discussion should also be provided for each area of the site for which runoff must be treated with non-LID treatment measures, and should include the following:

1. Uses of impervious surfaces that preclude the use of LID treatment; and
2. Technical constraints that preclude the use of any landscaped areas for LID treatment, such as:
   a. Inadequate size to accommodate biotreatment facilities that meet the sizing requirements for the drainage area;
   b. Slopes too steep to terrace;
   c. Proximity to an unstable bank or slope;
   d. Environmental constraints (e.g., landscaped area is within riparian corridor);
   e. High groundwater or shallow bedrock;
   f. Conflict with subsurface utilities;
   g. Cap over polluted soil or groundwater;
   h. Lack of head or routing path to move collected runoff to the landscaped area or from the landscaped area to the disposal point;
   i. Other conflicts or required uses that preclude use for stormwater treatment (explain).

J.6.2 Off-site LID Treatment.

The applicant must demonstrate to the municipality performing the project review that it is infeasible to provide LID treatment of an equivalent amount of runoff offsite either by paying in-lieu fees to a regional project or on other property owned by the project proponent in the same watershed (in other words, that alternative compliance, as described in Chapter 9, is infeasible).

Check with the local municipality to determine if there are any regional projects available for alternative compliance purposes (at the time of completion of this Appendix, there were none in Alameda County). These considerations should be documented in the narrative discussion of the feasibility and infeasibility of providing 100% L ID treatment.

J.6.3 Combination of On-site and Off-site LID Treatment

The applicant must also demonstrate to the municipality performing the project review that it is infeasible to provide LID treatment of 100% of the amount of runoff specified in Provision C.3.d with some combination of LID measures on-site, offsite, and or paying in-lieu fees to a regional project.

After determining the extent to which stormwater runoff can be optimized to route as much runoff as possible to LID treatment measures, if that amount is less than 100%, and if there are no options to provide LID treatment off-site on a property owned by the project proponent in the same watershed, check with the municipality to determine if there are any regional projects available for alternative compliance purposes for the remainder of the C.3.d amount of runoff. These considerations should be documented in the narrative discussion of the feasibility and infeasibility of providing 100% L ID treatment.

J.7 Select Non-LID Treatment Measures Certified by a Government Agency

MRP Provision C.3.e.vi.(3)(i) requires municipalities to report to the Regional Water Board, for each non-LID treatment measure that the municipality approves, "whether the treatment system either meets minimum design criteria published by a government agency or received certification issued by a government agency, and reference the applicable criteria or certification."

For Special Projects that are allowed to use non-LID treatment measures, applicants are advised to use treatment measures that have been certified by the Washington State Department of Ecology's Technical Assessment Protocol – Ecology (TAPE), under General Use Level Designation (GULD) for Basic Treatment.[3] You can identify proprietary media filters and high flow rate tree well filters currently holding this certification at the following link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html.

The municipality may require that any non-LID treatment measures used in a Special Project be TAPE-certified, or the municipality may allow the use of non-LID treatment measures certified by another governmental program.

If the TAPE system is used, treatment measures must be sized based on the hydraulic sizing criteria specified in MRP Provision C.3.d and the design operating rate for which the product received TAPE GULD certification for Basic Treatment. If a different certification program is used, specify the design operating rate for which the product received the relevant certification.

[3] "General Use" is distinguished from a pilot or conditional use designation. "Basic Treatment" is distinguished from treatment effectiveness for phosphorus removal. Basic treatment is intended to achieve 80 percent removal of total suspended solids (TSS) for influent concentrations from 100 mg/L to 200 mg/L TSS and achieve 20 mg/L TSS for less heavily loaded influents.

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Template for Narrative Discussion of LID Feasibility or Infeasibility

For each potential Special Project, provide a narrative discussion of the feasibility or infeasibility of 100% LID treatment, onsite and offsite, using the template provided below. Insert information specific to the project where indicated with brackets and yellow shading [[== insert information here ==]]. Delete this text box before completing your narrative discussion.

[[== Insert Project Name ==]]
Narrative Discussion of Low Impact Development Feasibility/Infeasibility

This report provides a narrative discussion of the feasibility or infeasibility of providing 100 percent low impact development (LID) treatment for [[== Insert Project Name ==]], which has been identified as a potential Special Project, based on Special Project criteria provided in Provision C.3.e.ii of the Municipal Regional Stormwater NPDES Permit (MRP). This report is prepared in accordance with the requirement in MRP Provision C.3.e.vi.(2), to include in Special Projects reporting a narrative discussion of the feasibility or infeasibility of 100 percent LID treatment onsite or offsite.

1. Feasibility/Infeasibility of Onsite LID Treatment

The project site was reviewed with regard to the feasibility and infeasibility of onsite LID treatment. The results of this review showed that it was [[== feasible/infeasible ==]] to treat [[==___ percent [fill in percentage] ==]] of the C.3.d amount of runoff with LID treatment. The findings of this review are presented below.

a. **On-site Drainage Conditions.** [[== Describe the site drainage, including the site slope, direction of flow, and how the site was divided into drainage management areas that will each drain to a separate stormwater treatment measure.==]]

b. **Self-treating and Self-Retaining Areas and LID Treatment Measures.** [[== Describe any drainage management areas for which self-treating or self-retaining areas (such as pervious pavement, green roofs or landscaped areas) or LID treatment measures are provided. If there are none, delete this paragraph. ==]].

c. **Maximizing Flow to LID Features and Facilities.** [[== Explain how the routing of drainage has been optimized to route as much drainage as possible to LID features and facilities (if any). If there are no LID features or facilities, delete this paragraph. ==]]

d. **Constraints to Providing On-site LID.** The drainage management areas that are proposed to drain to tree-box type high flow rate biofilters and/or vault-based high flow rate media filters include some areas that are not covered by buildings. [[== Briefly describe all areas within these portions of the site that are not covered by buildings.==]] In these areas, conditions and technical constraints are present that preclude the use of LID features and facilities, as described below.

   i. Impervious paved areas: [[== Describe the uses of all impervious paved areas in these areas, and why the uses preclude the use of LID treatment.==]]

   ii. Landscaped areas: [[== For any of the following bullet points that are applicable, briefly describe how the conditions apply to the applicable landscaped areas. Delete any of the bullet points that are not applicable.==]]

   - Inadequate size to accommodate biotreatment facilities that meet sizing requirements for the tributary area.
   - Slopes too steep to terrace;
   - Proximity to an unstable bank or slope;
   - Environmental constraints (for example, landscaped area is within riparian corridor);
   - High groundwater or shallow bedrock;
   - Conflict with subsurface utilities;
   - Cap over polluted soil or groundwater;

- Lack of head or routing path to move collected runoff to the landscaped area or from the landscaped area to a disposal point;
- Other conflicts, including required uses that preclude use for stormwater treatment (describe in more detail).

2. **Feasibility/Infeasibility of Off-Site LID Treatment.** The possibility of providing off-site LID treatment was found to be [[== feasible/infeasible ==]] for the following reasons.

   i. [[**==** Describe whether the project proponent owns or otherwise controls land within the same watershed of the project that can accommodate in perpetuity off-site bioretention facilities adequately sized to treat the runoff volume of the primary project. ==]]

   ii. [[**==** Indicate whether there is a regional LID stormwater mitigation program available to the project for in-lieu C.3 compliance. ==]]

Appendix

K

Soil Specifications

The revised regional Specification of Soils for Biotreatment or Bioretention Facilities, approved by the Regional Water Board on April 18, 2016, are provided on the following pages. Provision C.3.c.i.(2)(c)(ii) of the reissued MRP (Regional Water Board Order No. R2-2015-0049), dated November 19, 2015, allowed for the previous version of these specifications to be revised, subject to approval of the Regional Water Board's Executive Officer. Biotreatment facilities designed to meet Provision C.3 requirements must use biotreatment soil media that meet the minimum specifications set forth in the following pages. Alternative biotreatment mixes that achieve a long-term infiltration rate of 5 to 10 inches per hour, and are suitable for plant health, may be used in accordance with the requirements described in the specifications, under the heading "Verification of Alternative Bioretention Soil Mixes".

This appendix includes the following documents:

- Specification of Soils for Biotreatment or Bioretention Facilities
- Approval letter from the Regional Water Board Executive Officer
- Biotreatment Soil Mix Specification Verification Checklist
- Biotreatment Soil Mix Supplier List
- Biotreatment Soil Mix Supplier Certification Statement
- Bioretention Soil Installation Guidance

The documents included in this appendix may be downloaded from the Clean Water Program's website at:
www.cleanwaterprogram.org (click on "Resources," then "Development.")

Specification of soils for Biotreatment or Bioretention Facilities

Soils for biotreatment or bioretention areas shall meet two objectives:

- Be sufficiently permeable to infiltrate runoff at a minimum rate of 5" per hour during the life of the facility, and
- Have sufficient moisture retention to support healthy vegetation.

Achieving both objectives with an engineered soil mix requires careful specification of soil gradations and a substantial component of organic material (typically compost).

Local soil products suppliers have expressed interest in developing ‘brand-name’ mixes that meet these specifications. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a ‘brand-name’ mix from a soil supplier.

Tests must be conducted within 120 days prior to the delivery date of the bioretention soil to the project site.

Batch-specific test results and certification shall be required for projects installing more than 100 cubic yards of bioretention soil.

SOIL SPECIFICATIONS

Bioretention soils shall meet the following criteria. “Applicant” refers to the entity proposing the soil mixture for approval by a Permittee.

1. General Requirements – Bioretention soil shall:
   a. Achieve a long-term, in-place infiltration rate of at least 5 inches per hour.
   b. Support vigorous plant growth.
   c. Consist of the following mixture of fine sand and compost, measured on a volume basis:
      60%-70% Sand
      30%-40% Compost
2. Submittal Requirements – The applicant shall submit to the Permittee for approval:
   a. A minimum one-gallon size sample of mixed bioretention soil.
   b. Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.
   c. Grain size analysis results of the fine sand component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils or Caltrans Test Method (CTM) C202.
   d. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in 4.
   e. Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, “Loss-On-Ignition Organic Matter Method”.
   f. Grain size analysis results of compost component performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
   g. A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.

h. Provide the name of the testing laboratory(s) and the following information:

(1) Contact person(s)

(2) Address(s)

(3) Phone contact(s)

(4) E-mail address(s)

(5) Qualifications of laboratory(s), and personnel including date of current certification by USCC, ASTM, Caltrans, or approved equal

3. Sand for Bioretention Soil
   a. Sand shall be free of wood, waste, coating such as clay, stone dust, carbonate, etc., or any other deleterious material. All aggregate passing the No. 200 sieve size shall be nonplastic.
   b. Sand for Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #40 or #50, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422, CTM 202 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***
3/8 inch	100	100
No. 4	90	100
No. 8	70	100
No. 16	40	95
No. 30	15	70
No. 40 or No.50	5	55
No. 100	0	15
No. 200	0	5

Note: all sands complying with ASTM C33 for fine aggregate comply with the above gradation requirements.

4. Composted Material

   Compost shall be a well decomposed, stable, weed free organic matter source derived from waste materials including yard debris, wood wastes or other organic materials not including manure or biosolids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

a. Compost Quality Analysis by Laboratory – Before delivery of the soil, the supplier shall submit a copy of lab analysis performed by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Examination of Composting and Compost (TMECC). The lab report shall verify:
(1) Organic Matter Content: 35% - 75% by dry wt.
(2) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1
(3) Maturity/Stability: Any one of the following is required to indicate stability:
  (i) Oxygen Test < 1.3 O2 /unit TS /hr
  (ii) Specific oxy. Test < 1.5 O2 / unit BVS /hr
  (iii) Respiration test < 8 mg CO_2-C /g OM / day
  (iv) Dewar test < 20 Temp. rise (°C) e.
  (v) Solvita® > 5 Index value
(4) Toxicity: Any one of the following measures is sufficient to indicate non-toxicity.
  (i) NH_4^+ : NO_3^--N < 3
  (ii) Ammonium < 500 ppm, dry basis
  (iii) Seed Germination > 80 % of control
  (iv) Plant Trials > 80% of control
  (v) Solvita® = 5 Index value
(5) Nutrient Content: provide analysis detailing nutrient content including N-P-K, Ca, Na, Mg, S, and B.
  (i) Total Nitrogen content 0.9% or above preferred.
  (ii) Boron: Total shall be <80 ppm;
(6) Salinity: Must be reported; < 6.0 mmhos/cm
(7) pH shall be between 6.2 and 8.2 May vary with plant species.

b. Compost Quality Analysis by Compost Supplier – Before delivery of the compost to the soil supplier the Compost Supplier shall verify the following:
(1) Feedstock materials shall be specified and include one or more of the following: landscaping/yard trimmings, grass clippings, food scraps, and agricultural crop residues.
(2) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell or containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable.
(3) Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach min. 55C for 15 days with at least 5 turnings during that period.

c. Compost for Bioretention Soil Texture – Compost for bioretention soils shall be analyzed by an accredited lab using #200, 1/4 inch, 1/2 inch, and 1 inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)**	
	Min	***Max***

1 inch	99	100
1/2 inch	90	100
1/4 inch	40	90
No. 200	1	10

d. Bulk density shall be between 500 and 1100 dry lbs/cubic yard
e. Moisture content shall be between 30% - 55% of dry solids.
f. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.

g. Select Pathogens – Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <10000 MPN/gram.
h. Trace Contaminants Metals (Lead, Mercury, Etc.) – Product must meet US EPA, 40 CFR 503 regulations.
i. Compost Testing – The compost supplier will test all compost products within 120 calendar days prior to application. Samples will be taken using the STA sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test.

VERIFICATION OF ALTERNATIVE BIORETENTION SOIL MIXES

Bioretention soils not meeting the above criteria shall be evaluated on a case by case basis. Alternative bioretention soil shall meet the following specification: "Soils for bioretention facilities shall be sufficiently permeable to infiltrate runoff at a minimum rate of 5 inches per hour during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation."

The following steps shall be followed by municipalities to verify that alternative soil mixes meet the specification:

1. General Requirements – Bioretention soil shall achieve a long-term, in-place infiltration rate of at least 5 inches per hour. Bioretention soil shall also support vigorous plant growth. The applicant refers to the entity proposing the soil mixture for approval.
   a. Submittals – The applicant must submit to the municipality for approval:
      (1) A minimum one-gallon size sample of mixed bioretention soil.
      (2) Certification from the soil supplier or an accredited laboratory that the Bioretention Soil meets the requirements of this guideline specification.

(3) Certification from an accredited geotechnical testing laboratory that the Bioretention Soil has an infiltration rate between 5 and 12 inches per hour as tested according to Section 1.b.(2)(ii).
(4) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with by Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
(5) Grain size analysis results of mixed bioretention soil performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils.
(6) A description of the equipment and methods used to mix the sand and compost to produce Bioretention Soil.
(7) The name of the testing laboratory(s) and the following information:
    (i) Contact person(s)
    (ii) Address(s)
    (iii) Phone contact(s)
    (iv) E-mail address(s)
    (v) Qualifications of laboratory(s), and personnel including date of current certification by STA, ASTM, or approved equal.

b. Bioretention Soil
(1) Bioretention Soil Texture: Bioretention Soils shall be analyzed by an accredited lab using #200, and 1/2" inch sieves (ASTM D 422 or as approved by municipality), and meet the following gradation:

Sieve Size	**Percent Passing (by weight)** ***Min***	 ***Max***
1/2 inch	97	100
No. 200	2	5

(2) Bioretention Soil Permeability testing: Bioretention Soils shall be analyzed by an accredited geotechnical lab for the following tests:
    (i) Moisture – density relationships (compaction tests) shall be conducted on bioretention soil. Bioretention soil for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).
    (ii) Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.

MULCH FOR BIORETENTION FACILITIES

Three inches of mulch is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Projects subject to the State's Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least three inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Aged mulch can be obtained through soil suppliers or directly from commercial recycling yards. It is recommended to apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

April 18, 2016
CIWQS Place No. 756972 (SKM)

To: Municipal Regional Stormwater NPDES Permit (Order No. R2-2015-0049) Permittees

Sent via email to:

Mr. James Scanlin, Alameda Countywide Clean Water Program: jimd@acpwa.org
Mr. Tom Dalziel, Contra Costa Clean Water Program: tdalz@pw.cccounty.us
Mr. Kevin Cullen, Fairfield-Suisun Urban Runoff Management Program: kcullen@fssd.com
Matt Fabry, San Mateo countywide Water Pollution Prevention Program: mfabry@smcgov.org
Adam Olivieri, Santa Clara Valley Urban Runoff Pollution Prevention Program: awo@eoainc.com
Doug Scott, Vallejo Sanitation and Flood Control District: dscott@vsfcd.com
Geoff Brosseau, Bay Area Stormwater Management Agencies Association: Geoff@brosseau.us

Subject: Approval of Revisions to Biotreatment Soil Media Specifications in Water Board Order No. R2-2015-0049, Municipal Regional Stormwater NPDES Permit

On February 5, 2016, the Bay Area Stormwater Management Agencies Association (BASMAA) submitted proposed revisions to the biotreatment soil media specifications referenced in Provision C.3.c.i.(2)(c)((ii) of Board Order No. R2-2015-0049, the Municipal Regional Stormwater NPDES Permit (MRP). The proposed revisions were submitted on behalf of the 76 Permittees regulated by the MRP and were submitted as allowed under and in accordance with the requirements of Provision C.3.c.i.(2)(c)((ii).

The proposed revisions address issues with the current soil media specifications that Permittees have identified, based on implementation of these soil media specifications for the last 5 years under the previous MRP. These identified issues are as follows:

- Compost suppliers are having difficulties meeting the gradation specifications, soluble boron criteria, and occasionally the pH limits listed in the specifications.
- The specifications contain typographical errors and missing or incorrectly identified units of measurement.

This letter approves the Permittees' proposed changes to the biotreatment soil media specifications referenced in Provision C.3.c.i.(2)(c)(ii) of the MRP. We understand that BASMAA intends to convene a soil specification roundtable in Spring 2016 to investigate the need for alternative specifications that might enhance the performance of bioretention facilities under varying microclimates and drought conditions and with diverse planting palettes, including trees.

If you have questions, please contact Sue Ma of my staff at (510) 622-2386 or via email to sma@waterboards.ca.gov.

Sincerely,

for Bruce H. Wolfe
Executive Officer

Biotreatment Soil Mix
Specification Verification Checklist

This checklist is intended to supply municipal staff, contractors, designers and others with an easy-to-read summary of the detailed information needed to verify that the biotreatment soil mix being provided by the Soil Mix Supplier meets the BASMAA Regional Biotreatment Soil Specification[1] approved by the Regional Water Board Executive Officer on April 18, 2016[2].

The checklist should be provided to the Soil Mix Supplier by the municipality or contractor before the soil mix has been ordered to allow for sufficient time to compile the information and time to review the completed checklist before delivery of the soil mix to the job site.

Use of this checklist is not required by the MRP and is intended only for assistance in reviewing submittals. Additionally or alternatively, the one page Supplier Certification Statement, developed by the stormwater programs listed below, can be requested from the Supplier to guarantee that the product meets the specification.

The Certification Statement, a list of Soil Mix Suppliers, the BASMAA Regional Biotreatment Soil Specification (2016) and other materials are available at the following websites:

- Santa Clara Valley Urban Runoff Pollution Prevention Program:
  www.scvurppp-w2k.com/nd_wp.shtml
- San Mateo Countywide Water Pollution Prevention Program:
  www.flowstobay.org/newdevelopment
- Alameda Countywide Clean Water Program:
  www.cleanwaterprogram.org (click on "Resources," then "Development")

If a municipality chooses to use the checklist, the following five items are required to be submitted by the Soil Mix Supplier to the requesting municipality or contractor:

- **Sample of the Biotreatment Soil Mix**
  A minimum 1-gallon bag of soil mix.

- **Attachment A – Supplier Analysis of the Biotreatment Soil Mix**
  To be completed by the Soil Mix Supplier providing the soil mix.

- **Attachment B – Lab Analysis of Sand Component of the Biotreatment Soil Mix**
  To be completed by the laboratory conducting the analysis of the sand.

- **Attachment C – Lab Analysis of Compost Component of the Biotreatment Soil Mix**
  To be completed by the laboratory conducting the analysis of the compost. Compost analysis of a sample collected (in accordance with the STA sample collection protocol) shall be completed within the last 120 days. Analysis must be completed by a laboratory enrolled in the US Composting Council's Compost Analysis Proficiency program, and shall use the Test Methods for the Evaluation of Composting and Compost (TMECC).

- **Attachment D – Supplier Analysis of Compost Component of the Biotreatment Soil Mix**
  To be completed by the Compost Supplier providing the compost component of the soil mix.

1. www.basmaa.org
2. www.swrcb.ca.gov/rwqcb2/water_issues/programs/stormwater/mrp.shtml

Attachment A

Supplier Analysis of Biotreatment Soil Mix

The table below shall be completed by the Biotreatment Soil Mix Supplier.

Date: **(All lab tests must be done within the last 120 days)**	**Name of Person Filling Out This Form:**
Title:	**Signature:**
Phone:	**Email:**
Company Name:	**City:**
Street Address:	**Zip:**

I certify that the provided Biotreatment Soil Mix meets the requirements of the BASMAA Regional Biotreatment Soil Specification (2016).	☐ Yes (Pass) ☐ No (Fail)

Describe the equipment and methods used to mix the compost and sand components of the Biotreatment Soil Mix.	

Material	Standard Percent (by volume)	Actual Mix %	Pass	Fail
Sand	60% - 70%		☐	☐
Compost	30% - 40%		☐	☐

Does the soil mix have a permeability of at least 5 inches per hour?[1]	☐ Yes (Pass) ☐ No (Fail)
Will the soil mix support vigorous plant growth?	☐ Yes (Pass) ☐ No (Fail)

[1]Soil mix permeability testing is only required for alternative biotreatment soil mixes. Soil permeability tests must be conducted on a minimum of two samples using constant head permeability in accordance with ASTM D2434 with a 6-inch mold and vacuum saturation.

Attachment B

Lab Analysis of Sand Component of Biotreatment Soil Mix

The table below shall be completed by the laboratory conducting the sand analysis.

Name of Person Filling Out This Form:	**Signature:**
Title:	**Date:**
Phone:	**Email:**
Company:	**City:**
Street Address:	**Zip:**
Qualifications & relevant certifications (ASTM, CTM or approved equivalent certifications):	

Is sand free of wood, waste, coating (such as clay, stone dust, carbonate, etc.), or any other deleterious material?	☐ Yes (Pass) ☐ No (Fail)
Is all aggregate passing the No. 200 sieve non-plastic?	☐ Yes (Pass) ☐ No (Fail)

Particle size analysis shall be conducted in accordance with ASTM D 422 (Standard Test Method for Particle Size Analysis of Soils) or CTM 202. Other equivalent methods acceptable only if approved.

Sieve Size	Standard Percent Passing (% by weight)	Testing Results (%)	Pass	Fail
3/8 inch	100%		☐	☐
No. 4	90% - 100%		☐	☐
No. 8	70% - 100%		☐	☐
No. 16	40% - 95%		☐	☐
No. 30	15% - 70%		☐	☐
No. 40 or 50	5% - 55%		☐	☐
No. 100	0% - 15%		☐	☐
No. 200	0% - 5%		☐	☐

Attachment C

Lab Analysis of Compost Component of Biotreatment Soil Mix

The table below shall be completed by the laboratory conducting the compost analysis.

Name of Person Filling Out This Form:	**Signature:**
Title:	**Date:**
Phone:	**Email:**
Company:	**City:**
Street Address:	**Zip:**
Qualifications & relevant certifications: **(STA, ASTM or approved equivalent certification)**	

Specification	Standard	Testing Results		Pass	Fail
Organic Matter Content	35% - 75% (by dry weight)		%	☐	☐
Carbon-to-Nitrogen Ratio	15:1 to 25:1 (C:N)		C:N	☐	☐
Salinity	< 6.0 mm hos/cm		mm hos/cm	☐	☐
pH	6.2 - 8.2		pH	☐	☐
Bulk Density	500 – 1100 dry lbs / yd^3		dry lbs / yd^3	☐	☐
Moisture Content	30%-55% (of dry solids)		%	☐	☐
Percent inert ingredients (incl. plastic, glass, paper)	< 1% (by weight or volume)		%	☐	☐

Provide the results of <u>at least one</u> of the following analyses to indicate compost stability:

Specification	Standard	Testing Results		Pass	Fail
Oxygen Test	< 1.3 0_2 /unit TS/hr		0_2 /unit TS/hr	☐	☐
Specific Oxygen Test	< 1.5 0_2/unit BVS/hr		0_2/unit BVS/hr	☐	☐
Respiration Test	< 8mg CO_2-C/g OM/day		mgCO_2-C/g OM/day	☐	☐
Dewar test	< 20 ˚C Temp. rise e.		˚C Temp. rise e.	☐	☐
Solvita® Index value	> 5 Index value		Index value	☐	☐

Provide the results of <u>at least one</u> of the following analyses to indicate compost toxicity:

Specification	Standard	Testing Results		Pass	Fail
Ratio NH_4^+N: NO_3^--N	< 3		NH_4^+-N : NO_3^--N	☐	☐
Ammonium	< 500 ppm, dry basis		ppm, dry basis	☐	☐
Seed Germination	> 80% of control		% of control	☐	☐
Plant Trials	> 80% of control		% of control	☐	☐
Solvita® Index value	= 5 Index value		Index value	☐	☐

Provide the analysis of the nutrient content of the compost, including the following:

Specification	Standard	Testing Results		Pass	Fail
Boron (total, in ppm)	< 80 ppm		ppm	☐	☐
Nitrogen (N)(total %)	> 0.9% preferred.		%		
Phosphorus (as P_2O_5)	*[not specified]*		%		
Potassium (as K_2O)	*[not specified]*		%		
Calcium (Ca)	*[not specified]*		%		
Sodium (Na)	*[not specified]*		%		
Magnesium (Mg)	*[not specified]*		%		
Sulfur (S)	*[not specified]*		ppm		

Provide the results of <u>at least one</u> of the following select pathogens:

Specification	Standard	Testing Results		Pass	Fail
Salmonella	< 3 MPN/4 grams TS		MPN/4 grams TS	☐	☐
Coliform Bacteria	< 10,000 MPN/gram		MPN/gram	☐	☐

Does the product meet US EPA, 40CFR 503 regulations regarding trace contaminants metals (Lead, Mercury, etc.)?	☐ Yes (Pass) ☐ No (Fail)

Particle size analysis shall be conducted in accordance with ASTM D 422 (Standard Test Method for Particle Size Analysis of Soils)-washing not required. Equivalent methods acceptable if approved.

Sieve Size	Standard Percent Passing (by weight)	Testing Results (%)	Pass	Fail
1 inch	**99% - 100%**		☐	☐
½ inch	**90% - 100%**		☐	☐
¼ inch	**40% - 90%**		☐	☐
No. 200	**1% - 10%**		☐	☐

Attachment D

Supplier Analysis of Compost Component of Biotreatment Soil Mix

The table below shall be completed by the Compost Supplier providing the compost for the mix.

Name of Company:	**Date of Delivery:**
Qualifications & relevant certifications: **(STA, ASTM or approved equivalent certifications)**	**Date of the Compost Lab Analysis Report:** **(Must be dated within 120 days prior to delivery)**
Name of Person Filling Out This Form:	**Date:**
Signature:	**Street Address:**
Email address:	**City:**
Phone:	**Zip:**

Feedstock materials have been specified and include only the following: Landscape/yard trimmings, grass clippings, food scraps, or agricultural crop residues?	☐ Yes (Pass) ☐ No (Fail)
Compost has a dark brown color and a soil-like odor, does not exhibit a sour or putrid smell, does not contain recognizable grass or leaves, and is not hot (120˚F) upon delivery or rewetting?	☐ Yes (Pass) ☐ No (Fail)
The compost has gone through the process to further reduce pathogens (PFRP)? For example, turned windrows must reach a minimum temperature of 55˚C for 15 days with at least 5 turnings during that period.	☐ Yes (Pass) ☐ No (Fail)

BIOTREATMENT SOIL MIX SUPPLIER LIST

Company	Contact Name	Phone	Address	City	Zip	E-mail	Website
American Soil & Stone Products Inc.	Ryan Hoffman	510-292-3018	Richmond Annex, 2121 San Joaquin Street, Building A	Richmond	94804	ryan@americansoil.com	www.americansoil.com
L.H. Voss Materials, Inc.	Nyoka Corley	925-676-7910	5965 Dougherty Road	Dublin	94568	nyoka.corley@gmail.com	www.lhvoss.com
Lehigh Hanson Aggregates	Chris Stromberg	510-246-0393	4501 Tidewater Avenue	Oakland	94601	chris.stromberg@lehighhanson.com	www.lehighhanson.com
Lyngso Garden Materials, Inc.	Paul Truyts	650-333-1044 650-364-1730	19 Seaport Boulevard	Redwood City	94063	ptruyts@lyngsogarden.com	www.lyngsogarden.com
Marshall Brothers Enterprises, Inc.	Phillip Marshall	925-449-4020	P.O. Box 2188	Livermore	94551	phillip@mbenterprises.com	www.mbenterprises.com
Pleasanton Trucking Inc.	Tom Bonnell	925-449-5400	P.O. Box 11462	Pleasanton	94588	pleasanton_trucking@yahoo.com	www.pleasantontrucking.com
Recology Blossom Valley Organics	Denette Covarrubias	209-545-7718 209-597-1209	6133 Hammett Court	Modesto	95358	dcovarrubias@recology.com	www.recology.com/blossom-valley-organics-modesto/
Redi-Gro Corporation	Sharon Yon	916-381-6063 800-654-4358	8909 Elder Creek Road	Sacramento	95828	redigropro@redi-gro.com	www.redi-gro.com
TMT Enterprises, Inc.	Matt Moore	408-432-9040	1996 Oakland Road	San Jose	95131	info@tmtenterprises.net	www.tmtenterprises.net

As of: 10/31/2017

Disclaimer: ACCWP provides this list of biotreatment soil mix suppliers for the use of its member agencies, contractors, designers and others in finding suppliers for their projects. Suppliers are listed based on a general review of their soil mix product including test results, adherence to the biotreatment soil specification approved by the Regional Water Board Executive Officer on April 18, 2016, and knowledge of the specification. Therefore users of this ACCWP list must make the final determination as to the products and adherence to the approved biotreatment soil specification Users of the list assume all liability directly or indirectly arising from use of this list. The listing of any soil supplier is not be construed as an actual or implied endorsement, recommendation, or warranty of such soil provider or their products, nor is criticism implied of similar soil suppliers that are not listed. This disclaimer is applicable whether the information is obtained in hard copy or downloaded from the Internet. Check the ACCWP website for the “Biotreatment Soil Mix Verification Checklist” and “Biotreatment Soil Mix Supplier Verification Statement" for assistance in reviewing and approving soil mix submittals, http://cleanwaterprogram.org (click on "Resources," then "Development.")

<COMPANY NAME>
<ADDRESS>

To: <city rep, contractor or other appropriate party>

Job Ref: <XYZ STREET, PROJECT# 1234>

Certificate of Compliance for Biotreatment Soil Mix

I hereby certify that the Biotreatment Soil Mix, to be delivered to the project cited above from our company, meets the "Soil Specifications" criteria approved by the Executive Officer of the San Francisco Bay Regional Water Quality Control Board on April 18, 2016, in accordance with Provision C.3.c.i.(2)(c)(ii) of the Municipal Regional Stormwater NPDES Permit (MRP) adopted on November 19, 2015.

A copy of this Certificate of Compliance will be provided with the delivery of the soil mix. Our test results have been conducted within 120 days prior to the delivery date of the biotreatment soil mix to the project site.

Thank You,

Signed: ____

Name: ____

Title: ____

Contact email address_____________________________

Contact phone number_____________________________

Appendix

L

Site Design Requirements for Small Projects

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L.1 Permit Requirements for Small Projects

Since December 1, 2012, specific sizes of small projects have had to meet site design requirements in Provision C.3.i of the reissued Municipal Regional Stormwater NPDES Permit (MRP, Regional Water Board Order No. R2-2015-0049). This applies to projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface, and individual single family home projects that create and/or replace 2,500 square feet or more of impervious surface. Applicable projects must implement at least one of the following site design measures:

- Direct roof runoff into cisterns or rain barrels for use.
- Direct roof runoff onto vegetated areas.
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas.
- Direct runoff from driveways/uncovered parking lots onto vegetated areas.
- Construct sidewalks, walkways, and/or patios with permeable surfaces.
- Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.

Do the Requirements Apply to My Project?

The requirements apply to your project if it meets the size thresholds described above, and it received final discretionary approval on or after December 1, 2012. If your project does not require discretionary approval, such as tract map approval, conditional use permit, or design review, then the requirements apply if the building permit is issued on or after December 1, 2012.

Please note that projects in the following four ***"Special Land Use Categories"*** that create and/or replace 5,000 square feet or more of impervious surface are required to implement hydraulically-sized stormwater treatment, source control measures, AND site design measures:

- Restaurants;
- Retail gasoline outlets;
- Auto service facilities; and
- Surface parking (stand-alone or part of another use).

For these "Special Land Use Category" projects, the implementation of LID site design and stormwater treatment systems will satisfy the requirements of Provision C.3.i.

Consistent with Provision C.3.c, ***interior remodels and routine maintenance or repair are excluded from the Provision C.3.i requirements***, including:

- Roof replacement, including those that remove the entire roof;
- Exterior wall surface replacement; and
- Pavement resurfacing within the existing footprint. This exclusion applies to any routine maintenance of paved surfaces within the existing footprint, including the repaving that occurs after conducting utility work under the pavement, and the routine reconstruction of pavement, which may include removal and replacement of the subbase. If a repaving project results in changes to the footprint, grade, layout or configuration of the paved surfaces, it would trigger the requirements of Provision C.3. The pavement resurfacing exclusion also applies to the reconstruction of existing roads and trails.

L.2 Regional Guidance for Site Design Measures

To help you select and design site design measures appropriate for the project site, the Clean Water Program collaborated regionally through the Bay Area Stormwater Management Agencies Association (BASMAA) to develop four fact sheets that provide guidance regarding the six site design measures listed above. The fact sheet are included at the end of this appendix, and copies are available for download from the Clean Water Program's website www.cleanwaterprogram.org (Click on "Resources," then "Development").Table L-1 shows how the fact sheets correspond with the six site design measures.

Table L-1: Regional Fact Sheets and Corresponding Site Design Measures	
Fact Sheet	**Corresponding Site Design Measures listed in Provision C.3.i**
Managing Stormwater in Landscapes	▪ Direct roof runoff onto vegetated areas. ▪ Direct runoff from sidewalks, walkways, and/or patios onto vegetatedareas. ▪ Direct runoff from driveways/uncovered parking lots onto vegetated areas.
Rain Gardens	▪ Corresponds to the same site design measures as "Managing Stormwaterin Landscapes", above. Differences between rain gardens and other landscaped areainclude: ▪ Applicants may choose to select a rain garden if they want to capture and infiltrate more stormwater in a smaller area than is possible withmost nativesoils. ▪ Rain gardens should have well-drained soil; soil amendments maybe needed. ▪ An underdrain may be required if native soils are slow-draining.
Pervious Paving	▪ Construct sidewalks, walkways, and/or patios with permeable surfaces. ▪ Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.
Rain Barrels and Cisterns	▪ Direct roof runoff into cisterns or rain barrels for use.

L.3 Selecting Site Design Measures

To supplement guidance provided in the regional fact sheets, refer to Table L-2 to identify key opportunities and constraints for the site design measures listed in Provision C.3.i. Choose one or more site design measures that are a good match for your project site. Only one site design measure is required, but you may choose to implement additional measures to increase the water quality benefits of your project.

Table L-2: Opportunities and Constraints for Site DesignMeasures			
Site Design Measure	**Opportunities**	**Constraints**	**Guidance to Address Constraints**
Managing Stormwater in Landscapes	▪ Lowareas. ▪ Flat areas orminimal slope.	▪ Steepslopes ▪ Insufficient space for landscaping	▪ Avoid in steep slopes where increased infiltration may undermine slope. ▪ Landscaped area should be at least half the size of the impervious areadraining to it. ▪ Direct runoff away from building foundations.

Table L-2: Opportunities and Constraints for Site Design Measures

Site Design Measure	Opportunities	Constraints	Guidance to Address Constraints
Rain Gardens	▪ Low areas. ▪ Flat areas or minimal slope. ▪ Well-drained soil ▪ Existing storm drain to tie in underdrain (if underdrain is needed)	▪ Steep slopes ▪ Insufficient space for landscaping ▪ Poorly drained soil	▪ Avoid in steep slopes. ▪ Rain garden should be at least 4% of the size of the impervious area draining to it. ▪ If soils do not drain well, consider soil amendments. ▪ An underdrain may be needed if native soils are clayey. ▪ Recommended setbacks: 10 ft. from building foundation and 5 ft. from property line
Pervious Paving	▪ Flat areas or minimal slope. ▪ Well-drained soil. ▪ Existing storm drain to tie in underdrain (if underdrain is needed).	▪ Steep slopes ▪ Poorly drained soils ▪ Buildings close to pavement	▪ Avoid use in 5% slopes and greater, unless municipality approves use of underdrain. ▪ Underdrain may be needed if native soils are clayey. ▪ Install away from buildings, or provide impermeable barrier.
Rain Barrels and Cisterns	▪ Roof area that drains to downspouts. ▪ Flat, firm area near the building for rain barrel or cistern. ▪ Landscaping that is downslope from rain barrel or cistern, allowing gravity flow of water for irrigation and discharge of overflow.	▪ Lack of landscape that requires irrigation. ▪ Irrigation system that requires high water pressure. ▪ Absence of flat, firm area near the building. ▪ Lack of suitable areas to receive overflow	▪ Interior non-potable use may be considered, if allowed by municipality. ▪ Use with low-pressure irrigation systems. ▪ Ensure adequate space to safely install rain barrel or cistern and accommodate overflow.

L.4 Selecting Site Design Measures for Constrained Sites

Provision C.3.i does not allow for findings of infeasibility or impracticability, nor does it provide alternative compliance or in-lieu options. Therefore, one of the six site design measures must be implemented in applicable projects, even on sites with constraints such as those identified in Table L-2.

If your site has constraints such as poorly draining soils, steep slopes, or limited space for landscaping, consult with municipal staff regarding approaches to incorporating the site design measures within the constrained site.

Appendix

M

Green Streets

Table of Contents

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M.1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) developed Example GI Typical Details that may be used to design green infrastructure (also known as green stormwater infrastructure) facilities for projects located in the street right of way, subject to local jurisdiction approval (see Attachment M-1). To design future GI facilities that will provide stormwater treatment for runoff from existing streets, please refer to the Green Infrastructure Plan of the jurisdiction in which the project will be located for additional guidance, including guidance for sizing for GI facilities in street projects. Streets can represent 80% of a municipality's public property and typically occupy 25% of all the impervious surfaces in the jurisdiction. Therefore the planning, designing, construction and maintenance of streetscapes is an important aspect of a jurisdictional stormwater program. "Green streets" suite of BMPs is a sub-category of the larger sphere of systems described by the term "green infrastructure". According to the EPA:

"Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water.[1]

[1] water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

Implementation of a green infrastructure program in a municipality includes retrofit of impervious areas in streets, parking lots and other public property with the LID measures discussed in this C.3 Technical Guidance. Green infrastructure also includes urban forestry, gardens, parks and other places of vegetation that have purposes and benefits other than stormwater management.

In the San Francisco Bay Area, green streets most often use bioretention facilities to "slow, spread and sink" roadway runoff removing pollutants before the typical release back into the storm drain system via an underdrain. Stormwater curb extensions, sidewalk flow-through planters and tree filters are the most common types of BMPs used (see Attachment M-1 for ACCWP's Example GI Typical Details). Green streets also provide other eco-system services, such as habitat and temperature moderation, to the streetscape. Guidance from the City of Portland, Oregon describes their function in this way:

"Green streets transform impervious street surfaces into landscaped green spaces that capture stormwater runoff and let water soak into the ground as plants and soil filter pollutants. Green Streets convert stormwater from a waste directed into a pipe, to a resource that replenishes groundwater supplies. They also create attractive streetscapes and urban green spaces, provide natural habitat, and help connect neighborhoods, schools, parks, and business districts."[2]

Green street design elements such as stormwater curb extensions can be integrated with bicycle and pedestrian projects to achieve multiple benefits such as traffic calming and increased safety, which can lead to more active transportation and better community health.

M.2 Green Street Pilot Projects Summary Report

The previous Municipal Regional Stormwater NPDES Permit (MRP, Order No. R2-2009-0074) included a requirement that ten green street projects be completed by the permittees during the permit term and that a report summarizing the results of the projects be submitted to the Water Board by September 15, 2013. The report, entitled "Green Street Pilot Projects Summary Report", describes the ten projects that were substantially completed, and an additional ten projects that were in varying stages of planning and design.[3] Of the twenty projects described in the report, seven are in Alameda County. The report concluded that:

"Implementation of green streets (or "green infrastructure") can best be furthered not through permit provisions requiring development of green streets, but rather by facilitating grant funding, providing appropriate incentives in related sections of permits, and perhaps most importantly, working collaboratively with Permittees, transportation agencies, and state and federal agencies that provide water quality-related funding to better integrate green street objectives with transportation programs. Green street projects are most likely to occur in situations where a transportation project is already planned. Trying to acquire supplemental funding for green street features through grant solicitations that are not in sync with transportation funding programs and calendars is extremely challenging, at best."

Lessons learned from the completed projects include the following:

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[2] www.portlandoregon.gov/bes/article/209685

[3] The report is available at: www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/2013_AR/BASMAA/B ASMAA_2012-13_MRP_AR_Green_Streets.pdf

- Siting of treatment areas in streets is difficult due to limited space in the right-of-way and utility conflicts;
- Sizing treatment systems can be challenging with hard-to-define catchment areas;
- Curb cut design needs careful attention so that significant bypass does not occur;
- Streets with low cross slopes allow for more effective treatment area;
- Monitoring of the facility should be considered during the design phase so that the appropriate infrastructure can be built;
- Outreach to residents and property owners in the project area is effective not only for obtaining approval, but also for education, understanding concerns, and receiving feedback;
- A maintenance period following construction should be incorporated into the schedule.

M.3 Green Street Projects in Alameda County

Member agencies of the Alameda Countywide Clean Water Program are leaders in green streets development and implementation. With projects completed or in process in Albany, Berkeley, Emeryville, Fremont, Livermore, Oakland, Union City and Unincorporated County, green streets are becoming a common sight. Union City alone has over $6 million in Proposition 84 grant funding slated for two green streets projects.

Project Name	Jurisdiction	Street
Cordonices Creek Restoration Project	Albany/Berkeley	6th & 8th Str.
Stanley Blvd Safety & Landscape Improvement	Unincorporated Alameda County	Stanley Blvd.
Derby Street Stormwater Curb Extension	Berkeley	Derby Street
Park & Hollis Stormwater Curb Extension	Emeryville	Park Avenue
Green Street Tree Filter	Fremont	Various
Residential Green Street Bioswales	Livermore	Various
Broadway & Keith Avenues Bike Safety Project	Oakland	Broadway Ave
Decoto Green Streets Projects	Union City	C St., H St., other streets
San Pablo Avenue Stormwater Spine	Albany, Berkeley, Emeryville, Oakland	San Pablo Ave.

M.4 Resources

There are many excellent resources for Green Street planning, design, construction and maintenance. Some are listed below:

- San Mateo County - Sustainable Green Streets and Parking Lots Design Guidebook
  flowstobay.org/greenstreets
- Portland - Stormwater Manual (see Green Streets Details section)
  www.portlandoregon.gov/bes/64040
- Los Angeles County - Model Design Manual for Living Streets
  www.modelstreetdesignmanual.com
- Seattle - Right of Way Improvements Manual
  www.seattle.gov/transportation/rowmanual/manual/6_2.asp
- Washington D.C. - Green Infrastructure Standards
  ddot.dc.gov/node/818592
- San Francisco - Better Streets Plan
  www.sfbetterstreets.org/
- Boston - Complete Streets Manual
  bostoncompletestreets.org/
- Philadelphia - Green Streets Design Manual
  www.phillywatersheds.org/what_were_doing/gsdm
- City of San Mateo Green Streets Manual
  www.cityofsanmateo.org/2738/Plans-and-Policies

Attachment M-1

Example Typical Details

The Alameda Countywide Clean Water Program's Example Typical Details for designing green infrastructure facilities for projects located in the street right of way are listed below and provided on the following pages. Please note that the use of these details is subject to local jurisdiction approval.

Sheet No.	Title of Drawing/Standard Specifications
GI-2A	Bioretention Area: Plan view with street parking
GI-2B	Bioretention Area: Bulbout plan view
GI-2C	Bioretention Area: Street Median
GI-3A	Bioretention Area: Sloped Sides Cross Section
GI-3B	Bioretention Area: Vertical Side Wall Cross Section
GI-4	Bioretention Components: Outlet Detail
GI-5	Bioretention Components: Edge Treatment Detail
GI-6A	Bioretention Components: Gutter Curb Cut Inlet Detail
GI-6B	Bioretention Components: Trench Drain Curb Cut Inlet Detail
GI-6C	Bioretention Components: Curb Cut At Bulbout Inlet Detail
GI-7	Bioretention Components: Check Dam Detail
GI-8	Bioretention Area: With Bike Lane Plan View

PURPOSE:

PROVISION C.3 OF THE MUNICIPAL REGIONAL STORMWATER NPDES PERMIT (MRP) REQUIRES TREATMENT OF IMPERVIOUS SURFACES USING GREEN INFRASTRUCTURE FOR BOTH PUBLIC AND PRIVATE DEVELOPMENT PROJECTS. BIORETENTION AREAS ARE EXPECTED TO BE THE MOST COMMON GREEN INFRASTRUCTURE APPLICATION IN PUBLIC RIGHT-OF-WAY (ROW). THE PURPOSE OF THE BIORETENTION AREA IS TO IMPROVE WATER QUALITY BY FILTRATION THROUGH THE BIOTREATMENT SOIL AND TO CONTROL RUNOFF PEAK FLOW RATES AND VOLUMES THROUGH STORAGE AND INFILTRATION.

NOTES & GUIDELINES:

1. THE ENGINEER SHALL ADAPT PLAN AND SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. BIORETENTION AREA SHALL BE SIZED TO MEET THE REQUIREMENTS OF MRP PROVISION C.3 SIZING.
3. 48 HOUR MAXIMUM FACILITY DRAWDOWN TIME (TIME FOR MAXIMUM SURFACE PONDING TO DRAIN THROUGH THE BIOTREATMENT SOIL AFTER THE END OF A STORM). REFER TO C.3 TECHNICAL GUIDANCE MANUAL (ACCWP) FOR DRAINAGE CONSIDERATIONS.
4. A STORAGE LAYER OF CALTRANS STANDARD CLASS II PERMEABLE MATERIAL IS REQUIRED UNDER THE BIOTREATMENT SOIL. REFER TO C.3 TECHNICAL GUIDANCE MANUAL (ACCWP) FOR SPECIFICATIONS.
5. CHECK DAMS SHALL BE USED TO TERRACE FACILITIES TO PROVIDE SUFFICIENT PONDING FOR SLOPED INSTALLATIONS. ENGINEER SHALL SPECIFY CHECK DAM HEIGHT AND SPACING. REFER TO DETAIL **GI-7** FOR GUIDANCE ON CHECK DAM DESIGN.
6. DEPENDING ON THE DEPTH OF THE BIORETENTION AREA, ADDITIONAL STRUCTURAL CONSIDERATIONS MAY BE REQUIRED TO ADDRESS HORIZONTAL LOADING. REFER TO DETAIL **GI-5** FOR GUIDANCE ON EDGE TREATMENTS.
7. WHEN FACILITY CONSTRUCTION IMPACTS EXISTING SIDEWALK, ALL SAW CUTS SHALL ADHERE TO LOCAL JURISDICTION STANDARDS. SAW CUTS SHALL BE ALONG SCORE LINES OR ALONG CONSTRUCTION JOINTS, AS DETERMINED BY THE CITY ENGINEER, AND ANY DISTURBED SIDEWALK FLAGS SHALL BE REPLACED IN THEIR ENTIRETY.
8. BIORETENTION AREAS IN PUBLIC RIGHT OF WAY SHALL BE DESIGNED WITH AN EMERGENCY OVERFLOW. IN THE EVENT THE BIORETENTION AREA OVERFLOW DRAIN IS OBSTRUCTED OR CLOGGED, THE INUNDATION AREA SHALL BE CONTAINED WITHIN THE STREET AND SHALL NOT BE WITHIN ADJACENT PRIVATE PROPERTIES.
9. BIORETENTION AREA VEGETATION SHALL BE SPECIFIED BY LANDSCAPE DESIGN PROFESSIONAL. SEE C.3 TECHNICAL GUIDANCE MANUAL (ACCWP) FOR PLANT LIST AND VEGETATION GUIDANCE.
10. THE ENGINEER SHALL EVALUATE THE NEED FOR EROSION PROTECTION AT ALL INLET LOCATIONS. ALL COBBLES USED FOR ENERGY DISSIPATION SHALL BE GROUTED. ENGINEER TO CONSIDER MAINTENANCE REQUIREMENTS TO FACILITATE EASY SEDIMENT REMOVAL AND ADEQUATE VECTOR CONTROL.
11. THE PROJECT PLANS SHALL SHOW ALL EXISTING UTILITIES AND INDICATE POTENTIAL UTILITY CROSSINGS OR CONFLICTS.
12. CHECK WITH LOCAL JURISDICTION FOR UTILITY CROSSING PROVISIONS.
13. MINIMUM UTILITY SETBACKS AND PROTECTION MEASURES SHALL CONFORM TO CURRENT LOCAL JURISDICTION STANDARDS AND OTHER UTILITY PROVIDER REQUIREMENTS.
14. VERTICAL SIDEWALLS EXTENDING INTO EXISTING STORM DRAIN PIPE TRENCH BACKFILL SHALL BE DESIGNED WITH A CONCRETE BACKFILL ACCEPTABLE TO THE CITY ENGINEER.
15. OVERFLOW RISER MUST BE FORMED SUCH THAT IT IS A MINIMUM OF 6" ABOVE THE BOTTOM OF THE SYSTEM INLET, OR AS DESIGNED. PLACE STRUCTURE ADJACENT TO PEDESTRIAN EDGE TO ALLOW FOR MONITORING ACCESS.
16. DETAILS WERE ADAPTED FROM SFPUC GREEN INFRASTRUCTURE TYPICAL DETAILS AND SPECIFICATIONS.
17. DETAILS WERE DEVELOPED BY GEOSYNTEC CONSULTANTS.

ENGINEER CHECKLIST (SHALL SPECIFY, AS APPLICABLE):

- ☐ BIORETENTION AREA WIDTH AND LENGTH
- ☐ DEPTH OF PONDING
- ☐ AMOUNT OF FREEBOARD PROVIDED
- ☐ DEPTH OF BIOTREATMENT SOIL (18" MIN)
- ☐ UNDERDRAIN SPECIFICATIONS AND LOCATION (IF FACILITY IS LINED PLACE UNDERDRAIN AT BOTTOM OF FACILITY)
- ☐ BIORETENTION SURFACE ELEVATION (TOP OF BIOTREATMENT SOIL) AT UPSLOPE AND DOWNSLOPE ENDS OF FACILITY
- ☐ CONTROL POINTS AT EVERY BIORETENTION WALL CORNER AND POINT OF TANGENCY
- ☐ DIMENSIONS AND DISTANCE TO EVERY INLET, OUTLET, CHECK DAM, SIDEWALK NOTCH, ETC.
- ☐ ELEVATIONS OF EVERY INLET, OVERFLOW RISER, STRUCTURE RIM AND INVERT CHECK DAM, BIORETENTION AREA WALL CORNER, AND SIDEWALK NOTCH
- ☐ TYPE AND DESIGN OF BIORETENTION AREA COMPONENTS (E.G., EDGE TREATMENTS, INLETS/GUTTER MODIFICATIONS, UTILITY CROSSINGS, LINER, AND PLANTING DETAILS)
- ☐ DEPTH AND TYPE OF MULCH (NON-FLOATING; ORGANICALLY-DERIVED; NOT BARK OR GORILLA HAIR; 3" MIN)

RELATED TECHNICAL GUIDANCE	SOURCE
BIORETENTION: - BIOTREATMENT SOIL MIX - CALTRANS CLASS II PERM LAYER STORAGE - PERFORATED UNDERDRAIN - NON-FLOATING MULCH	C.3 TECHNICAL GUIDANCE MANUAL (ACCWP)

NOT FOR CONSTRUCTION

BIORETENTION AREA: NOTES

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

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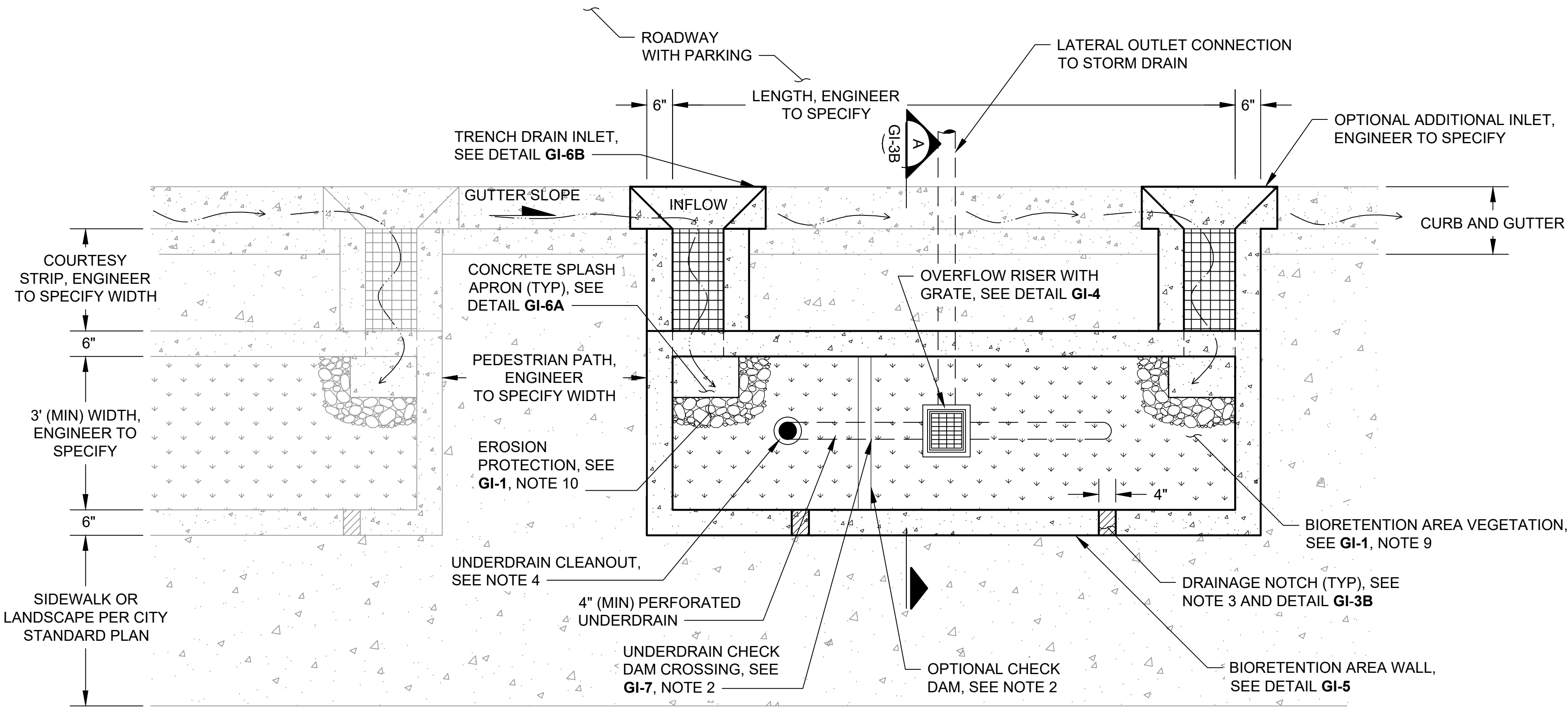
SCALE: NOT TO SCALE

DATE: MAY 11, 2018 REVISED: JUNE 11, 2019

DRAWN BY: K. K. REVISED BY: E. F.

CHECKED BY: A. R.

GI-1



NOTES:

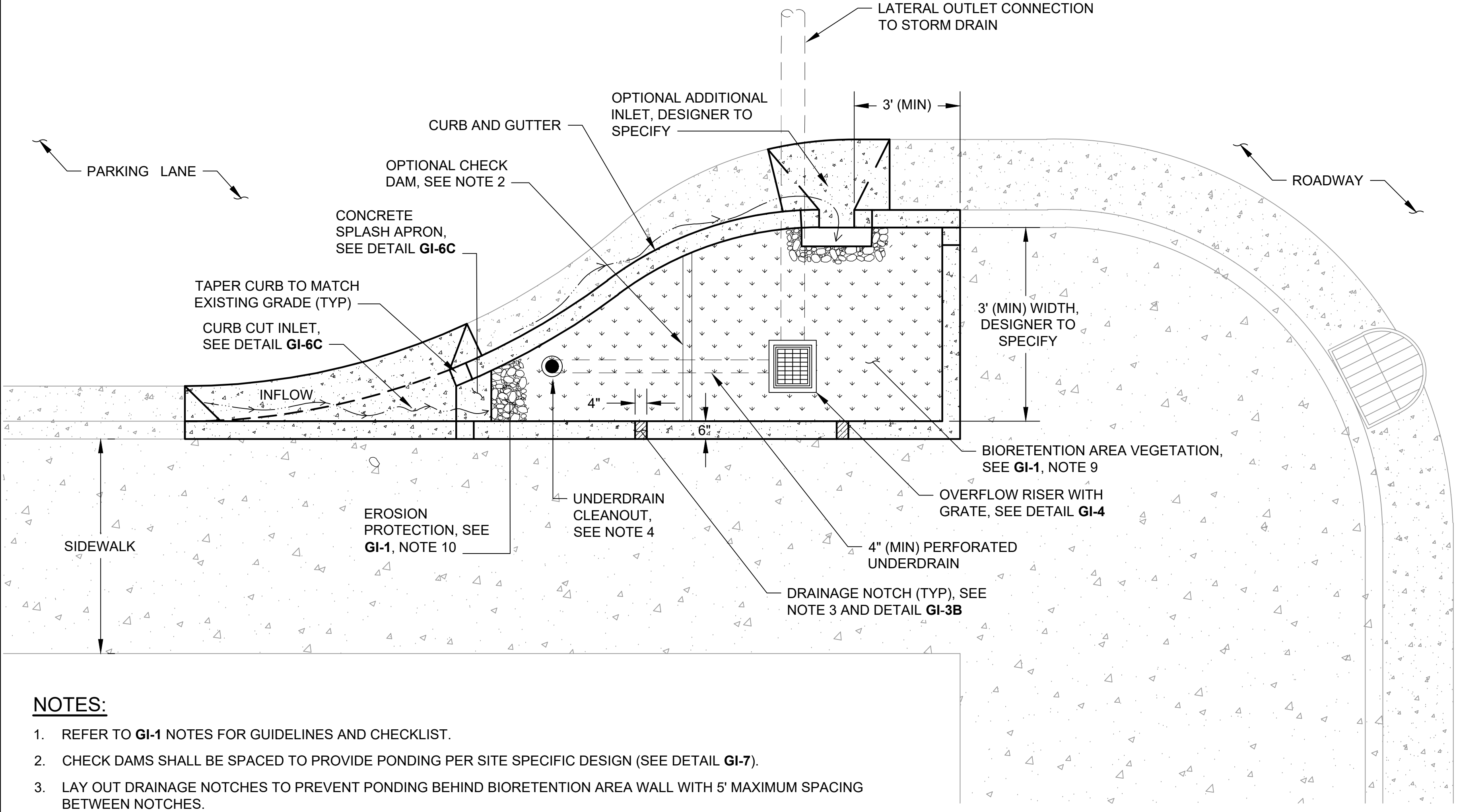
1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN (SEE DETAIL **GI-7**).
3. LAY OUT DRAINAGE NOTCHES AS APPLICABLE TO PREVENT PONDING BEHIND BIORETENTION AREA WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
4. PROVIDE ONE UNDERDRAIN CLEANOUT PER BIORETENTION AREA (MIN). CLEANOUT REQUIRED AT UPSTREAM END AND PIPE ANGLE POINTS EXCEEDING 45 DEGREES. LONGITUDINAL SLOPE OF PIPE SHALL BE 0.5% (MIN).

NOT FOR CONSTRUCTION

BIORETENTION AREA: PLAN VIEW WITH STREET PARKING

GREEN INFRASTRUCTURE EXAMPLE DETAILS	SCALE: NOT TO SCALE	
	DATE: MAY 11, 2018 REVISED: JUNE 11, 2019	
ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM	DRAWN BY: K. K REVISED BY: E. F.	GI-2A
	CHECKED BY: A. R.	

clean water PROGRAM



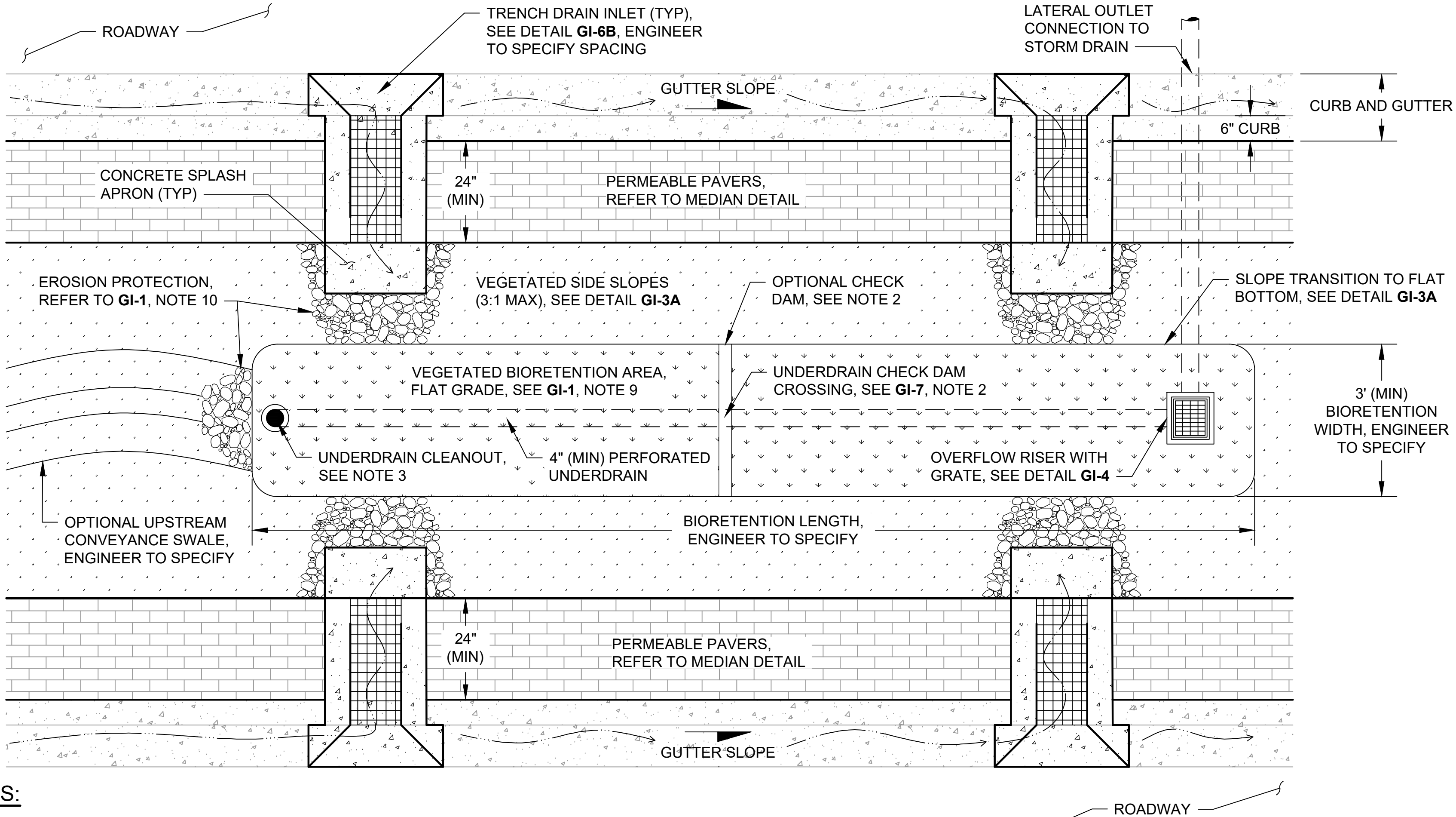
NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN (SEE DETAIL **GI-7**).
3. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND BIORETENTION AREA WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
4. PROVIDE ONE UNDERDRAIN CLEANOUT PER BIORETENTION AREA (MIN). CLEANOUT REQUIRED AT UPSTREAM END AND PIPE ANGLE POINTS EXCEEDING 45 DEGREES. LONGITUDINAL SLOPE OF PIPE SHALL BE 0.5% (MIN).

NOT FOR CONSTRUCTION

BIORETENTION AREA: BULBOUT PLAN VIEW

GREEN INFRASTRUCTURE EXAMPLE DETAILS	SCALE: NOT TO SCALE	
	DATE: MAY 11, 2018 REVISED: JUNE 11, 2019	
ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM	DRAWN BY: K. K. REVISED BY: E. F.	
	CHECKED BY: A. R.	GI-2B



NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN (SEE DETAIL **GI-7**).
3. PROVIDE ONE UNDERDRAIN CLEANOUT PER BIORETENTION AREA (MIN). CLEANOUT REQUIRED AT UPSTREAM END AND PIPE ANGLE POINTS EXCEEDING 45 DEGREES. LONGITUDINAL SLOPE OF PIPE SHALL BE 0.5% (MIN).
4. DESIGNERS TO REFERENCE AASHTO ROADSIDE SAFETY DESIGN REQUIREMENTS AND CONSIDER USE OF MEDIAN BIORETENTION AREAS IN RELATION TO STREET CLASSIFICATION AND STREET SPEEDS.
5. A STORAGE VOLUME SAFETY FACTOR OF 1.5 SHALL BE INCLUDED IN THE DESIGN OF MEDIAN BIORETENTION AREAS TO PREVENT FLOODING.
6. SLOPED SIDES (**GI-3A**) DEPICTED IN PLAN VIEW ABOVE, REFER TO **GI-3B** IF VERTICAL SIDE WALLS ARE USED.

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BIORETENTION AREA: STREET MEDIAN

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE

DATE: MAY 11, 2018 REVISED: JUNE 11, 2019

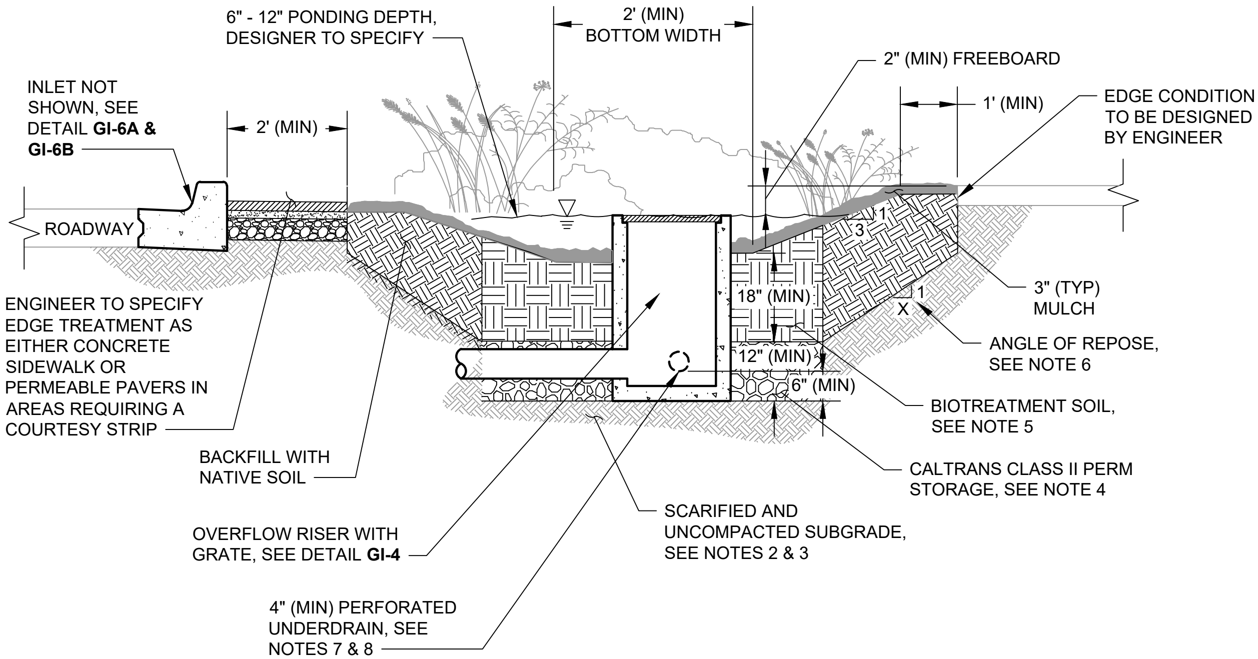
DRAWN BY: K. K. REVISED BY: E. F.

CHECKED BY: A. R.

GI-2C

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. AVOID UNNECESSARY COMPACTION OF EXISTING SUBGRADE BELOW AREA.
3. SCARIFY SUBGRADE TO A DEPTH OF 3" (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF CALTRANS CLASS 2 PERMEABLE MATERIAL STORAGE LAYER AND BIOTREATMENT SOIL MATERIALS.
4. AGGREGATE STORAGE LAYER COMPRISED OF 12" MIN CALTRANS CLASS 2 PERMEABLE MATERIAL.
5. REFER TO C.3 TECHNICAL GUIDANCE MANUAL (ACCWP) FOR BIOTREATMENT SOIL MIX SPECIFICATIONS. INSTALL BIOTREATMENT SOIL AT 85% COMPACTION FOLLOWING BASMAA INSTALLATION GUIDANCE.
6. ANGLE OF REPOSE VARIES PER GEOTECHNICAL ENGINEER RECOMMENDATIONS.
7. UNDERDRAIN AND CLEAN OUT PIPE (1 MIN PER FACILITY) REQUIRED, REFER TO C.3 TECHNICAL GUIDANCE MANUAL (ACCWP) FOR DESIGN CONSIDERATIONS. UNDERDRAINS SHOULD BE ELEVATED 6" (MIN) WITHIN THE CALTRANS CLASS 2 PERMEABLE MATERIAL STORAGE LAYER TO PROMOTE INFILTRATION. IN FACILITIES WITH AN IMPERMEABLE LINER, THE UNDERDRAIN SHOULD BE PLACED AT THE BOTTOM OF THE CALTRANS CLASS 2 PERMEABLE MATERIAL STORAGE LAYER. PERFORATED/SLOT DRAINS SHOULD BE DOWNWARD FACING TO FACILITATE BETTER STORAGE IN THE GRAVEL LAYER.
8. THE UNDERDRAIN IN ALL FACILITIES LOCATED IN THE PUBLIC RIGHT-OF-WAY SHALL BE VIDEO RECORDED AND PROVIDED TO THE CITY FOR REVIEW PRIOR TO PROJECT ACCEPTANCE.
9. REFER TO LOCAL JURISDICTION STANDARDS FOR CURB AND SIDEWALK DETAILS.



NOT FOR CONSTRUCTION

BIORETENTION AREA: SLOPED SIDES CROSS SECTION

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE

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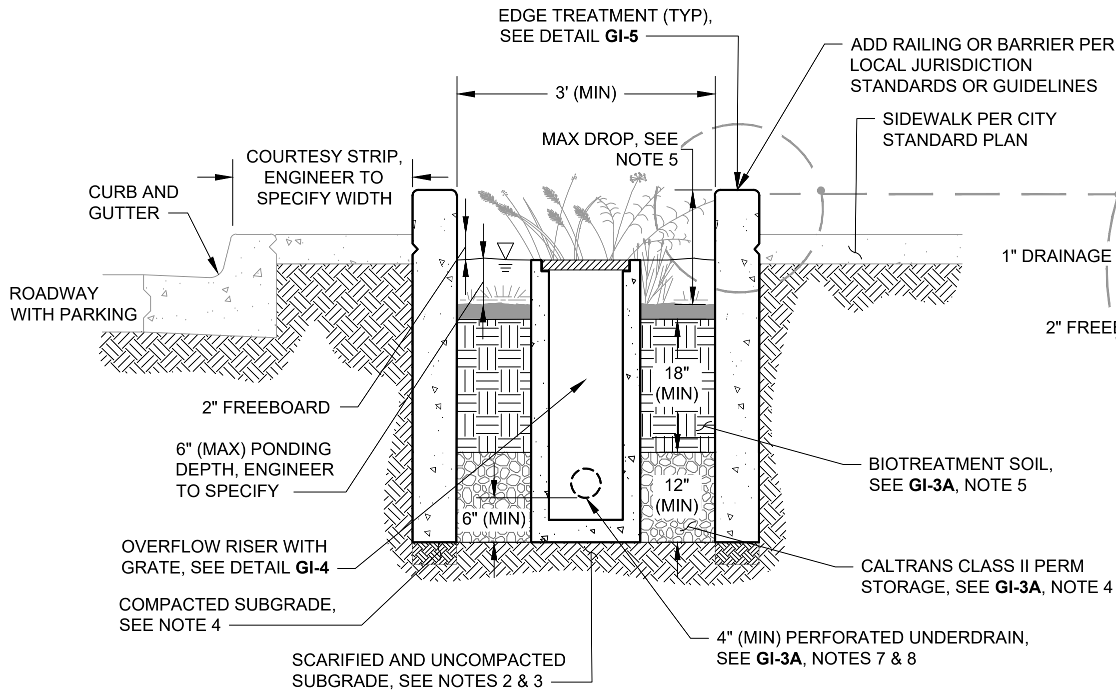
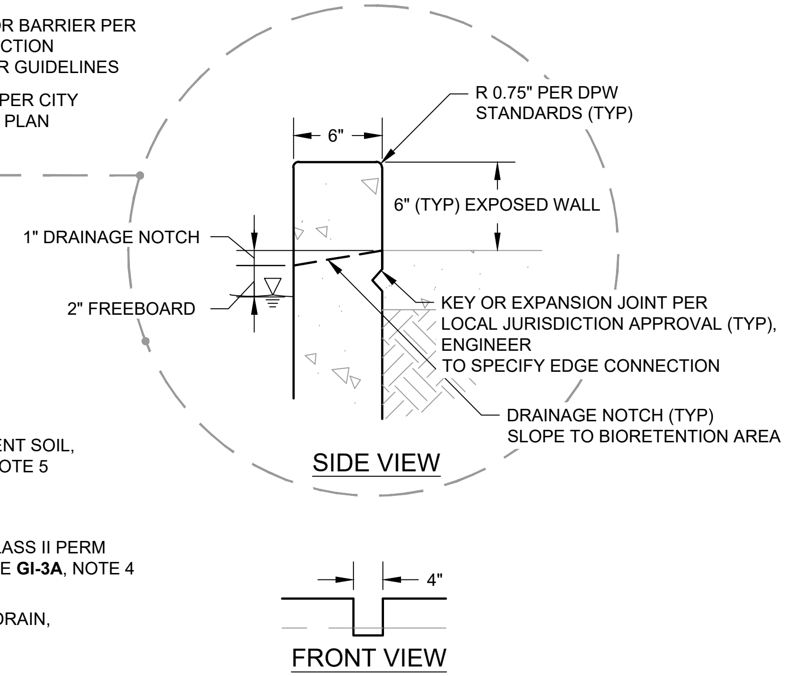
GI-3A



BIORETENTION AREA WITH VERTICAL SIDE WALLS (A)



DRAINAGE NOTCH DETAIL

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. AVOID UNNECESSARY COMPACTION OF EXISTING SUBGRADE BELOW BIORETENTION AREA.
3. SCARIFY SUBGRADE TO A DEPTH OF 3" (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIOTREATMENT SOIL MATERIAL.
4. FOR STRUCTURAL SUPPORT, SUBGRADE UNDER WALLS ONLY COMPACTED PER ENGINEER SPECIFICATIONS.
5. MAXIMUM DROP, PER LOCAL BUILDING CODE, FROM TOP OF CURB TO TOP OF BIOTREATMENT SOIL SHALL INCLUDE CONSIDERATIONS FOR BIOTREATMENT SOIL SETTLEMENT. THE DROP IS THE SUM OF PONDING DEPTH (6" TYP), FREEBOARD (2" TYP), AND CURB HEIGHT (6" TYP).
6. REFER TO LOCAL JURISDICTION STANDARDS FOR CURB AND SIDEWALK DETAILS.

NOT FOR CONSTRUCTION

BIORETENTION AREA: VERTICAL SIDE WALL CROSS SECTION

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GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE

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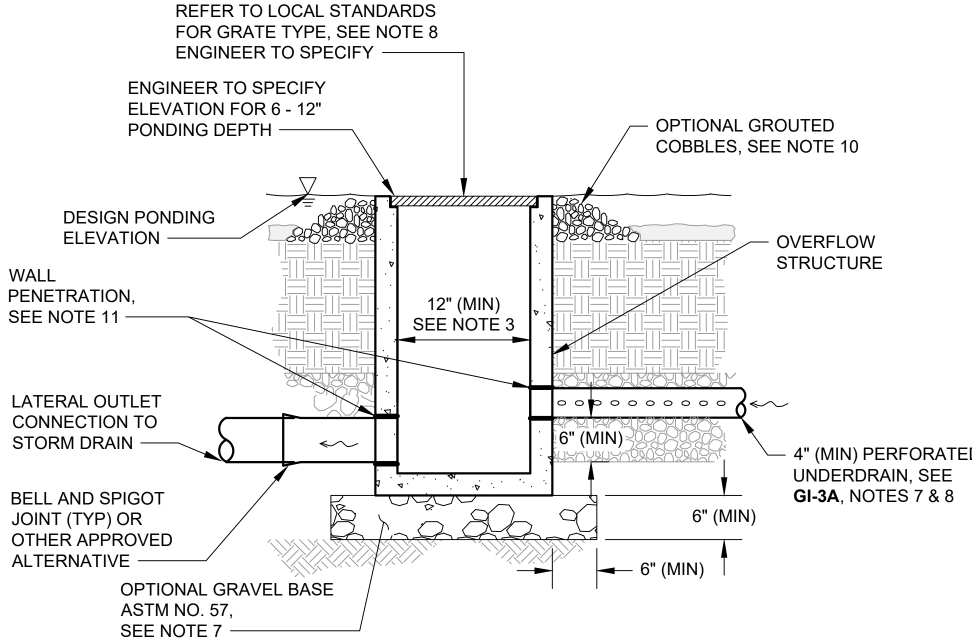
CHECKED BY: A. R.

GI-3B

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. ALL MATERIAL AND WORKMANSHIP FOR OVERFLOW STRUCTURES SHALL CONFORM TO LOCAL JURISDICTION STANDARDS.
3. DESIGN OVERFLOW WEIR AND OUTLET PIPE TO CONVEY 10-YR, 24-HR STORM FLOW OR DESIGN INLET TO DIVERT FLOWS LARGER THAN THE DESIGN STORM DIRECTLY TO THE STORM DRAIN. LOCATE ALL OVERFLOW PIPES AT AN ELEVATION HIGHER THAN THE STORM SEWER HYDRAULIC GRADE LINE TO PREVENT BACKFLOW INTO THE BIORETENTION FACILITY.
4. STORM DRAIN OUTLET PIPES SHALL BE SIZED TO MEET HYDRAULIC REQUIREMENTS WITH APPROPRIATE COVER DEPTH AND PIPE MATERIAL.
5. PERFORATED UNDERDRAINS WITH CLEANOUT PIPES ARE REQUIRED. PERFORATED/SLOT DRAINS SHOULD BE DOWNWARD FACING TO FACILITATE BETTER STORAGE IN THE GRAVEL LAYER.
6. MAINTENANCE ACCESS IS REQUIRED FOR ALL OUTLET STRUCTURES AND CLEANOUT FACILITIES. 12" (MIN) CLEARANCE WITHIN OVERFLOW STRUCTURE SHALL BE PROVIDED FOR MAINTENANCE ACCESS.
7. ENGINEER SHALL REFER TO LOCAL JURISDICTION STANDARDS AND/OR ASSESS NEED FOR GRAVEL BASE. ENGINEER SHALL EVALUATE BUOYANCY OF STRUCTURES FOR SITE SPECIFIC APPLICATION AND SPECIFY THICKENED OR EXTENDED BASE / ANTI-FLOATATION COLLAR, AS NECESSARY.
8. SIZE OF GRATE SHALL MATCH SIZE OF RISER SPECIFIED IN PLANS, SHALL BE REMOVABLE TO PROVIDE MAINTENANCE ACCESS, AND SHALL BE BOLTED IN PLACE OR OUTFITTED WITH APPROVED TAMPER-RESISTANT LOCKING MECHANISM. MAXIMUM GRATE OPENING SHALL BE 2".
9. IF INTERIOR DEPTH OF OVERFLOW STRUCTURE EXCEEDS 5', A PERMANENT BOLTED LADDER AND MINIMUM CLEAR SPACE OF 30" BY 30" SHALL BE PROVIDED FOR MAINTENANCE ACCESS.
10. MINIMUM DIAMETER OF OPTIONAL GROUTED COBBLES SHALL BE LARGER THAN MAXIMUM GRATE OPENING.
11. GROUT ALL PENETRATIONS, CRACKS, SEAMS, AND JOINTS WITH CLASS "C" MORTAR.



NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: OUTLET DETAIL

GREEN INFRASTRUCTURE EXAMPLE DETAILS

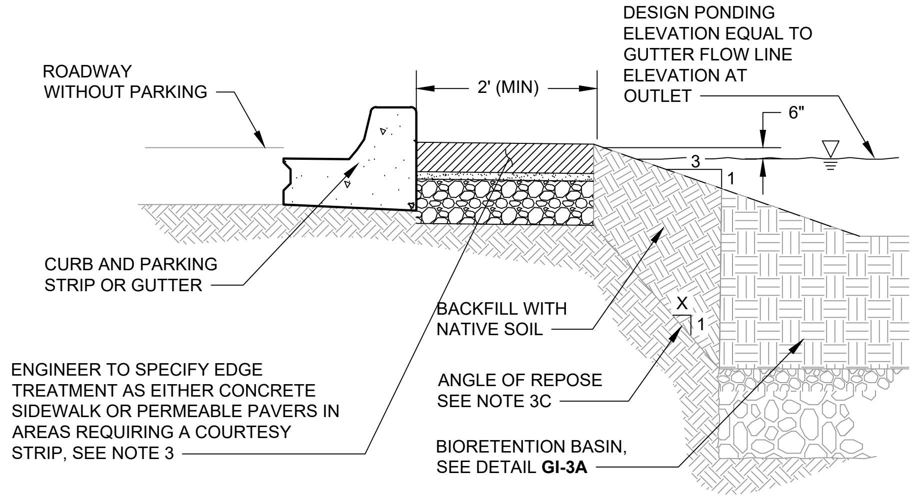
ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE	
DATE: MAY 11, 2018	REVISED: JUNE 11, 2019
DRAWN BY: K. K.	REVISED BY: E. F.
CHECKED BY: A. R.	

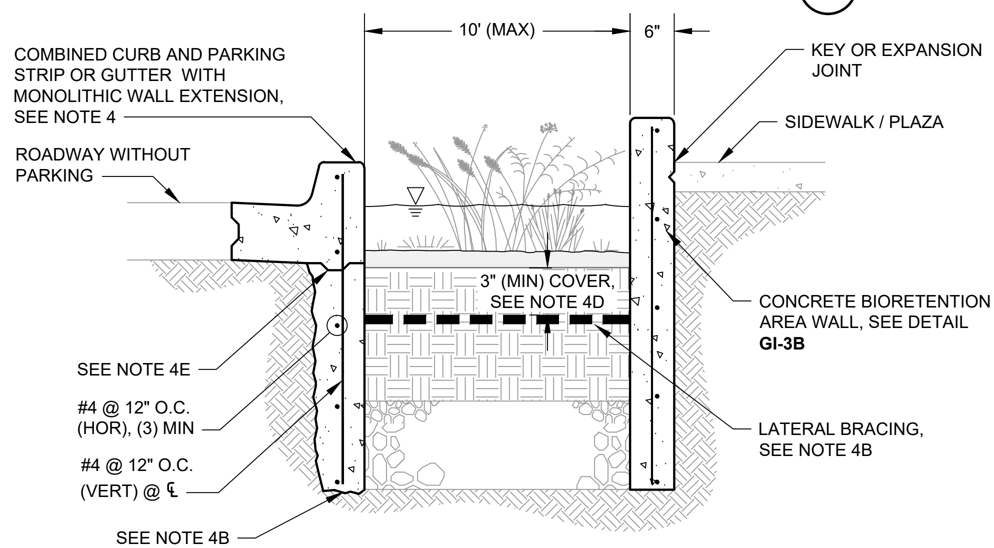
GI-4

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. THE ENGINEER SHALL ADAPT EDGE TREATMENT DESIGN TO ADDRESS SITE SPECIFIC CONSTRAINTS TO EFFECTIVELY STABILIZE ADJACENT PAVEMENT AND MINIMIZE LATERAL MOVEMENT OF WATER.
3. STANDARD CURB EDGE (WHEN SPACE AVAILABLE):
   A. REFER TO LOCAL JURISDICTION STANDARDS FOR CURB AND SIDEWALK DETAILS.
   B. ANGLE OF REPOSE VARIES PER GEOTECHNICAL ENGINEERS RECOMMENDATIONS.
4. VERTICAL SIDE WALLS (WHEN SPACE LIMITED):
   A. ALL BIORETENTION AREA WALLS SHALL EXTEND TO BOTTOM OF AGGREGATE STORAGE LAYER OR DEEPER. MINIMUM DEPTHS SHALL BE DESIGNED TO PREVENT LATERAL SEEPAGE INTO THE ADJACENT PAVEMENT SECTION.
   B. FOOTING AND/OR LATERAL BRACING SHALL SHALL BE DESIGNED BY THE ENGINEER TO WITHSTAND ANTICIPATED LOADING ASSUMING NO REACTIVE FORCES FROM THE UNCOMPACTED BIOTREATMENT SOIL.
   C. BIORETENTION AREA WALLS EXTENDING MORE THAN 36" BELOW ADJACENT LOAD-BEARING SURFACE, OR WHEN LOCATED ADJACENT TO PAVERS, SHALL HAVE FOOTING OR LATERAL BRACING. FOOTING OR LATERAL BRACING MAY BE EXCLUDED ONLY IF THE ENGINEER DEMONSTRATES THAT THE PROPOSED WALL DESIGN MEETS LOADING REQUIREMENTS. WALL SHALL NOT ENCROACH INTO TREATMENT AREA.
   D. CONTRACTOR TO PROVIDE 3" MINIMUM COVER OVER ALL LATERAL BRACING FOR PLANT ESTABLISHMENT.
   E. ALL CONSTRUCTION COLD JOINTS SHALL INCORPORATE EPOXY, DOWEL/TIE BAR, KEYWAY, OR WATER STOP.



STANDARD CURB EDGE AT BIORETENTION BASIN (1)



EXTENDED BIORETENTION AREA WALL WITH LATERAL BRACING (2)

NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: EDGE TREATMENT DETAIL

GREEN INFRASTRUCTURE EXAMPLE DETAILS

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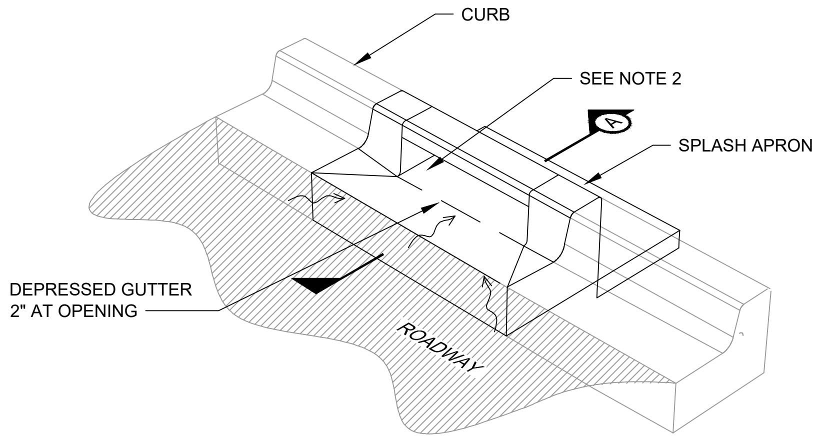
GI-5



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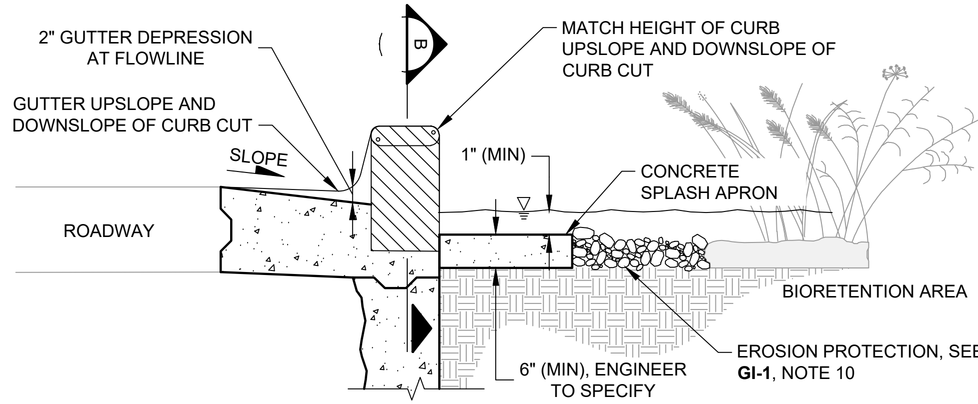
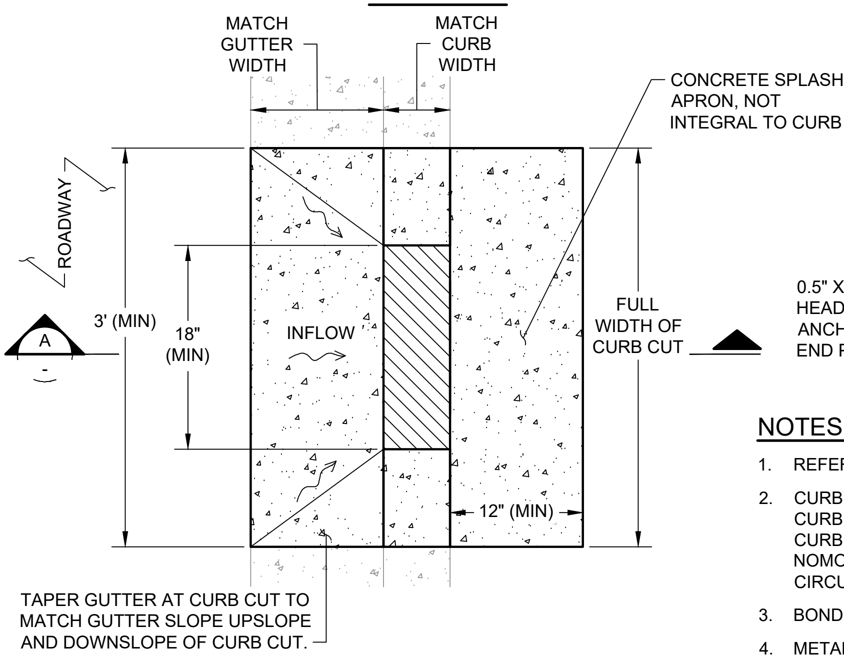
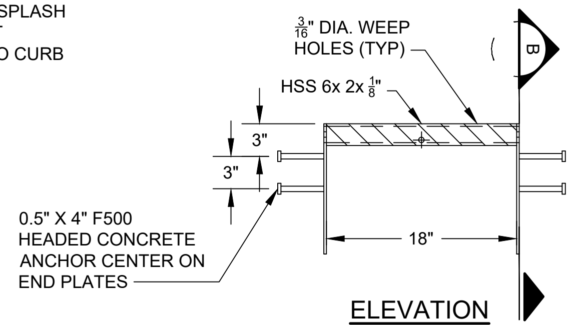


SECTION A

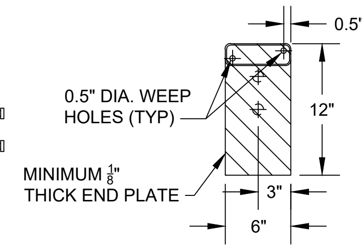


PLAN

METAL INLET ASSEMBLY



ELEVATION



SECTION B

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. CURB CUT INLETS SHALL BE ADEQUATELY SIZED, SPACED, AND SLOPED TO MEET HYDRAULIC REQUIREMENTS. THE CURB CUT OPENING WIDTH SHALL BE SIZED BASED ON THE CATCHMENT AREA, LONGITUDINAL SLOPE ALONG THE CURB, AND THE CROSS SLOPE OF THE GUTTER OR ADJACENT PAVEMENT AT THE INLET. SEE SIZING EQUATIONS AND NOMOGRAPHS FOR CURB OPENING INLETS IN THE U.S. DEPARTMENT OF TRANSPORTATION HYDRAULIC ENGINEERING CIRCULAR NO. 27.
3. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
4. METAL INLET ASSEMBLY SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH ASTM A-123.

NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: GUTTER CURB CUT INLET DETAIL

clean water PROGRAM

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE

DATE: MAY 11, 2018 REVISED: JUNE 11, 2019

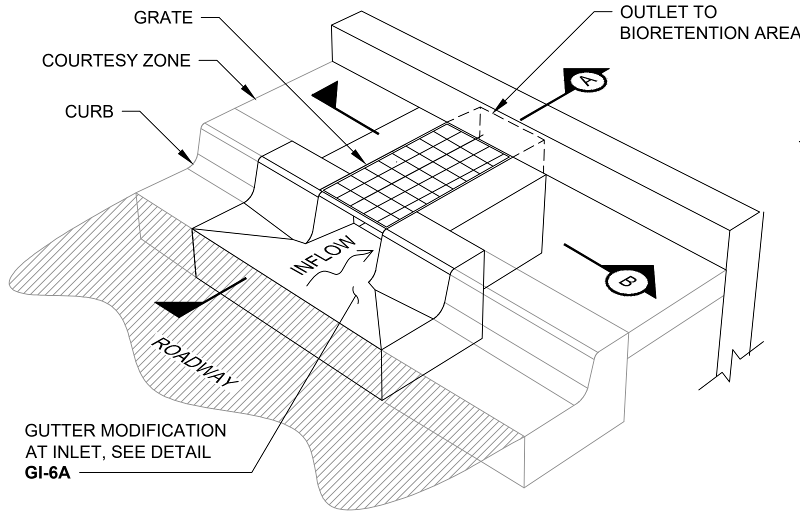
DRAWN BY: K. K. REVISED BY: E.F.

CHECKED BY: A. R.

GI-6A

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. ALL MATERIAL AND WORKMANSHIP FOR TRENCH DRAIN ASSEMBLY SHALL CONFORM TO LOCAL JURISDICTION STANDARDS.
3. TRENCH DRAIN INLETS SHALL BE ADEQUATELY SIZED, SPACED, AND SLOPED TO MEET HYDRAULIC REQUIREMENTS. SEE NOTE 2 DETAIL **GI-6A** FOR REFERENCE.
4. SLOPE TO PROVIDE AT LEAST 1" DROP OVER LENGTH OF CHANNEL OR A MINIMUM OF 2%, WHICHEVER IS LARGER.
5. ALL TRENCH GRATES SHALL BE REMOVABLE, RATED PER THE ANTICIPATED LOADING, AND BOLTED IN PLACE OR OUTFITTED WITH APPROVED TAMPER-RESISTANT LOCKING MECHANISM, FLUSH OR RECESSED IN GRATE.
6. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
7. HORIZONTAL CONTROL JOINTS SHALL BE PROVIDED EVERY 10' (LINEAR), OR PER MANUFACTURER'S RECOMMENDATIONS.
8. APPLY EPOXY BONDING AGENT AT ALL TRENCH DRAIN CONSTRUCTION COLD JOINTS.
9. INLET CURB CUT AND CONCRETE CHANNEL WIDTH SHALL BE SIZED TO ACCOUNT FOR CATCHMENT AREA AND GUTTER SLOPE.



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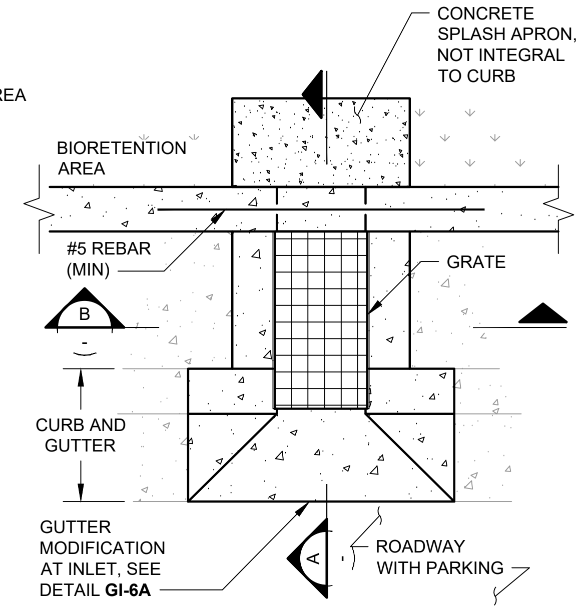
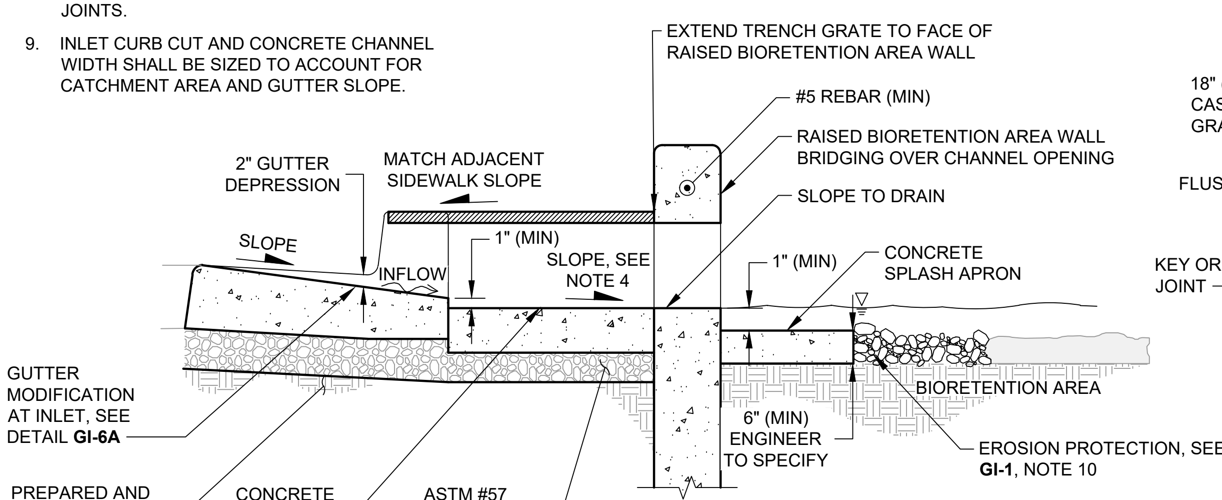
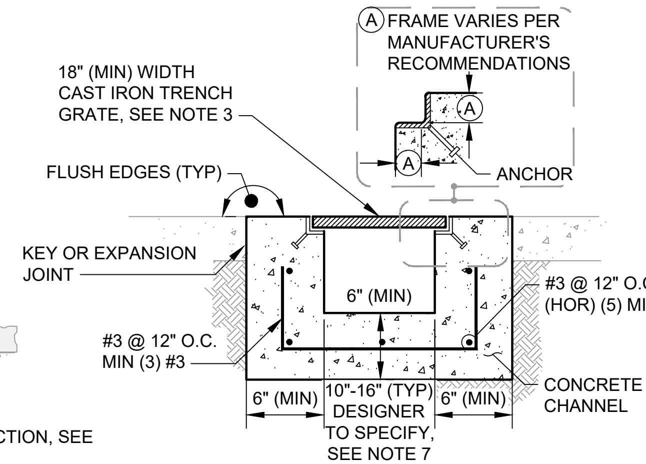




SECTION A



SECTION B

NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: TRENCH DRAIN CURB CUT INLET DETAIL

clean water PROGRAM

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

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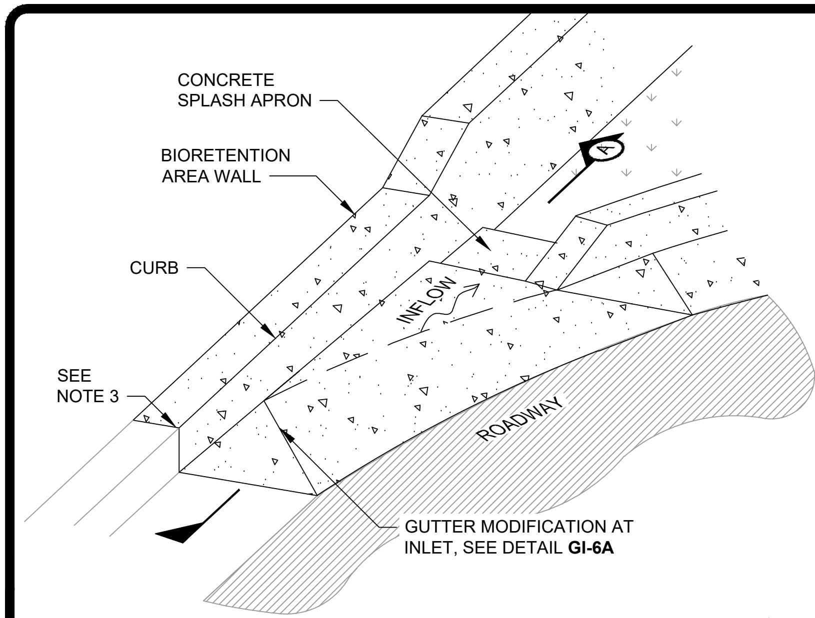
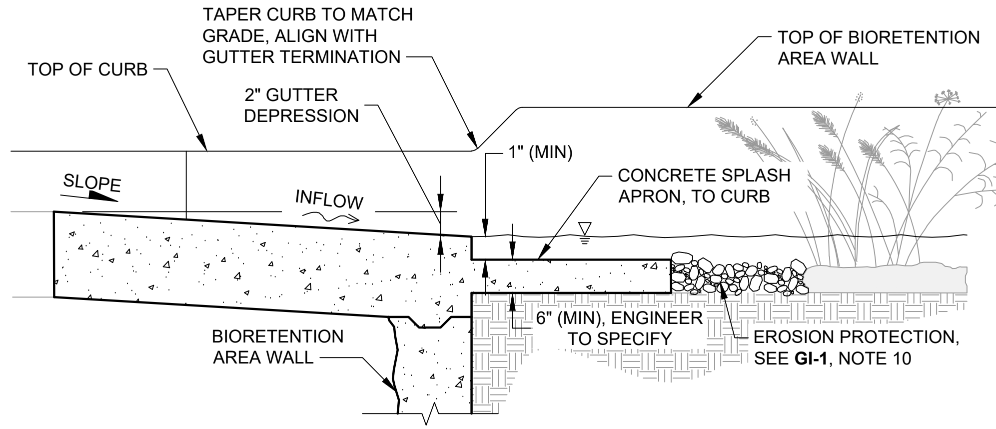
CHECKED BY: A. R.	

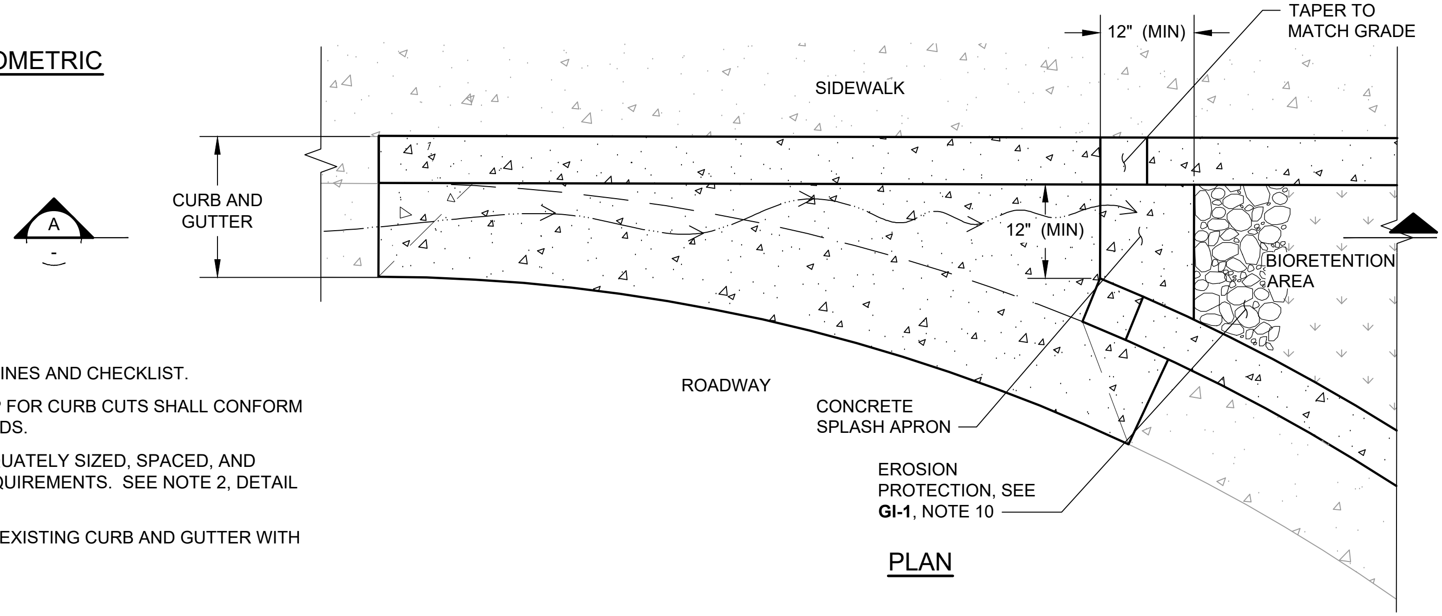
GI-6B



ISOMETRIC



SECTION A



PLAN

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. ALL MATERIAL AND WORKMANSHIP FOR CURB CUTS SHALL CONFORM TO LOCAL JURISDICTION STANDARDS.
3. CURB CUT INLETS SHALL BE ADEQUATELY SIZED, SPACED, AND SLOPED TO MEET HYDRAULIC REQUIREMENTS. SEE NOTE 2, DETAIL **GI-6A** FOR REFERENCE.
4. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.

NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: CURB CUT AT BULBOUT INLET DETAIL

cleanwater PROGRAM

GREEN INFRASTRUCTURE EXAMPLE DETAILS

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

SCALE: NOT TO SCALE

DATE: MAY 11, 2018 REVISED: JUNE 11, 2019

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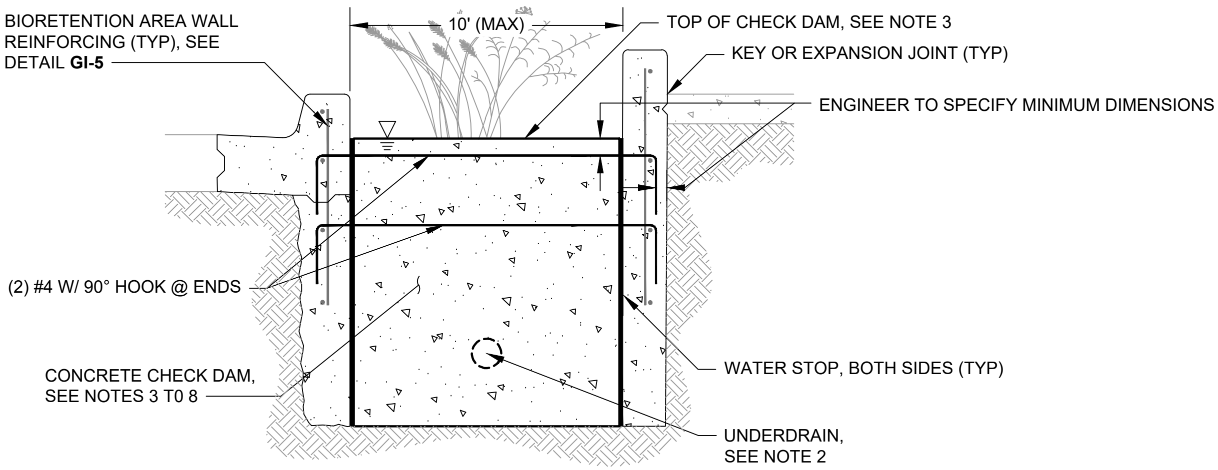
CHECKED BY: A. R.

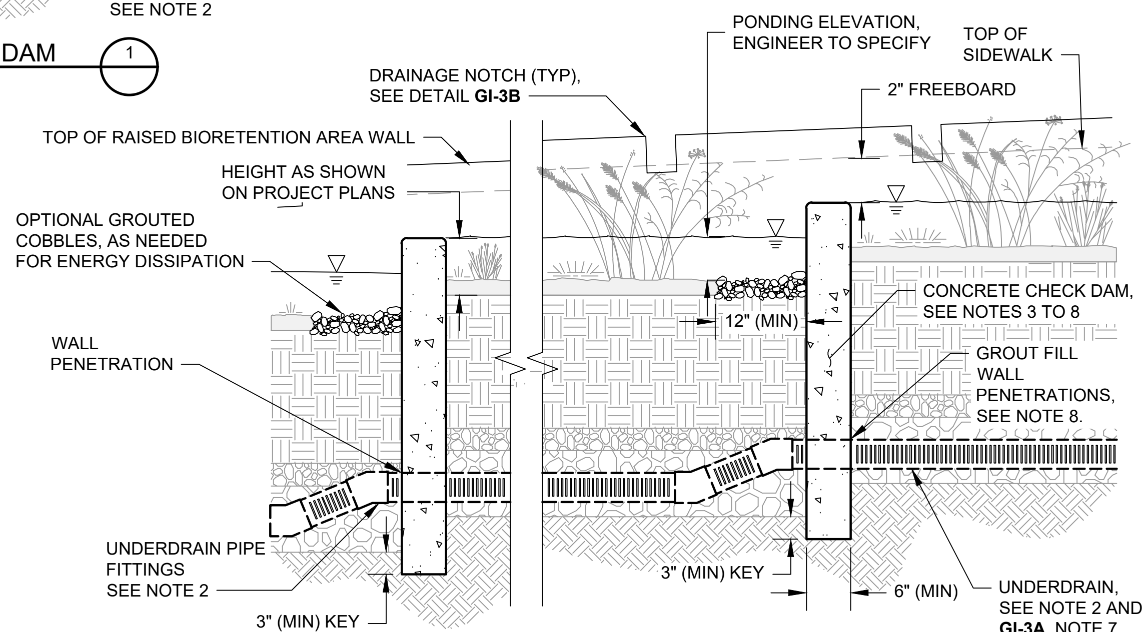
GI-6C



SECTION - CONCRETE CHECK DAM (1)

NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. UNDERDRAIN TO PASS THROUGH CHECK DAM IN NON-PERFORATED PIPE. PIPE FITTINGS SHALL BE USED TO ACCOMMODATE CHANGES IN GRADE, AS NEEDED.
3. HEIGHT AND SPACING OF CHECK DAMS SHALL BE ESTABLISHED BASED ON THE PONDING DEPTH REQUIRED TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS AND THE MAXIMUM DESIRED DROP FROM THE SURROUNDING GRADE TO THE FACILITY BOTTOM.
4. ALL MATERIAL AND WORKMANSHIP FOR CHECK DAM ASSEMBLY SHALL CONFORM TO LOCAL JURISDICTION STANDARD SPECIFICATIONS.
5. CONCRETE CHECK DAM SHALL BE CONTINUOUS (NO JOINTS) AND REINFORCED WITH #4 BAR, PLACED AT 18" ON CENTER, EACH WAY.
6. CONCRETE CHECK DAM SHALL BE DESIGNED BY THE ENGINEER AND MEET STRUCTURAL REQUIREMENTS FOR LATERAL BRACING WHEN USED AS LATERAL BRACING.
7. TOP OF CHECK DAM TO BE LEVEL WITH CREST ELEVATION MATCHING PONDING ELEVATION UNLESS NOTCH SIZED TO CONVEY DESIGN FLOWS PROVIDED.
8. GROUT ALL PENETRATIONS, CRACKS, SEAMS, AND JOINTS WITH CLASS "C" MORTAR.

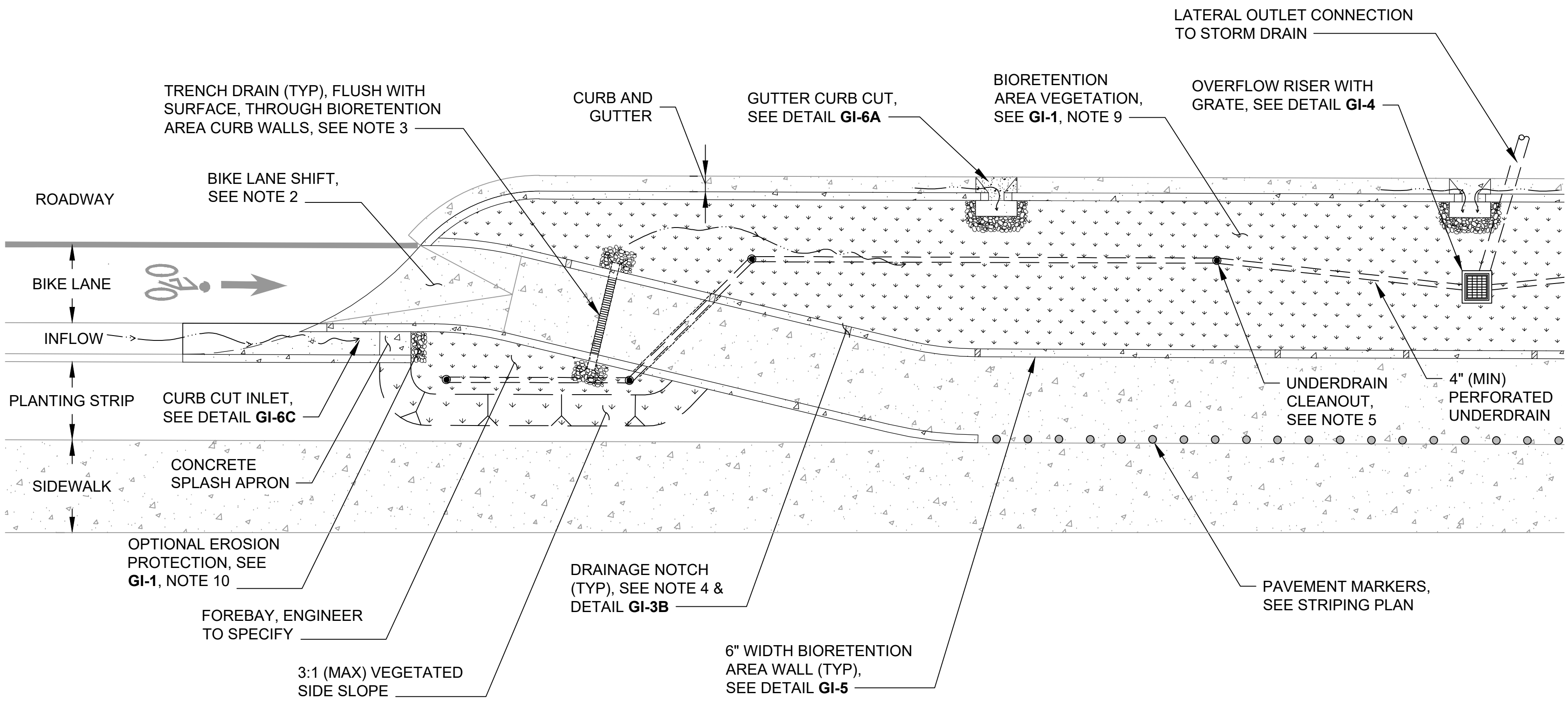


PROFILE - CONCRETE CHECK DAM (2)

NOT FOR CONSTRUCTION

BIORETENTION COMPONENTS: CHECK DAM DETAIL

GREEN INFRASTRUCTURE EXAMPLE DETAILS	SCALE: NOT TO SCALE	
	DATE: MAY 11, 2018 REVISED: JUNE 11, 2019	
ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM	DRAWN BY: K. K. REVISED BY: E. F.	
	CHECKED BY: A. R.	GI-7



NOTES:

1. REFER TO **GI-1** NOTES FOR GUIDELINES AND CHECKLIST.
2. RAMP BIKE LANE UP ONTO BULBOUT AND SHIFT LANE OVER. MAXIMUM 1:5 HORIZONTAL TRANSITION RATE. TRANSITION GEOMETRY SHALL CONFORM TO LOCAL JURISDICTION STANDARDS.
3. HYDRAULIC CONNECTION OF SEPARATED BIORETENTION AREAS PROVIDED BY TRENCH DRAINS. ENGINEER TO SPECIFY, FOLLOWING FLOW AND STRUCTURAL REQUIREMENTS.
4. LAY OUT DRAINAGE NOTCHES AS APPLICABLE TO PREVENT PONDING BEHIND BIORETENTION AREA WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
5. PROVIDE ONE UNDERDRAIN CLEANOUT PER BIORETENTION AREA (MIN). CLEANOUT REQUIRED AT UPSTREAM END AND PIPE ANGLE POINTS EXCEEDING 45 DEGREES. LONGITUDINAL SLOPE OF PIPE SHALL BE 0.5% (MIN). PIPE SLEEVES REQUIRED FOR UNDERDRAINS TRANSITIONING BETWEEN BIORETENTION AREAS.
6. DRAWING GI-XX MODIFIED FROM THE BASMAA URBAN GREENING BAY AREA TYPICAL GI DETAILS FIGURE C-1.4.

NOT FOR CONSTRUCTION

clean water PROGRAM

BIORETENTION AREA: WITH BIKE LANE PLAN VIEW

GREEN INFRASTRUCTURE EXAMPLE DETAILS	SCALE: NOT TO SCALE	
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GREEN RESERVE

The **American Recovery and Reinvestment Act (ARRA), Green Reserve** of 2009, through the State Revolving Fund, provides funding for a wide variety of qualifying projects in the categories of: ***green infrastructure, energy efficiency, water efficiency, and other innovative projects***. For more information on ARRA, to find out if your current or future planned project meets the necessary criteria, and how to apply, visit **www.Recovery.gov**.

A CONCEPTUAL GUIDE TO EFFECTIVE GREEN STREETS DESIGN SOLUTIONS

Green Streets

Residential Streets
Commercial Streets
Arterial Streets
Alleys

Green Street designs provide better environmental performance while creating attractive, safer environments.

A Green Street is a street that uses natural processes to manage stormwater runoff at its source.

Streets comprise a significant percentage of publicly owned land in most communities, and thus offer a unique opportunity to manage for environmental outcomes. A Green Street uses a natural systems approach to reduce stormwater flow, improve water quality, reduce urban heating, enhance pedestrian safety, reduce carbon footprints, and beautify neighborhoods.

Through various combinations of plants and soils, these objectives—and several others—can be met on different types of streets in many settings. Green Street features include vegetated curb extensions, sidewalk planters, landscaped medians, vegetated swales, permeable paving, and street trees. This guide provides an overview of different strategies that can be employed in transportation rights-of-way at the local or neighborhood scale.

Residential Streets

STORMWATER CURB EXTENSIONS
PERMEABLE PAVING
VEGETATED SWALES

Residential streets offer the greatest potential for building Green Streets in new neighborhoods or retrofitting existing streets because the streets are typically slower, less trafficked, and likely to already have some landscape elements.

These days, it is fairly common for homes to have rain gardens incorporated into their landscaping to collect and store stormwater runoff from rooftops, driveways, and patios. "Rain garden" is the general term used to describe stormwater strategies that use plants and soils to filter, absorb, and slow rainwater on the landscape surface.

Similar types of rain gardens can take various forms within the street right-of-way itself—the edges of the street can be built to allow stormwater to flow into a landscape area, or space within the paved area of the street can be converted to landscape, increasing permeability. Additionally, permeable paving that is durable, load-bearing, and built with an underlying reservoir can temporarily store water prior to infiltration.

In new construction situations, Green Streets can be designed to handle significant volumes of water. In retrofit situations, they can typically handle all of the rain from small storms, while excess water from large storms can overflow into existing storm sewer systems.

Rain gardens are beautiful landscape features that naturally filter runoff and require less maintenance than turf grass.

STORMWATER CURB EXTENSIONS

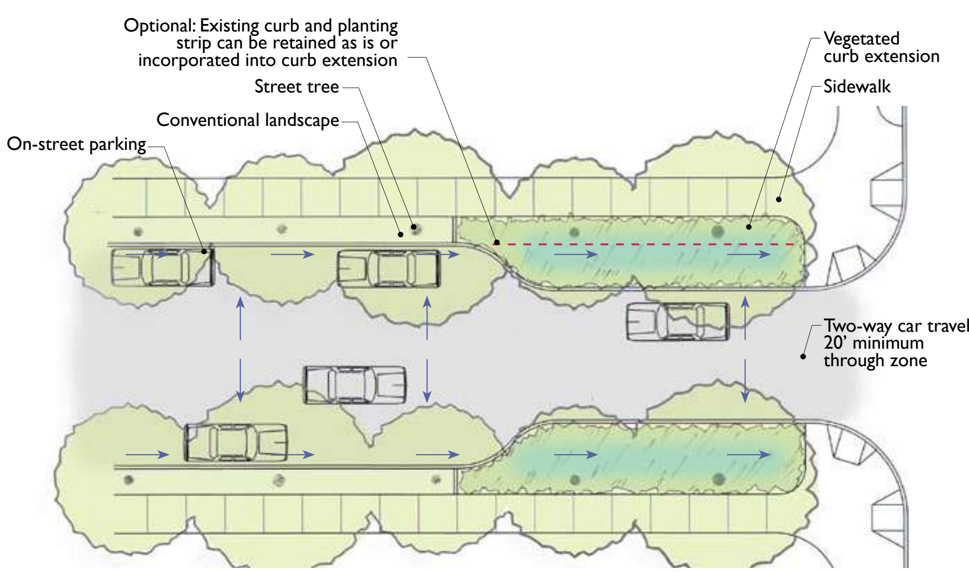
Conventional curb extensions (also known as curb bulb outs, chokers, or chicanes) have been used for decades to enhance pedestrian safety and help in traffic calming.

A stormwater curb extension simply incorporates a rain garden into which runoff flows.

TYPICAL STREET

OPPORTUNITY

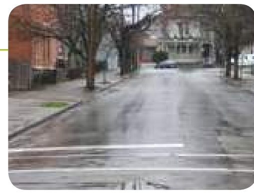
IMPLEMENTATION



PERMEABLE PAVING

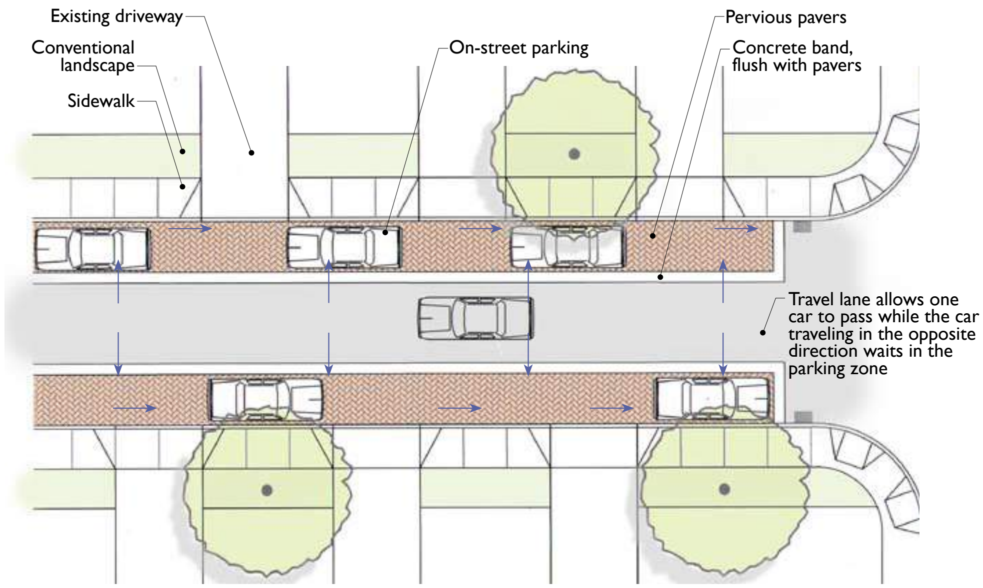
Permeable paving (pavers, or porous asphalt and pervious concrete) in the parking lane converts impervious surfaces to allow stormwater to absorb into the ground, which reduces the amount of runoff without any loss of parking on the street.

The aesthetics of permeable paving can also give the illusion of a narrower street and therefore help calm traffic.


EXISTING


OPPORTUNITY


IMPLEMENTATION



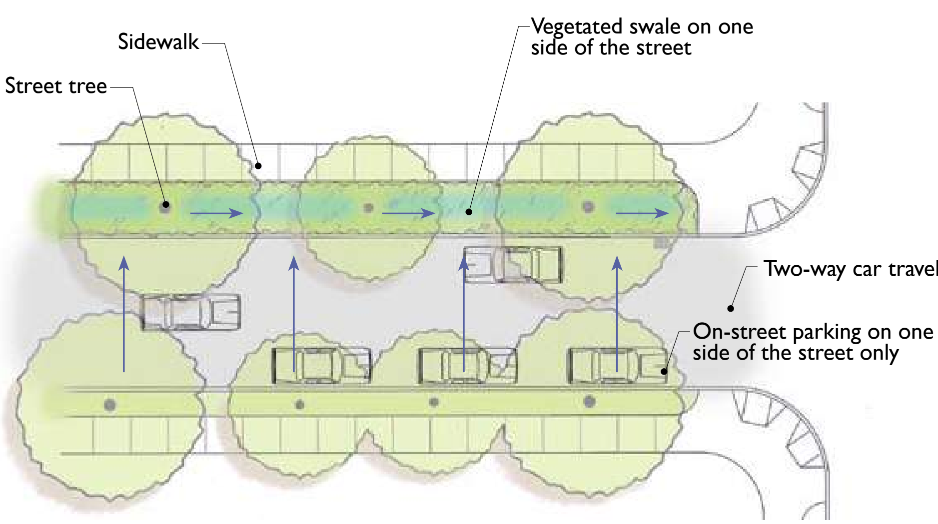
VEGETATED SWALES

Swales are long, shallow vegetated depressions, with a slight longitudinal slope. As water flows through the swale, it is slowed by the interaction with plants and soil, allowing sediments and pollutants to settle out. Water soaks into the soil and is taken up by plants, and may infiltrate further into the ground if the soil is well-drained.


EXISTING


OPPORTUNITY


IMPLEMENTATION



Commercial Streets

STORMWATER PLANTERS
STORMWATER CURB EXTENSIONS
PERMEABLE PAVING

Commercial streets in most urban areas need to accommodate a wide range of users and uses including pedestrians, drivers, bikers, transit riders, on-street parking, outdoor seating, lighting, trees, etc. Because of all these demands, finding space to collect and manage stormwater can at first appear challenging. There are, however, several design options that towns and cities can consider when integrating stormwater mangement into even their most active streets.

The key is thinking creatively in finding space that can accommodate multiple purposes in one space, such as a street tree pit designed to collect runoff, or the curb extensions (also known as "pedestrian bulb outs") at the corners designed to reducing crossing distances for pedestrians that can also contain a rain garden. These design options are more easily accommodated in new streets where the location of underground utilities is considered from the start. More strategic design is necessary for streets with existing utilities. The pay-off of these efforts, though, is a more attractive, walkable street that considerably reduces polluted runoff.

A community's identity is often most evident on its commercial streets. Green Street techniques not only achieve environmental goals but can greatly improve the look and feel of a community.

STORMWATER PLANTERS

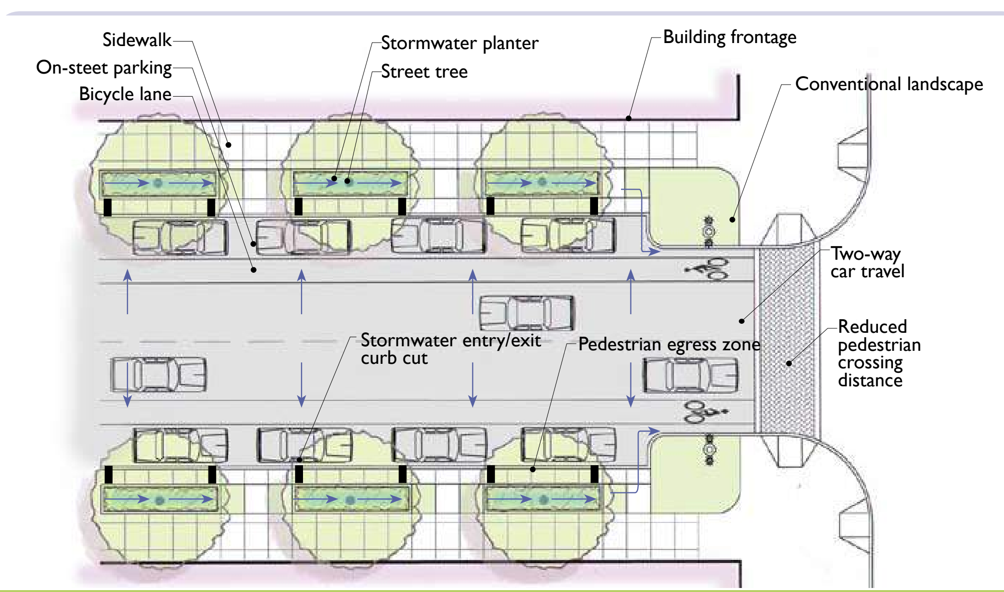
Planters are long, narrow landscaped areas with vertical walls and flat bottoms, typically open to the underlying soil. They allow for more storage volume than a swale in less space.

Water flows into the planter, absorbs into the plants and topsoil, fills to a predetermined level, and then, if necessary, overflows into a storm sewer system. If desired, planters can accommodate street trees.

TYPICAL STREET

OPPORTUNITY

IMPLEMENTATION



STORMWATER CURB EXTENSIONS

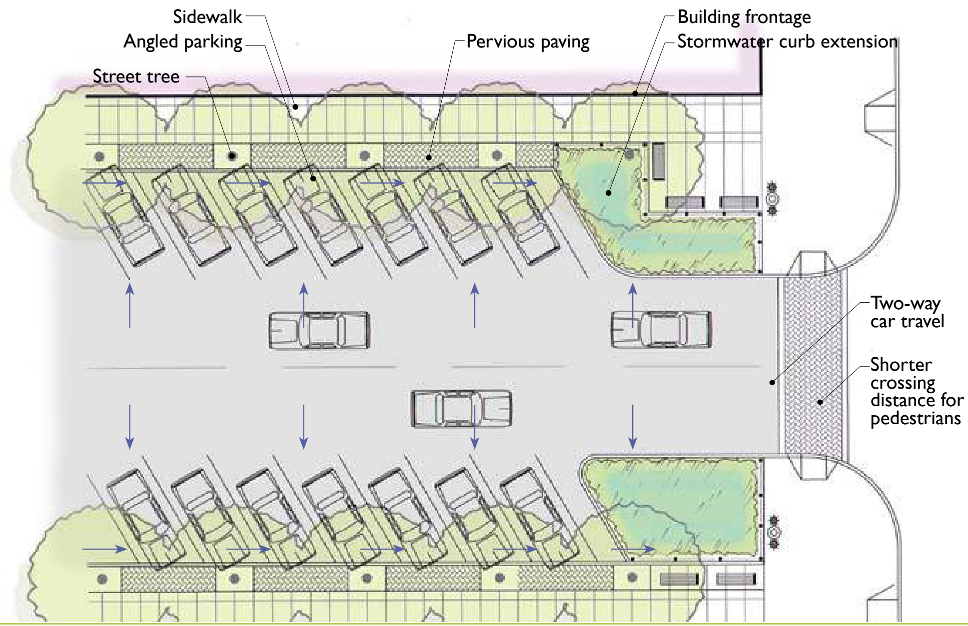
Stormwater curb extensions on commercial streets are similar to those on residential streets. They are rain gardens typically located near the corners that can also provide the pedestrian with a more comfortable crossing.

Curb extensions can also be located mid-block by converting one or more parking spaces.


EXISTING


OPPORTUNITY


IMPLEMENTATION



PERMEABLE PAVING

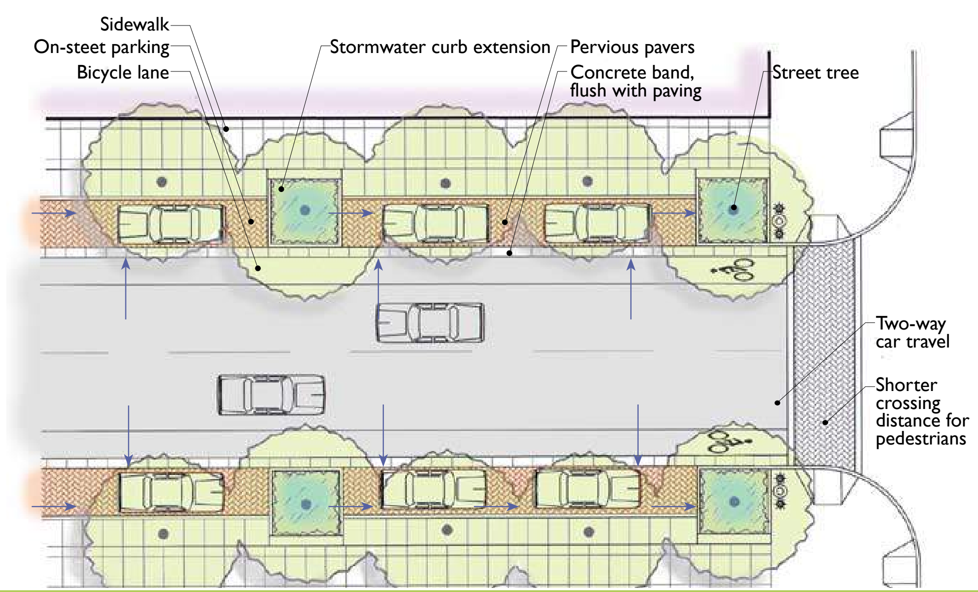
Permeable paving on commercial streets can be incorporated into sidewalks and parking lanes.

Recent advances in permeable paving technologies now make many appropriate for higher speeds or where large, heavy vehicles are expected to be parked—areas such as loading zones and bus stops.


EXISTING


OPPORTUNITY


IMPLEMENTATION



Arterial Streets

VEGETATED SWALES

Arterial streets in towns and cites are often characterized by wide expanses of pavement, little greenery, and little to address pedestrian needs. Should an arterial street already have landscape areas adjacent to the roadway or within grassy medians, then retrofitting these areas to accommodate rainwater will significantly reduce runoff and help protect water quality.

Where adjacent landscape space does not exist, a process of "road dieting" can be undertaken. This involves determining just how much paved surface is necessary to safely manage travel, and how much can be converted to green space. In addition to managing runoff, this is also an opportunity to retrofit the functionality of arterial streets, making them more "multi-modal" by incorporating sidewalks, on-street bike lanes, or landscape-separated bike greenways.

Again, as with residential and commercial streets, though it is easier to plan and design all of these uses into a roadway from the beginning, most arterials present opportunities to incorporate Green Street features, and can be highly successful.

Busy arterials need not only be a conduit for traffic. They have the potential to be attractive, green boulevards that reduce runoff and reinforce a community's identity.

VEGETATED SWALES

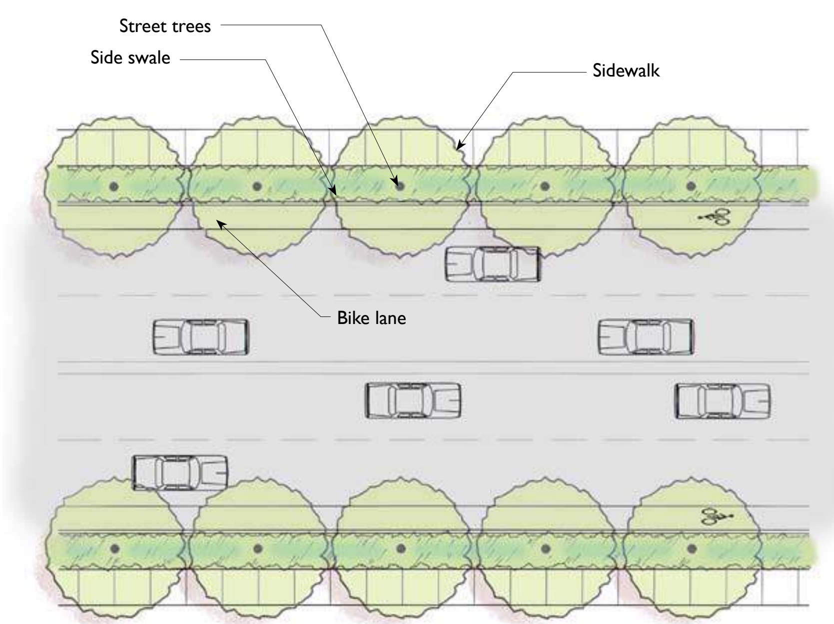
Like residential streets, arterial roadways are good street types for swales because they typically have long, linear stretches of uninterrupted space that can be used to manage stormwater.

Some arterials may not have landscape space in place but do have travel lanes or paved shoulders that can be narrowed to create space for swales.

TYPICAL STREET

OPPORTUNITY

IMPLEMENTATION



Alleys

PERMEABLE PAVING
VEGETATED SWALES

In many towns and cities, alleys comprise a significant amount of impervious surface and are sometimes prone to flooding because they are often not connected to the sewer system. Green Street techniques like vegetated swales and permeable paving effectively reduce and treat runoff, alleviate flooding, and are far less expensive than installing connections to sewers.

Alleys are the "low-hanging fruit" of Green Street design—a good starting point for towns and cities to begin incorporating stormwater management.

PERMEABLE PAVING

Alleys are typically low-speed and low-trafficked streets and therefore suitable locations for using permeable paving. The entire surface could be permeable, or if heavier vehicles are anticipated for loading and unloading, or the alley is "reversed crowned" (sloping toward the center line), then only the middle section needs to be permeable.

TYPICAL ALLEY

OPPORTUNITY

IMPLEMENTATION

VEGETATED SWALES

If the alley is crowned in such a way that water flows to the side, then stormwater can be accommodated by simply greening edges of the alley with swales and planters.

If necessary, water can flow through pipes or covered trenches to allow vehicle access to garages and driveways.

TYPICAL ALLEY

OPPORTUNITY

IMPLEMENTATION

Illustrations and photographs used in this brochure are from the EPA publication *Stormwater Management Handbook–Implementing Green Infrastructure in Northern Kentucky Communities* and were created by Nevue Ngan Associations of Portland, Oregon.

This handbook, as well as other valuable resources, are available at both www.epa.gov/smartgrowth and www.epa.gov/greeninfrastructure.

EPA-833-F-09-002 | August 2009 | www.epa.gov/greeninfrastructure

EPA GREEN RESERVE

Appendix

N

Rainwater Harvesting

For a rainwater harvesting system to fully meet Provision C.3 stormwater treatment requirements, there must be sufficient demand to use 80 percent of the average annual rainfall runoff ("C.3.d amount of runoff"), as specified in Provision C.3.d of the MRP. In order to size the cistern (or other storage device) to achieve the appropriate combination of drawdown time and cistern volume to harvest and use the C.3.d amount of runoff, project designers may refer to the sizing curves presented in this appendix, which are from Appendix F of the 2011 report, "Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report" (BASMAA 2011)[1].

This appendix includes the following excerpts from the 2011 report:

- Map of Alameda County Precipitation Polygons for applicable precipitation gages:
- Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-Hour Drawdown Time (by precipitation gage)
- Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less (by precipitation gage)
- Curves for Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1 Acre 100% Impervious Tributary Area (by precipitation gage):
    - Figure F-1: Berkeley
    - Figure F-3: Dublin
    - Figure F-4: Hayward
    - Figure F-8: Palo Alto
    - Figure F-11: San Jose

[1] This report is available on the Clean Water Program's website (www.cleanwaterprogram.org – click on "Resources", then "Development" and scroll to "Feasibility Infeasibility Criteria Report").

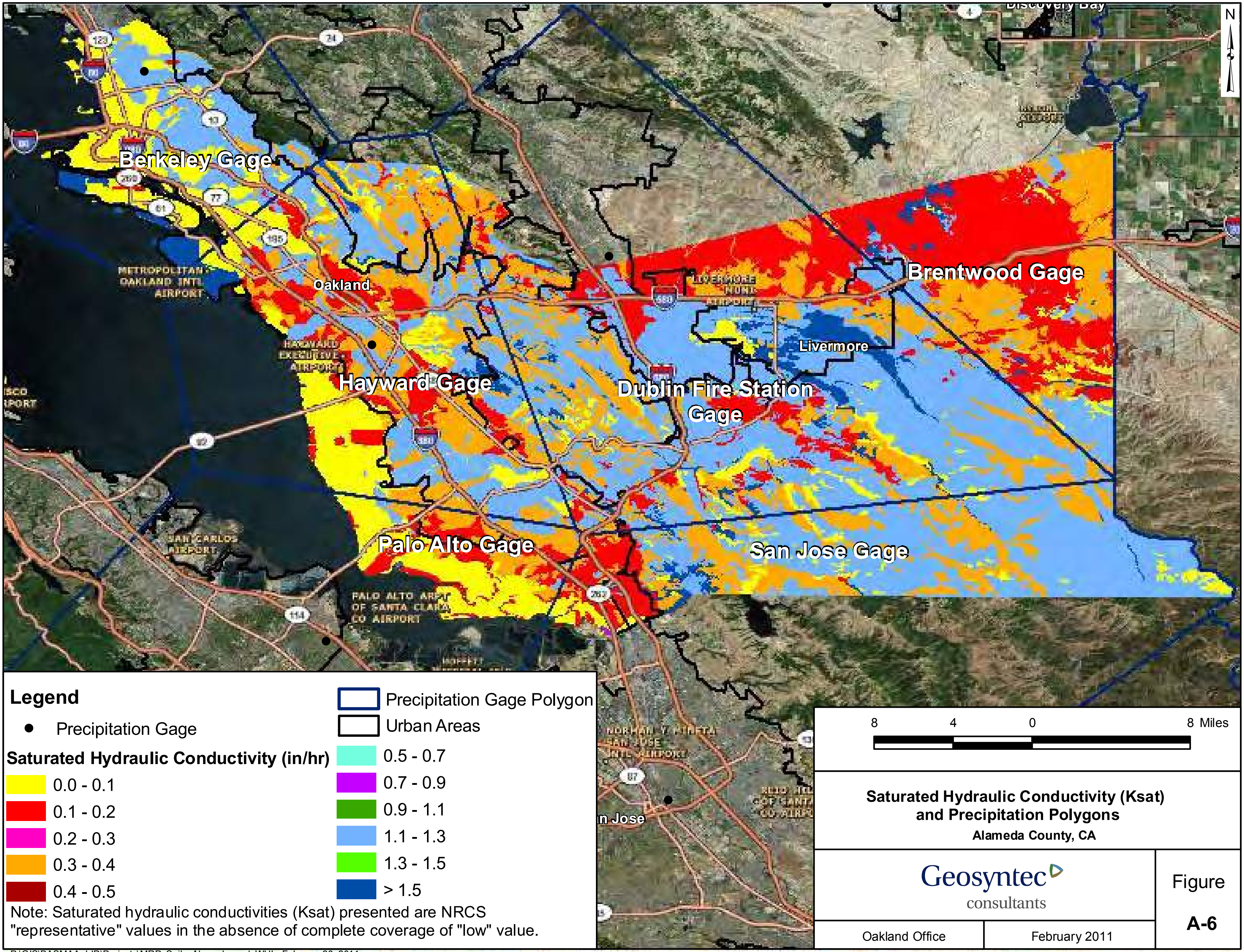


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Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-hour Drawdown Time

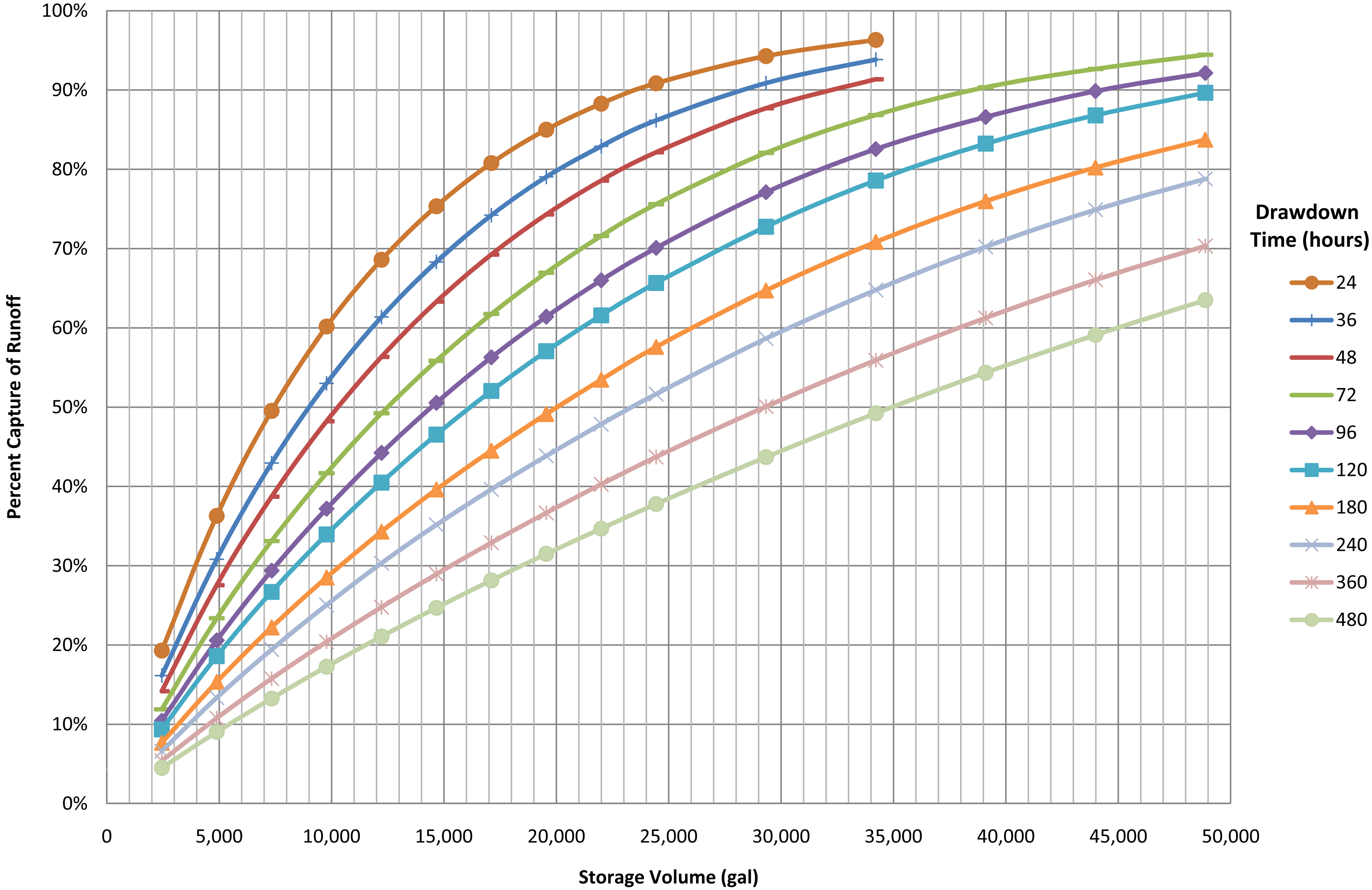
Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	48	23,000	11,500
Brentwood	48	19,000	9,500
Dublin	48	21,000	10,500
Hayward	48	23,500	11,750
Lake Solano	48	29,000	14,500
Martinez	48	23,000	11,500
Morgan Hill	48	25,500	12,750
Palo Alto	48	16,500	8,250
San Francisco	48	20,000	10,000
San Francisco Oceanside	48	19,000	9,500
San Jose	48	15,000	7,500

If a longer drawdown time (and lower minimum demand) is desired, Table 9 includes the maximum drawdown time allowable to achieve 80 percent capture for a cistern sized at 50,000 gallons or less per acre of impervious area, along with the required cistern sizes and daily demands.

Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less

Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	180	44,000	5,900
Brentwood	240	42,000	4,200
Dublin	240	41,000	4,100
Hayward	240	47,500	4,800
Lake Solano	120	45,000	9,000
Martinez	180	44,000	5,900
Morgan Hill	180	49,000	6,500
Palo Alto	360	44,000	2,900
San Francisco	240	45,500	4,600
San Francisco Oceanside	240	43,000	4,300
San Jose	480	48,000	2,400

Figure F-1: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Berkeley



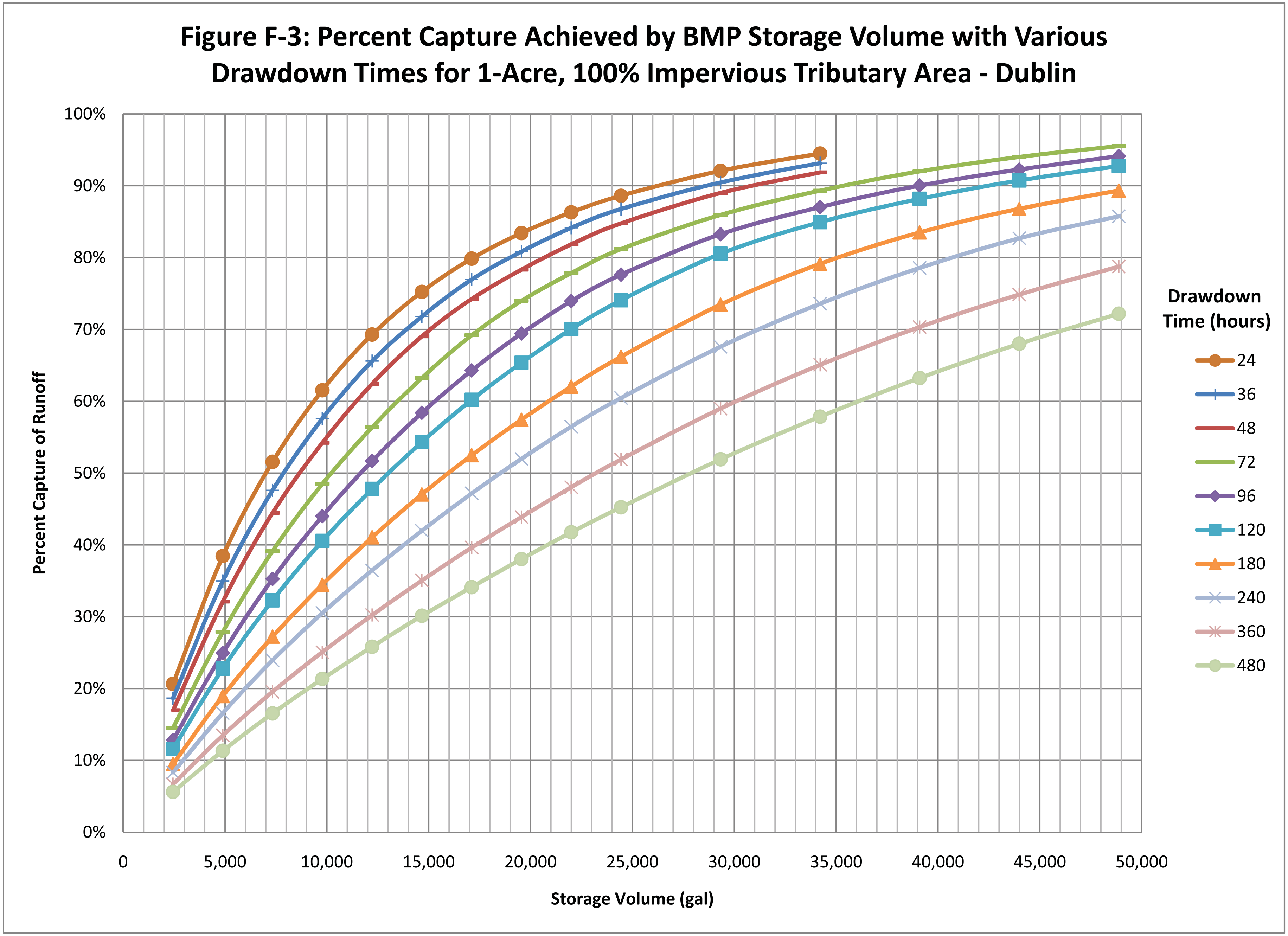


Figure F-3: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Dublin
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

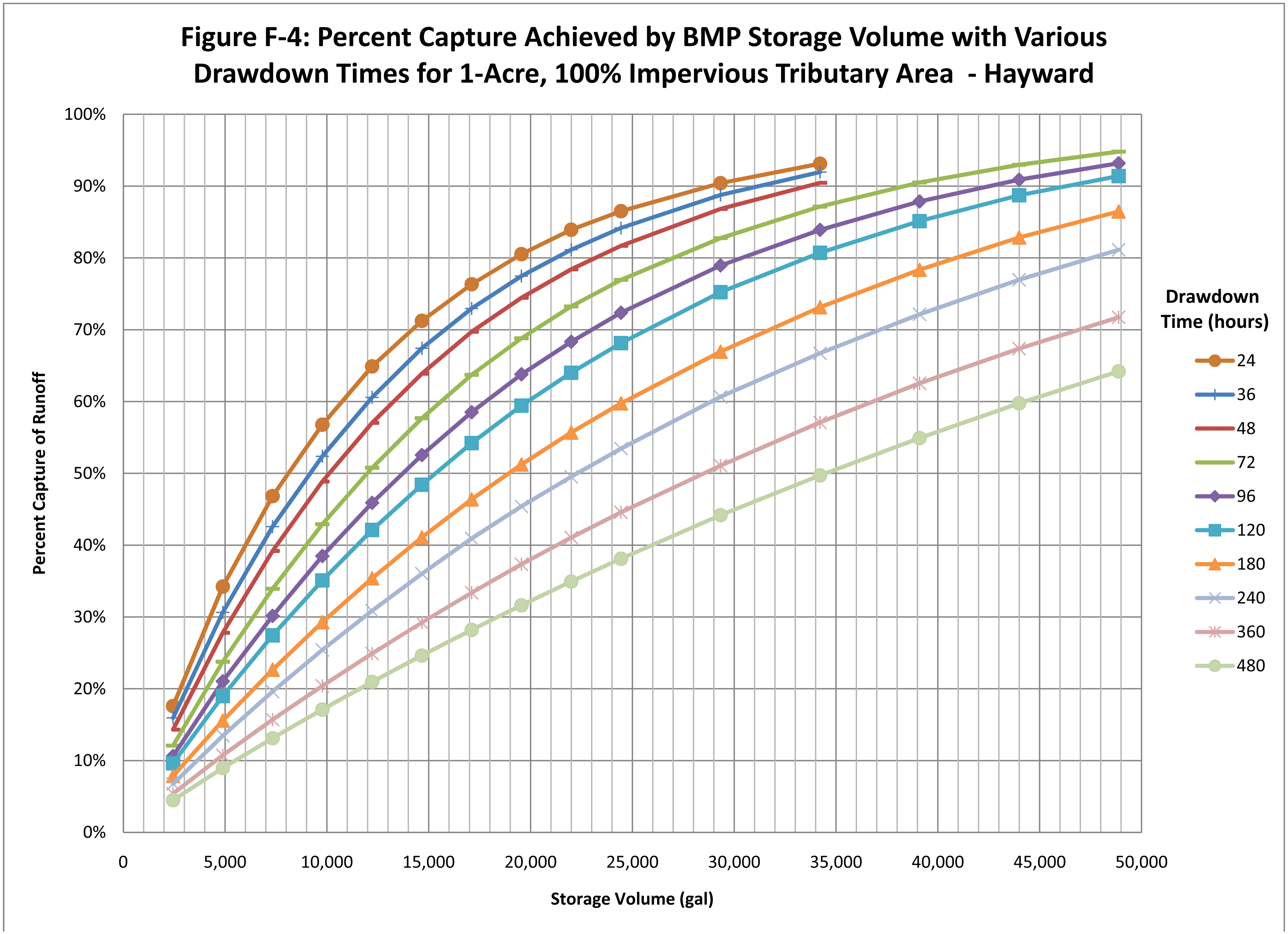


Figure F-4: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Hayward
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

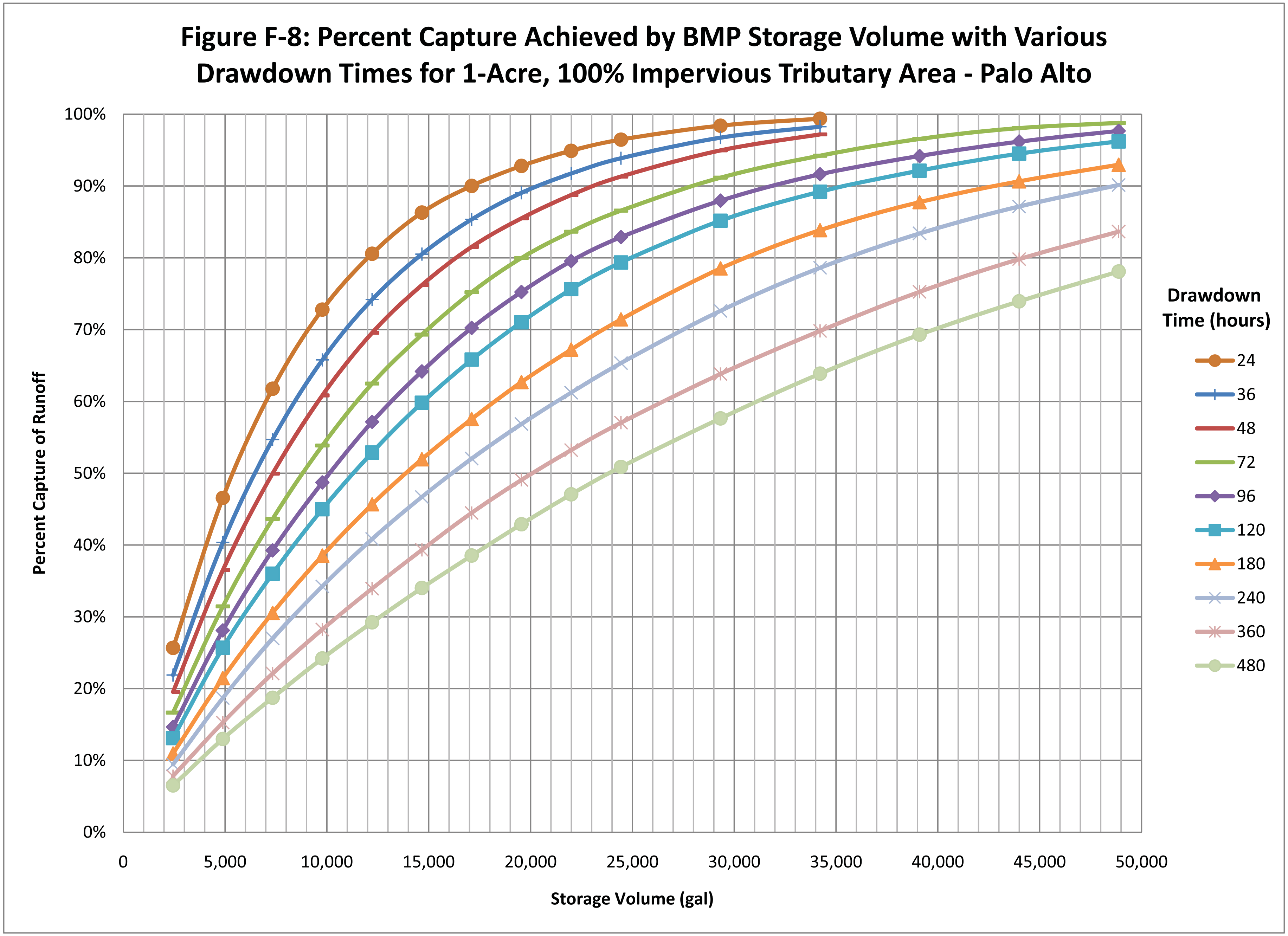


Figure F-8: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Palo Alto
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

Figure F-11: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - San Jose