# C.3 Stormwater Technical Guidance

*For use by developers, builders and project applicants to design and build low impact development projects*

October 2014

Version 4.1

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
Clean Water. Healthy Community.
www.flowstobay.org

***A Program of the City/County Association of Governments***

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# Credits

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# Glossary of Terms

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| **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 Permit. The BAHM is available for download at www.bayareahydrologymodel.com. |
| **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** | The Bay-Friendly Landscaping & Gardening Coalition is a non-profit organization that works in partnership with public agencies, the landscape industry, and property owners to reduce waste and pollution, conserve natural resources, and create vibrant landscapes and gardens.<br>http://www.bayfriendlycoalition.org/ |
| **Beneficial Use** | A waterbody's beneficial uses are the resources, services, and qualities of aquatic systems that are the ultimate goals of protecting and achieving high water quality. The beneficial uses of surface waters, groundwaters, marshes, and mudflats are legally defined in the San Francisco Bay Basin Water Quality Control Basin Plan and serve as a basis for establishing water quality objectives and the discharge prohibitions or conditions necessary to attain them. |
| **Best Management Practice (BMP)** | Any program, technology, process, siting criteria, operational method or measure, or engineered system, which when implemented prevents, controls, removes, or reduces pollution. Includes schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce water pollution. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, litter or waste disposal, or drainage from raw material storage. |
| **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, |

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| | 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, if infiltration, evapotranspiration and rainwater harvesting and use are infeasible. 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 approved by the Regional Water Board, or equivalent. |
| **Buffer Strip or Zone** | Strip of erosion-resistant vegetation over which stormwater runoff as sheet flow 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 |

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| | 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.cabmphandbooks.com. Successor to the Storm Water Quality Task Force (SWQTF). |
| **Clean Water Act (CWA)** | The Federal Water Pollution Prevention and Control Act, or Clean Water Act (33 U.S. Code 1251 *et seq.*) is intended to control or eliminate surface water pollution and establishes the National Pollutant Discharge Elimination System of permits to regulate surface water discharges from municipal storm drains, publicly-owned treatment works and industrial discharges. |
| **Cobbles** | Natural stones of various sizes generally consisting of larger granular material ranging from 6 inches to 24 inches diameter set on soil. |
| **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 municipality may adopt for a project in connection with a discretionary action (e.g., adoption of an EIR or negative declaration or issuance of a use permit). COAs may include features to be incorporated into the final plans for the project and may also specify uses, activities, and operational measures that must be observed over the life of the project. |
| **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 adopted by the State Water Resources Control Board (SWRCB) for the discharge of stormwater associated with |

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| | 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. |
| **Countywide Program** | San Mateo Countywide Water Pollution Prevention Program. |
| **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 in order to transmit runoff directly to subsurface soil. |
| **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 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 creek channel. Dry weather flows in storm drains may result from human activities, such as over-irrigation. |
| **Dry Well** | Structure placed in an excavation or boring, or excavation filled with open-graded rock, that is designed to collect stormwater and infiltrate into the subsurface soil. |
| **Erosion** | The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or timber cutting. |

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| **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, sedimentation 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 based on a long-term time history of rainfall and runoff records, 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 mitigate 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 excavation and/or filling of the land surface to a desired shape or elevation. |
| **Green Roof/ Roof Garden** | Vegetated roof systems that retain and filter stormwater prior to drainage off building rooftops. |
| **Groundwater** | Subsurface water that occurs in pervious 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 water elevation. In slow-flowing open systems, the difference in water surface elevation, e.g., between an inlet and outlet. |

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| **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** | "Hydrograph modification", or more generally the changes in natural watershed hydrological processes and runoff characteristics caused by urbanization or other land use changes that result in increased stream flows and sediment transport. |
| **Hydrologic Soil Group** | Classification of soils by the Natural Resources Conservation Service 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 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 |

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| | 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, or, where these are infeasible, 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)** | Standard, established by the 1987 amendments to the Clean Water Act, for the implementation of municipal stormwater pollution prevention programs. The Countywide Program uses a continuous improvement approach, regularly updating its performance standards to achieve MEP. |
| **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 Permit (MRP)** | The Phase I municipal stormwater NPDES permit under which discharges are permitted from municipal separate storm sewer systems throughout San Mateo County and other NPDES Phase I |

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| | 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. |
| **Notice of Intent (NOI)** | A formal notice to State Water Resources Control Board submitted by the owner/developer to obtain coverage under the Construction General NPDES Permit. The NOI provides information on the owner, location, and type of project, and certifies that the permittee will comply with the conditions of the State Construction General Permit. |
| **NPDES Permit** | An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of the National Pollutant Discharge Elimination System (NPDES) program. As part of the 1972 Clean Water Act, Congress established the NPDES permitting system to regulate the discharge of pollutants from municipal sanitary 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 in order to regulate 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 countywide stormwater NPDES permit. |
| **Operation and Maintenance (O&M)** | Refers to requirements in the stormwater NPDES permit to inspect treatment BMPs and implement preventative and corrective maintenance in perpetuity. See Chapter 8. |
| **Operational Source Control Measure** | Low technology, low cost activities, procedures, or management practices designed to prevent pollutants associated with site functions and activities from being discharged with stormwater runoff. Examples include good housekeeping practices, employee training, standard operating practices, inventory control measures. |
| **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 Concrete** | A discontinuous mixture of coarse aggregate, hydraulic cement and other cementitious materials, admixtures, and water; having a surface void content of 15-25% allowing water to pass through. |

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| **Pervious Paving** | For the purposes of this document, pervious paving shall be 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 Blocks, bricks and stones set on a gravel base with gravel joints, Grasscrete etc. Additionally, pervious paving or pavement is that which stores and infiltrates rainfall at a rate equal to immediately surrounding unpaved, landscaped areas, or that stores and infiltrates 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). |
| **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 the receiving water. |
| **Porous Asphalt** | Open-graded asphalt concrete over an open-graded aggregate base, over a draining soil. Contains very little fine aggregate (dust or sand) and is comprised almost entirely of stone aggregate and asphalt binder. |
| **Post-Construction Stormwater Control** | See Stormwater Control. |
| **Potential Rainwater Capture Area** | The impervious area from which rainwater may be potentially be captured, if rainwater harvesting and use were implemented for a project. If the entire site is evaluated for rainwater harvesting and use feasibility, this consists of the impervious area of the proposed project; for redevelopment projects that replace 50% or more of the existing impervious surface, it also includes the areas of existing impervious surface that are not modified by the project. If only a roof area is evaluated for rainwater harvesting and use feasibility, the potential rainwater capture area consists only of the applicable roof area. |
| **Precipitation** | Any form of rain or snow. |
| **The Program** | San Mateo Countywide Water Pollution Prevention Program |
| **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. |

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| **Redevelopment** | A project on a previously developed site that adds or replaces impervious surface on the site. 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, and any other reconstruction work within a public street or road right-of-way where both sides of the right-of-way are developed. |
| **Regional Water Quality Control Board, San Francisco Bay Area Water Board (RWQCB)** | One of nine California Regional Water Boards, the Regional Water Board for the San Francisco Bay Region is responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within the area that drains to San Francisco Bay and ocean. 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. |
| **San Mateo Countywide Water Pollution Prevention Program ("Countywide Program" or "Program")** | A program of the City/County Association of Governments consisting of the 16 San Mateo County cities, 4 San Mateo County towns and San Mateo County. All these municipalities are listed as Co-permittees in a municipal stormwater NPDES permit adopted by the Regional Water Quality Control Board. The Program implements common tasks and assists the municipalities to implement their local stormwater pollution prevention programs. The Program's former name was the San Mateo Countywide Stormwater Pollution Prevention program (STOPPP). |
| **Screening Density** | A threshold of density (e.g., number of units or interior floor area) per acre of impervious surface, associated with a certain potential demand for non-potable water, for C.3 regulated projects. Screening densities are used to determine the feasibility and infeasibility of rainwater harvesting and use. Screening density varies according to location (see Attachment 2 of the LID feasibility worksheets in Appendix I.) If the screening density is met or exceeded, the Rainwater Harvesting and Use Feasibility Worksheet must be completed for the project. |
| **Sedimentation** | The process of depositing soil particles, clays, sands, or other sediments that were picked up by runoff. |
| **Sediments** | Soil, sand, and minerals washed from land, roofing material, and pavements into water usually after rain, which accumulate in reservoirs, rivers, and harbors. |
| **Self-Retaining Area** | A portion of a development site designed to retain the first one inch of rainfall (by ponding and infiltration and/or |

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| | 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** | Any schedules of activities, structural devices, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent stormwater pollution by reducing the potential for pollution at its source. |
| **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. The specific development project types will be described in an amendment to the MRP, anticipated in Fall 2011. |
| **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** | A plan providing for temporary measure to control sediment and other |

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| **Prevention Plan (SWPPP)** | pollutants during construction. |
| **Storm Water Quality Task Force (SWQTF)** | Publisher of the 2003 California Storm Water BMP Handbooks. See California Association of Stormwater Quality Agencies (CASQA). |
| **Stormwater Treatment Measure** | Any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process. Sometimes called a treatment control, treatment control measure, or treatment control BMP. |
| **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** | The application of engineered systems that use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to, filtration, gravity separation, media adsorption, biodegradation, biological uptake, and infiltration. |
| **Turf Block** | Open celled unit paver filled with soil and planted with turf. |
| **Vector Control** | Any method to limit or eradicate the carriers of vector borne diseases, for which the pathogen (e.g. virus or parasite) is transmitted by a vector which can be mammals, birds or arthropods, especially insects, and more specifically mosquitoes. For the purposes of this document, vector control refers to mosquito control. |
| **Vegetated Filter Strip** | Linear strips of vegetated surfaces that are designed to treat sheet runoff flow from adjacent surfaces. |
| **Vegetated Swale** | Open, shallow channels with vegetation covering side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. Use only for conveyance or pretreatment – no longer considered an LID treatment system in the MRP. See Bioretention Area. |
| **Volume-Based Stormwater Treatment Measures** | Stormwater treatment measures that detain stormwater for a certain period and treat primarily through sedimentation and infiltration. |
| **Water Quality Inlet** | Systems that contain one or more chambers that promote sedimentation of coarse materials and separation of undissolved oil and grease from stormwater. Also referred to as oil/water separators. |
| **Water Quality Volume (WQV)** | For stormwater treatment measures that depend on detention to work, the volume of water that must be detained to achieve maximum extent practicable pollutant removal. This volume of water must be detained for a specified drawdown time. |
| **WEF Method** | A method for determining the required volume of treatment BMPs, recommended by the Water Environment Federation and American Society of Civil Engineers. Described in Urban Runoff Quality |

| | |
|---|---|
| | Management (WEF/ASCE, 1998). |
| **Wet Pond** | Constructed detention basins that have a permanent pool of water throughout the year and capacity for temporary additional storage of runoff that is released via an outlet structure. They differ from constructed wetlands in that they typically have a greater average depth and less vegetation. |

Chapter

# 1

# Introduction / How to Use this Handbook

***In this Chapter:***

- *Purpose of this handbook*
- *Overview of the handbook's contents*

## 1.1 Purpose of this Handbook

This countywide handbook is meant to help developers, builders, and project sponsors include post-construction stormwater controls in their projects, in order to meet local municipal requirements and requirements in the Municipal Regional Stormwater Permit (MRP). The municipalities have to require post-construct 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.

> See the Countywide Program's ***Sustainable Green Streets and Parking Lots Design Guidebook*** for more design concepts on treating stormwater runoff from streets and parking lots.

The Countywide Program has also prepared a Sustainable Green Streets and Parking Lots Design Guidebook to specifically assist municipalities and project applicants with ***designing street and parking lot projects*** that treat stormwater runoff in landscape-based treatment measures. The Guidebook includes over 400 photographs and drawings to illustrate potential design solutions to a wide range of project sites. You can download the Guidebook at www.flowstobay.org (click on Business, then New Development).


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.

This handbook does not provide information on the construction best management practices (BMPs) that protect stormwater during construction activities.

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 Countywide Program?

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) is a program of the City/County Association of Governments, which is comprised of local elected city council representatives from each municipality, one member of the County Board of Supervisors, and representatives from the local transit district and transportation authority. Each of the Program's member agencies is responsible for preventing stormwater pollution and implementing its local stormwater pollution prevention and control activities. The Program has 21 member agencies: the 20 cities in the County and unincorporated San Mateo County.

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

## 1.3 How to Use this Handbook

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

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


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, an overview of the handbook's chapters and appendices follows:

- Chapter 2 explains how development affects stormwater quality, how post-construction stormwater measures help reduce these impacts, and gives a detailed explanation of ***Provision C.3 requirements***.
- Chapter 3 gives an overview of how the post-construction stormwater requirements fit into a typical development review process, and offers ***step-by-step instructions***

on how to incorporate stormwater control/LID designs into planning permit and building permit application submittals for your project.

- Chapter 4 presents information on ***site design measures***, which can help reduce the size of treatment measures.
- Chapter 5 provides ***general technical guidance for stormwater treatment measures***, including hydraulic sizing criteria, the applicability of non-landscape-based treatment measures, manufactured treatment measures, using “treatment trains,” infiltration guidelines, plant selection and maintenance, mosquito control, and integrating stormwater treatment with hydromodification management.
- Chapter 6 gives technical guidance for ***specific types of stormwater treatment measures***, including bioretention areas, flow-through planters, tree well filters, infiltration trenches, extended detention basins, pervious paving, green roofs, rainwater harvesting, media filters and subsurface infiltration system.
- 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 alternative compliance provision of the MRP, which allows projects to contribute to off-site **alternative compliance** projects instead of constructing on-site stormwater treatment measures.
- Appendix A includes a ***list of plants*** appropriate for use in LID treatment measures. It also offers general guidance on plant selection and maintenance.
- Appendix B presents ***example scenarios***, showing how site design, source controls and treatment measures can be incorporated into projects.
- Appendix C consists of the ***Design Criteria Regions*** for San Mateo County.
- Appendix D describes manufactured stormwater treatment measures that may have ***limited applicability***, including inlet filters, oil/water separators, hydrodynamic separators, and media filters.
- Appendix E presents guidelines for using stormwater controls that promote on-site ***infiltration*** of stormwater.
- Appendix F provides guidance for ***controlling mosquito production*** in stormwater treatment measures.
- Appendix G includes templates for preparing stormwater treatment measure ***maintenance plans***.
- Appendix H presents the ***Hydromodification Management Susceptibility Map*****.**
- Appendix I includes guidance for using the ***Feasibility/Infeasibility Criteria*** to determine when the full C.3.d amount of stormwater runoff cannot be treated with rainwater harvesting and use, infiltration or evapotranspiration, in which case stormwater treatment requirements can be met with biotreatment.

- Appendix J provides guidance on using the ***Special Projects Criteria*** approved by the Regional Board to identify infill, high density and transit oriented 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 features ***BMP Specifications for Small Projects***,

## 1.4 Precedence

In case of conflicting information between this handbook and the Municipal Regional Stormwater 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

### *In this Chapter:*

- *How stormwater problems result from development*
- *Post-construction requirements for development projects*

## 2.1 Stormwater Problems in Developed Areas

Throughout the country, stormwater runoff is a leading source of pollutants for water bodies that fail to meet water quality standards[1]. In the San Francisco Bay watershed, urban and agricultural runoff 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.

### 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. Natural vegetation tends to slow the runoff in a meandering fashion, allowing suspended particles and sediments to settle. In

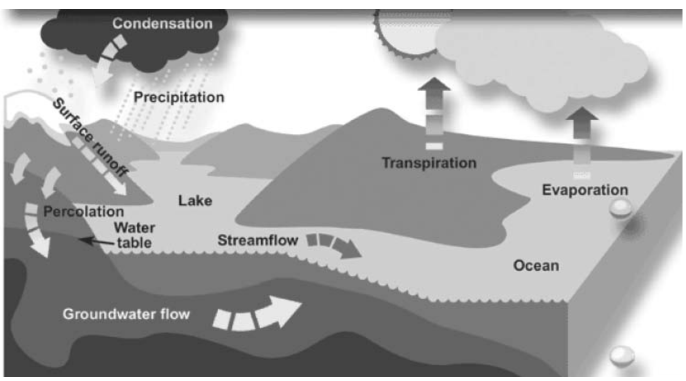


Figure 2-1: The Water Cycle (NGRDC/GDNR, 2005/06)

[1] USEPA, Stormwater Frequently Asked Questions, http://cfpub.epa.gov/npdes/faqs.cfm?program_id=6

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

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 creeks typically find an equilibrium in which sediment is carried without impairing beneficial uses.

### 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 runoff flows across the surface***, where it washes debris, dirt, vehicle fluids, chemicals, and other pollutants into the local storm drain systems. Once in the storm drain, polluted runoff flows directly into creeks and other natural bodies of water. Figure 2-2 contrasts the percentage of rainfall that becomes stormwater runoff in a natural and an urban setting.

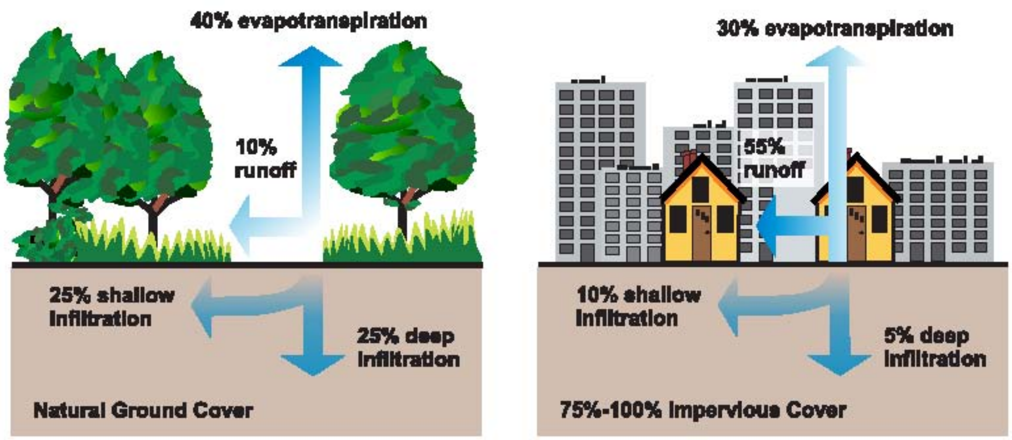



Figure 2-2: Change in volume of stormwater runoff after development. (USEPA, 2003)

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

## 2.2 Low Impact Development Stormwater Controls

Key Point

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.

Figure 2-3: Creek with Natural Banks

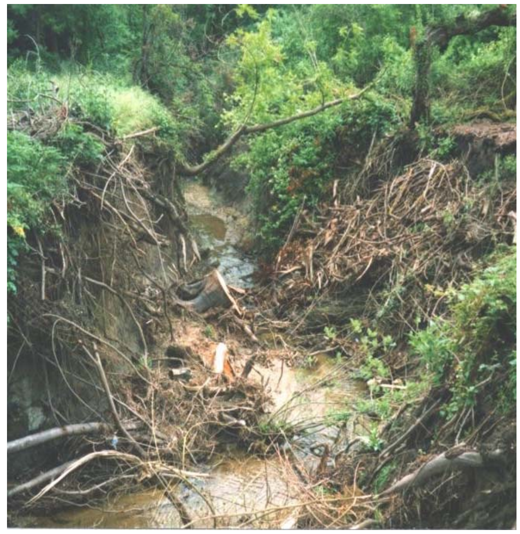


Figure 2-4: Creek Subject to Hydromodification

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

### 2.2.1 Site Design Measures

Site design measures are ***site planning techniques*** for pollution prevention and reduction in flow rates and durations, 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, such as by keeping pollutants from coming into contact with stormwater. Examples of structural source controls include:

- Roofed trash enclosures,

- Berms that control run-on 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

Effective ***December 1, 2011***, the Municipal Regional Stormwater Permit (MRP) requires stormwater treatment requirements to be met by using evapotranspiration, infiltration, rainwater harvesting and reuse. Where this is infeasible, landscape-based biotreatment is allowed. In some Special Projects, media filters and high flow rate tree well filters are allowed. See Section 2.3.1 for more information on stormwater treatment requirements and Appendix J for information on Special Projects.

Stormwater treatment measures must be sized to comply with one of the hydraulic design criteria listed in the municipal regional 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, commonly used treatment measures:

- Bioretention areas,
- Flow-through planter boxes,
- Tree well filters (effective December 1, 2011, high flow rate tree well filters are allowed only in Special Projects - see Appendix J),
- Infiltration trenches,
- Extended detention basins,
- Green roofs,
- Pervious Paving, and grid pavements,
- Rainwater harvesting and use,
- Media filters (effective December 1, 2011, media filters are allowed only in Special Projects - see Appendix J), and
- Subsurface infiltration systems.

### 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. The Municipal Regional Stormwater Permit (MRP), adopted by the Water Board in October 2009, includes more prescriptive requirements for incorporating post-construction stormwater control/LID measures into new development and redevelopment projects than the previous countywide stormwater permit. These requirements are known as Provision C.3 requirements. Download Provision C.3 and the full MRP at www.flowstobay.org (click on “Municipalities,” then “NPDES Permit R-2-2009-0074 Oct142009”).

Provision C.3.c establishes thresholds at which new development and redevelopment projects must comply with Provision C.3, 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 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 projects that receive


***PROVISION C.3 THRESHOLDS***

Thresholds for determining whether Provision C.3 applies to a project (in which case the project is a “C.3 Regulated Project”) are based on the amount of impervious surface that is created and/or replaced by a project, as described below.

- Since 2006, private or public projects that create and/or replace ***10,000 or more or impervious surface*** have been C.3 Regulated Projects.
- Effective ***December 1, 2011***, the threshold for requiring stormwater treatment is reduced from 10,000 to 5,000 square feet of impervious surface for the following project categories: uncovered parking areas (stand-alone or part of another use), restaurants, auto service facilities[1] and retail gasoline outlets.

[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.

### *"DEEMED COMPLETE" EXCLUSIONS*

- Development applications that were "deemed complete" for review by the planning department on or after December 1, 2009, but receive final discretionary approval before ***December 1, 2011***, are not subject to the new, additional requirements.
- Development applications that were "deemed complete" for review by the planning department on or after December 1, 2009, but receive final discretionary approval before ***December 1, 2011*** are not subject to the additional, new requirements.

### *CALCULATING IMPERVIOUS SURFACE*

An "impervious surface" is any material that prevents or substantially ***reduces infiltration of water into the soil.*** This includes building roofs, driveways, patios, parking lots, impervious decking, streets, sidewalks, and any other continuous watertight pavement or covering. Impervious surface is calculated in terms of square feet or acres. When calculating the area of building roofs, be sure to include not only the footprint of the main building or structure, but also any garages, carports, sheds, or other miscellaneous structures.

> Pervious paving is not considered an impervious surface, as long as it is underlain with a pervious storage material that holds at least the Provision C.3.d amount of rainfall runoff.

Pervious paving is not considered an impervious surface, as long as it is underlain with a pervious storage material (such as gravel) that holds at least the Provision C.3.d volume of rainfall runoff. Open, uncovered retention/detention facilities are not considered impervious surfaces for purposes of determining whether a project is a Regulated Project, but they are considered impervious surfaces for purposes of runoff modeling and meeting the Hydromodification standard. The municipalities use a "C.3 Regulated Projects Checklist" to help applicants with these calculations. ***Contact your local jurisdiction*** for its checklist.


### *EXCLUSIONS FROM PROVISION C.3*

Provision C.3.c of the MRP excludes specific types of projects from the C.3 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.

**Table 2-1**
**Projects Excluded from Provision C.3 Numerically Sized Treatment Requirements**

| | **Excluded Projects** |
|---|---|
| Commercial, industrial, residential, or other development | 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 |

[4] Effective December 1, 2012, 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.

**Table 2-1**
**Projects Excluded from Provision C.3 Numerically Sized Treatment Requirements**

| | Excluded Projects |
|---|---|
| | lanes of travel or a new roadway;<br>▪ Widening of roadways that does not add one or more new lanes of travel;<br>▪ Impervious trails with a width of 10 feet or less and located more than 50 feet from top of creek banks.<br>▪ Sidewalk projects in the public right of way that are not built as part of new streets or roads;<br>▪ Bicycle lane projects in the public right of way that are not built as part of new streets or roads.[5]<br>▪ Sidewalks built as part of new streets or roads that are constructed to drain to adjacent vegetated areas;<br>▪ 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;<br>▪ 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;<br>▪ Sidewalks, bicycle lanes or trails built with permeable surfaces;<br>▪ Caltrans highway projects and associated facilities. |
| Redevelopment projects (including pavement resurfacing) | Interior remodels and routine maintenance or repair, including:<br>▪ Roof replacement. This exclusion applies to all roof replacement projects, including those that remove the entire roof.<br>▪ Exterior wall surface replacement;<br>▪ 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. |

## *ROAD PROJECTS*

If your roadway project (including sidewalks and bicycle lanes built as part of new streets or roads) creates 10,000 square feet or more of ***newly constructed, contiguous impervious surface***, the project 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. If the roadway project widens existing roads with additional traffic lanes, the ***"50 Percent Rule"*** for stormwater treatment

[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.

applies (see the C.3 requirements for redevelopment projects, below). Road projects excluded from Provision C.3 are listed in Table 2-1.

### 2.3.1 What is Required by Provision C.3?


Projects that are subject to Provision C.3 (C.3 Regulated Projects) must implement:

- Site design measures,
- Source control measures, and
- Low impact development (LID) treatment measures.

***What Are C.3 Regulated Projects?*** 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 are C.3 Regulated Projects. Effective ***December 1, 2011,*** 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 are also C.3 Regulated Projects.

***What Are LID Treatment Measures?*** The MRP identifies two tiers of LID treatment. The preferred tier of LID treatment consists of approaches that retain stormwater on the site, instead of releasing treated water to the storm drain. The top tier of LID treatment consists of evapotranspiration, infiltration, and/or rainwater harvesting and use. C.3 Regulated Projects must evapotranspire, infiltrate or harvest and use amount of stormwater runoff specified in MRP Provision C.3.d, unless this is infeasible as defined by criteria and procedures in Appendix I. When the three preferred types of LID treatment are infeasible, biotreatment is allowed (see below). In some limited cases, LID treatment reduction is allowed for certain smart growth, high density or transit-oriented development Special Projects, described below. Treatment measures must be hydraulically sized as specified in MRP Provision C.3.d.

***Biotreatment – Second Tier LID.*** Biotreatment is the second tier of LID treatment. Biotreatment measures are designed to filter stormwater through soil and then release some or all of the treated water to the storm drain system. In locations where infiltration should be avoided (steep slopes, high groundwater table, etc.) the biotreatment measure should be lined with an impermeable liner, or placed in a concrete planter box. In all other locations, infiltration should be maximized as illustrated in Figure 2.5. Soils in biotreatment measures must have a long-term minimum infiltration rate of 5 inches per hour over the life of the system, in accordance with the soil specifications approved by the Regional Water Board in Appendix K. Biotreatment systems must also have a surface area no smaller than what is required to accommodate a 5 inches per hour stormwater runoff surface loading rate. Biotreatment systems include an underdrain in a rock layer below the engineered soil.

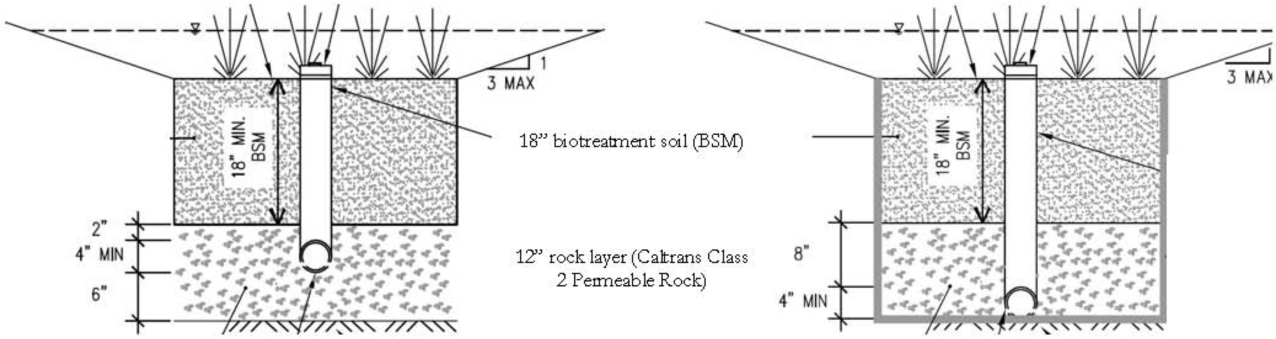



Figure 2.5: Bioretention Areas Designed to Maximize or Prevent Infiltration.

- The bioretention area on the left is designed to maximize infiltration. There is no liner at the bottom of the 12" rock layer, and the underdrain is positioned 6" above the bottom of the rock layer.
- The bioretention area on the right is designed to prevent infiltration. An impermeable liner is placed at the base and sides, and the underdrain is at the bottom of the rock layer.

***When Do Bioretention Areas Provide Preferred-Tier Treatment?*** Bioretention areas function as preferred-tier treatment measures in locations where the soil hydraulic conductivity rate is 1.6 inches per hour or higher, because in these soil conditions, the amount of runoff specified in Provision C.3.d is fully treated by evapotranspiration and infiltration. In other locations, bioretention areas function as biotreatment measures, since only some of the C.3.d amount of runoff is treated with evapotranspiration and infiltration.

***Special Projects.*** LID treatment requirements are reduced for certain smart growth, high density, or transit-oriented development Special Projects. If a project meets the Special Projects criteria provided in Appendix J, specific non-LID treatment measures may be used to treat a percentage of the total C.3.d amount of stormwater runoff that requires treatment. Two types of non-LID treatment measures are allowed in Special Projects: high flow rate tree well filters and high flow rate media filters. See Appendix J for criteria and procedures for identifying Special Projects and calculating the LID treatment reduction.

### *HYDROMODIFICATION MANAGEMENT REQUIREMENTS*

Projects that create and/or replace ***one acre or more*** of impervious surface must incorporate hydromodification management measures, if the project is located in an area susceptible to hydromodification (shown in a map in Appendix H), and if the amount of impervious surface area is increased above pre-project conditions. 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:"*** Redevelopment projects that replace 50 percent or less of existing impervious surface need to treat stormwater runoff only from the portion of the site that is redeveloped. Redevelopment projects that replace or alter more than 50 percent of the existing impervious surface are required to treat runoff from the entire site.

- A project that does not increase impervious surface over the pre-project condition is not an HM project.

***ALTERNATIVE COMPLIANCE***

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

See Chapter 3 for ***step-by-step instructions*** on incorporating C.3 stormwater submittals into your permit applications.

### How Do Projects Meet the C.3 Requirements?

The project's development permit application submittals must include detailed information showing how the Provision C.3 stormwater requirements will be met.

Chapter 3 provides ***step-by-step instructions*** for incorporating C.3 stormwater submittals into your permit applications.

### 2.3.2 Site Design Requirements for Small Projects

Effective December 1, 2012, specific sizes of small projects must meet site design requirements in Provision C.3.i of the Municipal Regional Stormwater 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; 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.

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.

Projects in the following four ***"Special Land Use Categories"*** that create and/or replace 5,000 square feet or more of impervious surface are considered Regulated Projects and are required to implement low impact development (LID) 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).

The LID site design and treatment measures implemented for Special Land Use Category projects will satisfy the C.3.i requirements.

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.

## 2.4 Regulatory Authority


The Countywide Program's municipalities derive their authority to regulate stormwater quality and hydrograph modification impacts from their stormwater ordinances. Each municipal stormwater ordinance may have unique elements, but they provide the municipalities the authority to implement the municipal regional stormwater permit, including the requirements of Provision C.3 as described above. ***Violations of a municipal stormwater ordinance*** may be subject to civil actions such as:

- Temporary and/or permanent injunction;
- Assessing costs of any investigation or inspection to establish the violation and bring legal action;
- Costs incurred in removing, correcting, or terminating adverse effects of the violation;
- Compensatory damages for loss or destruction to water quality, wildlife, fish and aquatic life;
- Order to cease and desist a violation;
- Notice to remove waste or other material that may result in an increase in pollutants entering the stormwater drainage system; and
- Arrest or citation of persons violating the stormwater ordinance.

Chapter

# 3

# Preparing Permit Application Submittals

### *In this Chapter:*

- *Outline of the development review process*
- *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.
- Improve site aesthetics and produce a better quality project
- Speed project review times.
- Avoid unnecessary redesign.
- Reduce overall project costs.

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

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

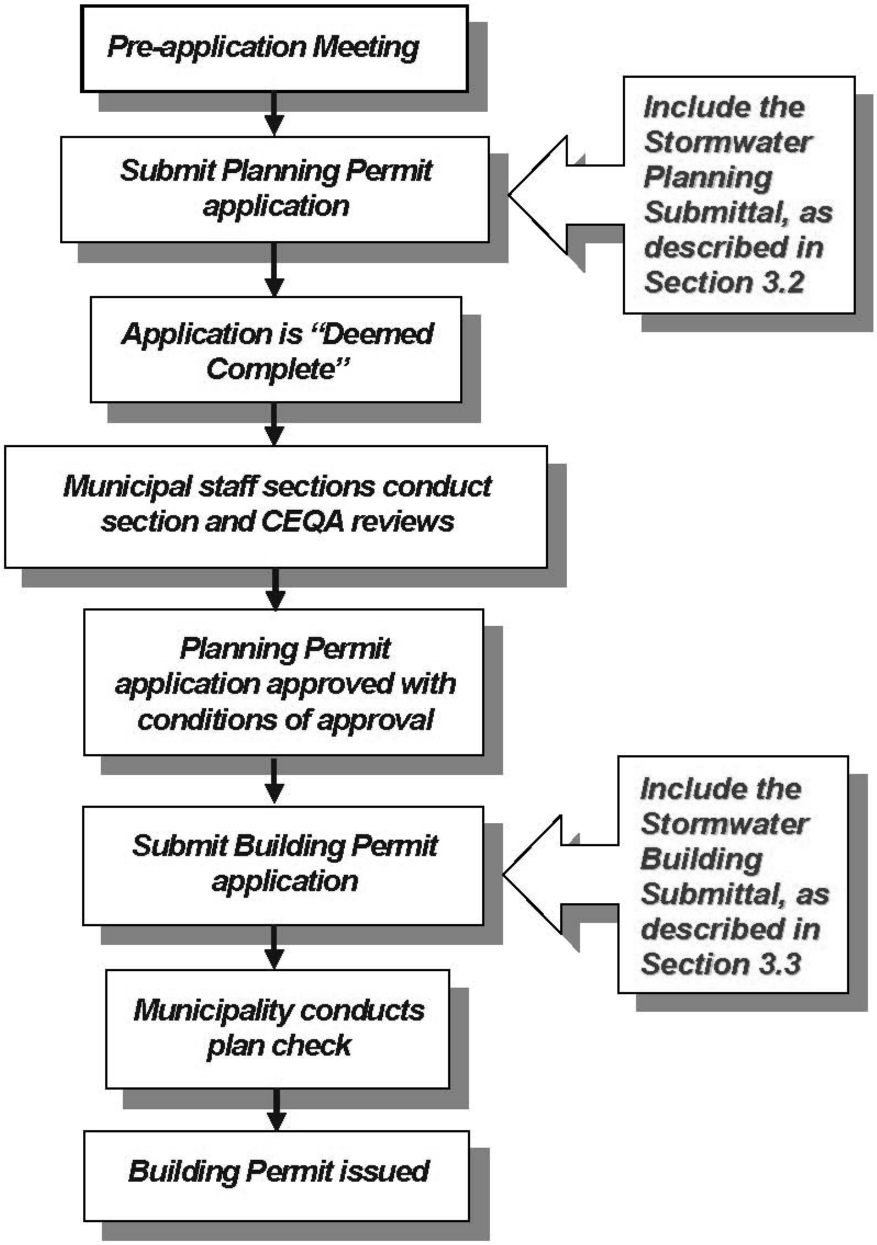



Figure 3-1: Sample Development Review Process for projects subject to Provision C.3 requirements for site design measures, source controls and stormwater treatment measures

Although the development review process may vary from one municipality to the next, Figure 3-1 highlights the steps in the development review process where 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 the life of the project***. The municipality will require you to prepare separate documents to show how sedimentation and erosion will be controlled ***during construction***. Sections 3.2 and 3.3 presents step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

## 3.2 How to Prepare Planning Permit Submittals

The Countywide Program has developed two checklists that the municipalities may use to identify the requirements for post-construction stormwater controls that apply to your project at this phase in project development. The ***NPDES Permit Compliance Checklist*** may be used to identify specific requirements regarding the types of site designs, source controls, treatment measures and hydrograph modification measures that should be incorporated in the project. Municipal staff also use this checklist to identify erosion and sediment controls that will be required during construction of the project.

> 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.


The ***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. Please note that 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 (between 10,000 sq. ft. up to one acre) are encouraged to read Section 3.4, "***Simple Instructions for Small Sites***," before using the Step-by-Step instructions.

### 3.2.1 The Planning Permit Submittal Checklist


Table 3-1 presents a checklist of C.3 post-construction stormwater/low impact development 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] | | Information on Project Drawings | Corresponding Planning Step (Section 3.2) |
| Yes | No | | |
| ❑ | ❑ | Existing natural hydrologic features (depressions, watercourses, relatively undisturbed areas) and significant natural resources. | Step 1 |
| ❑ | ❑ | Soil types and depth to groundwater. | Step 1 |
| ❑ | ❑ | Existing and proposed site drainage network and connections to drainage offsite. | Step 1 |
| ❑ | ❑ | For more complex drainage networks, show separate drainage areas in the existing and proposed site drainage network. | Step 1 |
| ❑ | ❑ | Existing condition, including pervious and impervious areas, for each drainage area. | Step 1 |
| ❑ | ❑ | Proposed pervious surfaces, including sensitive natural areas to be preserved and protected from development (for each drainage area). | Steps 2 and 3 |
| ❑ | ❑ | Proposed site design measures to minimize impervious surfaces and promote infiltration[2], which will affect the size of treatment measures. | Steps 3 and 4 |
| ❑ | ❑ | Proposed impervious surfaces, e.g., roof, plaza, sidewalk, street, parking lot (for each drainage area). | 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 C.3 Regulated Projects Checklist (obtain from municipality). | Step 4 |
| ❑ | ❑ | Completed Feasibility Screening Worksheet, and, if applicable, the completed Rainwater Harvesting Feasibility Worksheet, Infiltration Feasibility Worksheet, and/or Special Projects Worksheet (obtain from local agency). | Steps 5 and 6 |
| ❑ | ❑ | Preliminary calculations for each treatment or hydromodification management measures. | 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 a project. Municipal staff may check the boxes in the “Required” column to indicate items required for a 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.

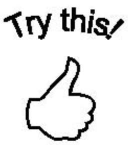
*PLANNING PERMIT SUBMITTAL*

### *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, US Fish and Wildlife Service (USFWS) wetland inventory maps, and the Oakland Museum of California Creek & Watershed Maps (www.museumca.org/creeks).
- 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. For additional information on soil types, see Appendix E – Infiltration Guidelines.
- ***Existing impervious areas.*** Measuring the area of existing impervious surface is necessary to calculate the amount of impervious surface that will be replaced. The countywide NPDES municipal stormwater permit requires that redevelopment projects that replace 50 percent or more of impervious surface treat the stormwater runoff from the entire site, not just the redeveloped area. If less than 50 percent of existing impervious surface is replaced, and the existing development was not subject to stormwater treatment measures, then only the affected portion must be included in treatment measure design.
- ***Zoning*** information, such as setback and open space requirements.

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*** for siting stormwater controls 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 moving stormwater runoff through treatment measures). Preparing a table or brief written summary of constraints and opportunities can prove helpful in selecting and siting stormwater controls.

> ***Constraints*** may include impermeable soils, high groundwater, steep slopes, or geotechnical instability. ***Opportunities*** for siting stormwater controls may include existing natural areas, low areas, or landscaping.

*PLANNING PERMIT SUBMITTAL*

### *Step 2: Minimize Site Disturbance and Protect Sensitive Areas*

Design the site layout to minimize changes to the natural topography. Using information collected in Step 1, identify any existing sensitive natural resources on the site to protect and preserve 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, you will need to obtain approvals from a number of resource protection agencies, including but not limited to the San Francisco Bay Regional Water Quality Control Board and the California Department of Fish and Game. Guidance for obtaining these approvals is provided in San Mateo County's *Guide to Creek and Wetland Project Permitting*, at http://www.flowstobay.org/pdfs/bmp/Construction%20Series/creek_wetland.pdf. Go to http://sfep.abag.ca.gov/projects/JARPA/JARPA.html for information on creek and wetland permits, and the required Joint Aquatic Resources Permit Application (JARPA).
- 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. See the above reference to the *Guide to Creek and Wetland Project Permitting* and the JARPA website.
- The project will need to comply with any local tree preservation ordinances and other policies protecting ***heritage or significant trees***. Mature trees offer substantial stormwater benefits, and their preservation is recommended, where feasible, even if it is not required by law.
- The project needs to comply with any local restrictions on development of ***steep slopes*** and soils that are susceptible to ***erosion***. Even where not required by law, the avoidance of such areas is advisable in order to reduce stormwater impacts.

*PLANNING PERMIT SUBMITTAL*

### *Step 3: Incorporate Site Design Measures*

Design the project to minimize the overall coverage of paving and roofs, with a special focus on reducing the amount of impervious area that is directly connected to the storm drain system. Using site design measures to reduce impervious surfaces on your site can ***reduce the size of stormwater treatment measures*** that you will need to install. But remember: even vegetated areas will generate some runoff. If runoff from landscaped areas flows to a stormwater treatment measure, that treatment measure will need

> 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.

to be sized to handle these relatively small amounts of runoff, as well as runoff from impervious surfaces. Using self-treating areas (described below) can reduce the size of treatment measures even further.

Figure 3-2 provides an example of a site design measure. More photos of site design measures are in the countywide Guidebook of Post-Construction BMP Examples at: www.flowstobay.org (click on Business, then New Development, then scroll to Developments Protecting Water Quality: A Guidebook of Low Impact Development Examples). More information on site design measures is provided in Chapter 4, along with technical guidance for green roofs, pervious paving, unit pavers and turf block. A range of site design examples are described in the following list:

- Use ***alternative site layout techniques*** to reduce the total amount of impervious area. This may include designing compact, multi-story structures or clustering buildings. Some cities may allow narrow streets and (in very low-density neighborhoods) sidewalks on only one side of the street.
- ***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.*** Bioretention areas, depressed landscape areas, vegetated buffers, and flow-through planters can serve as visual amenities and focal points in the landscape design of your site.
- ***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.
- Include alternative, pervious surfaces. ***Green roofs*** can partially or fully replace traditional roofing materials. ***Pervious surfaces*** such as crushed aggregate, turf block, unit pavers, or pervious paving may be appropriate for sidewalks, parking lots, and low-volume residential areas.

*Figure 3-2: Turf block fire access road, Santa Clara University, Santa Clara*

- 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, and areas of turf block. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. As long as the self-treating areas do ***not receive runoff from impervious areas*** on the site and integrated pest management is used, your drainage design may direct the runoff from self-treating areas directly to the storm drain system or other receiving water. More information on self-treating areas is given in Section 4.2.

- Direct ***runoff to depressed landscaped areas.*** You may be able to design an area within your site to function as a "self-retaining area" or "zero discharge 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. Much higher ratios are possible if the runoff is directed to a bioretention area or other landscape-based treatment measures. More information is provided in Section 4.3.

*PLANNING PERMIT SUBMITTAL*

### *Step 4: Measure Pervious and Impervious Surfaces*


The **C.3 Regulated Projects Checklist** (or equivalent checklist) that is provided by the local jurisdiction must be completed as part of the planning permit application submittal. This checklist is used to calculate the amount of impervious surface that will be created and/or replaced, and determine whether treatment and/or HM measures are required. Impervious surfaces are those areas in which development prevents water from infiltrating into the ground and results in runoff. Impervious surfaces include but are not limited to:

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


Areas of pervious paving that are 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 considered impervious surfaces, and are 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 stormwater treatment measures (with some exceptions that are listed in Chapter 2)
- Effective December 1, 2011, projects in the following categories that create and/or replace ***5,000 to 10,000 square feet*** of impervious surface must implement stormwater treatment measures:
  - Uncovered parking areas (stand-alone or part of another use),
  - Restaurants,
  - Auto service facilities[1], and

[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.

  - Retail gasoline outlets.

- Effective December 1, 2012, 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 for information on projects that are "grandfathered in" under the previous permit requirement.)

Hydromodification management (HM) is required for projects that create and/or replace one acre or more of impervious surface AND are located in susceptible areas identified in the Hydromodification Management Susceptibility Map (see Appendix H). Section 7.3 describes this map and lists exceptions to the requirements.


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

*PLANNING PERMIT SUBMITTAL*

### *Step 5: Determine if Special Projects 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: Determine if New Low Impact Development (LID) Requirements apply*

Stormwater treatment requirements must be met using evapotranspiration, infiltration, and/or rainwater harvesting and reuse. Where this is infeasible, biotreatment measures may be used. Refer to Appendix I for the feasibility worksheets and guidance based on regional criteria and procedures in order to determine feasibility at a site.

*PLANNING PERMIT SUBMITTAL*

### *Step 7: Select Treatment/HM Measures*

Effective December 1, 2011, stormwater treatment must be accomplished with infiltration, evapotranspiration, and rainwater harvesting and use, unless this in infeasible, based on criteria provided in Appendix I, in which case landscape-based "biotreatment" measures may be used. ***Chapter 6*** provides technical guidance for specific types of stormwater treatment measures that are commonly used in San Mateo County. While other treatment measures may be approved, it may be possible to

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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.

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:

- Effective ***December 1, 2011***, vault-based systems are allowed only in a limited number of locations and types of development (see Appendix J).
- Is ***Hydromodification management*** (HM) required? If your project needs to meet both treatment and HM requirements, to the extent feasible, it is recommended that stormwater control measures be designed to meet both treatment and HM needs. HM detention requirements are likely to exceed the volume required for treatment, and may also need to be coordinated with separate requirements for flood control detention.
- ***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 generally 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.*** Some sites may have sufficient space for stormwater runoff could to be routed one or more cisterns and used for non-potable uses, such as irrigation or flushing toilets (***rainwater harvesting and use***). Alternatively, smaller stormwater treatment measures may be dispersed throughout the site.
- 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 about the maintenance requirements for various treatment measures.

[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.


- ***Avoid mosquito problems.*** Mosquito control guidance provided in ***Appendix F*** needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water. Underground mechanical systems can be particularly problematic because many retain water that is not visible from the surface. Project plans that include stormwater treatment measures (and their maintenance plans), are routed to the San Mateo County Mosquito Abatement District for review. You may consider consulting with Mosquito Abatement District staff for guidance.

> The ***mosquito control guidance*** (Appendix G) needs to be implemented for all stormwater treatment measures, especially treatment measures 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 E*** to protect groundwater from contamination by pollutants in stormwater runoff.

*PLANNING PERMIT SUBMITTAL*

### ***Step 8: Locate Treatment/HM Measures on the Site***

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

- ***Design for gravity flow.*** If at all possible, treatment/HM measures should be designed so that drainage into and out of the treatment measure is by gravity flow. This promotes effective, low-maintenance operation and helps avoid mosquito problems. Pumped systems can be feasible, but they are more expensive, require more maintenance, and can introduce areas with standing water that attract mosquito breeding.
- Determine ***final ownership and maintenance responsibility.*** All treatment measures should be available for ready access by maintenance workers, inspectors from the local municipality, and staff from the San Mateo County Mosquito Abatement 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.

Figure 3-3: Playing Fields/Detention Area, Pacific Shores, Redwood City. (photograph from www.pacificshores.com)

- 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 buffer strips 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 control of emergent vegetation. Underground treatment measures and media filters may require special equipment for periodic cleanout and media replacement.

PLANNING PERMIT SUBMITTAL

### *Step 9: 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 SMCWPPP in cooperation with the Santa Clara Valley Urban Runoff Pollution Prevention Program and the Alameda Countywide Clean Water Program. The BAHM may be downloaded at www.bayareahydrologymodel.com. See Chapter 7 for more information on the BAHM and the design of HM measures.

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

PLANNING PERMIT SUBMITTAL

### *Step 10: Consider Planting Palettes for Treatment Measures*

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


The selection of appropriate plant materials is an important part of designing a successful LID stormwater treatment measure. Plants need to be hardy, low-maintenance, and tolerant of saturated soils. Although irrigation systems are typically required for landscape-based stormwater treatment measures, selecting plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements***. 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 A provides guidance regarding the selection of plant materials for landscape-based treatment measures, including information about Bay-Friendly Landscaping. Bay-Friendly Landscaping Guidelines are available at www.bayfriendly.org.

PLANNING PERMIT SUBMITTAL


### *Step 11: Prepare a Preliminary Maintenance Plan (if required)*

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

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

*PLANNING PERMIT SUBMITTAL*

### *Step 12: Use Applicable Source Control Measures*


Pollutants are generated by many 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 potential 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 typically focus on ***structural source controls***: 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. The municipality may also require your project to commit to implementing operational source controls: "good housekeeping" activities that must be conducted routinely during the operations phase of the project, such as street sweeping and cleaning storm drain inlets.


Your project will need to incorporate the applicable source controls for any project activity that is included in the local source control list. 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 a Table of Example Source Controls.

**Table 3-2: Table of Example 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 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 be used for self-treatment 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 an adequate drop in elevation is not provided, runoff will tend to pond on the edge of the paved surface.

- ***Provide for Differential Settlement.*** While the soil in landscaped-based stormwater treatment measures and self-treating areas must be left loose and uncompacted, concrete structures (such as inlets and outlets) must be supported on a firm foundation. Otherwise they may settle more than the surrounding ground, creating depressions that can hold standing water and contribute to nuisances such as mosquito breeding.
- ***Prevent Erosion.*** There is potential for erosion to occur at points where the stormwater runoff flows from impervious areas into landscape-based treatment measures. Include in project plans any proposed erosion controls, such as cobbles or splash blocks.

Figure 3-4: Cobbles help prevent erosion as stormwater enters treatment measure at Legacy Tech Park in San Jose. (Photo credit: RBF Consulting)


- ***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. More information on this topic is provided in Section 5.6. Check with your local jurisdiction regarding the need to prepare a drainage plan, and whether it is required only as part of the building permit submittal, or if a preliminary drainage plan is needed with the planning permit submittal.
- ***Signage for Traffic and Parking.*** If your project includes depressed landscaped areas next to parking lots, driveways or roadways, it may be necessary to include bollards, striping or signs to guide traffic, particularly if curbs are designed to be flush with the pavement. Traffic striping may not be practical for permeable pavements such as crushed aggregate and unit pavers. In these areas signs and bollards may be needed to help direct traffic.

*PLANNING PERMIT SUBMITTAL*

***Step 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 How to Prepare Building Permit Submittals

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

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

- Submit ***construction level detail***, rather than preliminary plans;

- Changes are ***highlighted and explained***, if plans differ from the planning permit submittal;
- ***Detailed maintenance plans*** are included, along with documentation to support the maintenance agreement.

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

### *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 as part of planning permit approval.
- 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.

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 planning 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 and/or replaced and not exempted) 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 C.3 Regulated Projects 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 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, and Mosquito Abatement 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, as its option, 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, Bioretention Area 1, Bioretention Area 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 G 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 of 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 G.

*BUILDING PERMIT SUBMITTAL*

***Step 3: Submit Building Application***

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

## 3.4 Simple Instructions for Small Sites 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 many strategies for reducing impervious surfaces, and it offers guidance for using self-treating areas (for example, landscaped areas, areas paved with turf

block, or green roofs) to further ***reduce the size*** of treatment measures. Beginning ***December 1, 2012***, projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface will be required to incorporate site design measures, using specifications that will be included in Appendix L.

- ***Use LID treatment measures.*** For small sites subject to treatment requirements, LID treatment measures must be used, except for projects that may receive LID treatment reduction credits as a Special Project (described in Appendix K). 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***. Bioretention areas that maximize infiltration to the underlying soils are encouraged even if it is infeasible to infiltrate the C.3.d amount of runoff, if there are no conditions that would make infiltration unsafe. If infiltration is precluded due to on-site conditions (such as proximity to buildings, high groundwater or contaminated soils), fllow-through planters may be a good option.

Figure 3-5: Flow-through planters in a dense, urban setting (Source: City of Emeryville)

- ***Avoid vault systems.*** Beginning ***December 1, 2011,*** mechanical vault-based treatment is only allowed for some special projects (criteria to be included in Appendix J, when available). However, these systems in general are not as effective nor as easy to maintain as landscape-based biotreatment measures.

- ***Consider using simplified sizing methods.*** The technical guidance in Chapter 6 includes simplified sizing methods for several types of stormwater treatment measures, including flow-through planters, and bioretention areas. The technical guidance for each of these treatment measures highlights the easy-to-follow calculations for sizing the treatment measures. Please note, however, that there is a trade-off for simplicity. The simplified sizing calculations may result in treatment measures that are conservatively large. If space is at a premium, it may be cost-effective to hire a civil engineer with experience sizing stormwater treatment measures and use the more detailed sizing calculations, in order to potentially reduce the amount of land needed for stormwater treatment.

- ***Use the planting guidance.*** Appendix A provides guidance for selecting appropriate plantings for landscape-based stormwater treatment measures. Municipal staff will confirm that the plants included in your design meet the criteria set forth in this guidance.

Chapter

# 4

# Low Impact Development Site Design

## *In this Chapter:*

- *How site design measures can reduce stormwater treatment measure size*
- *Tree preservation and planting*
- *Self-treating and self-retaining areas*
- *Reducing the size of impervious areas*
- *On-site water storage*


Site design measures for water quality protection are used 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.

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

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

- Tree Preservation/Planting and Interceptor Tree Credits
- Self-Treating Areas
- Self-Retaining Areas
- Reducing the Size of Impervious Areas
- Rainwater Harvesting and Use

- Site Design Requirements for Small Projects

Where landscaped areas are designed to have a stormwater drainage function, it is important that they be installed and maintained without the use of fertilizers and pesticides. Consult ***Bay Friendly Landscaping*** (see Resources) and the Planting Guidelines in Appendix A. Landscaped areas with stormwater drainage functions also 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 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.

A project may earn stormwater treatment credits by planting new trees and preserving existing trees at the project site. For each qualifying tree that is planted or preserved, the project earns stormwater treatment credits, which reduce the surface area (measured in square feet) of the project that must receive stormwater treatment. In other words, the stormwater treatment credit can be subtracted from the amount of impervious surface area requiring treatment.

As shown in Table 4-1, different amounts of stormwater reduction credit are assigned to new evergreen and new deciduous trees, and existing trees receive credit for the square footage that is under the existing tree canopy. To be eligible for these credits, the trees need to meet the minimum requirements listed in Section 4.1.1. Guidance for planting and protection during construction is provided in Section 4.1.2. Additional information about planting trees in dense, urban settings is provided in Section 4.1.3.

### 4.1.1 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.

**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 for 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)

***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 yrs 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.

***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.

### 4.1.2 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, 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.

### 4.1.3 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.

***Soil volume, density, and compost***, along with appropriate irrigation the first three years, are important to tree performance. Other aspects that influence how street trees perform include resistance to exposure (wind and heat) and resistance to disease and pest infestations.

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 health 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.

***Load-bearing modular grid products***, such as the Silva Cell, have also been developed to allow the planting of trees in uncompacted native soils, fill soils, or stormwater treatment soils, 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 Figure 4-1). 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.

Figure 4-1: 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.

# 4.2 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), 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 MRP. These areas are considered “self-treating” because ***infiltration and natural processes that occur in these areas remove pollutants*** from stormwater.

As long as the self-treating areas are not used to receive runoff from other impervious areas on the site, and are installed and maintained without the use of pesticides or quick-release synthetic fertilizers, your drainage design may route the runoff from self-treating areas ***directly to the storm drain*** system or other receiving water. Consult Appendix A for guidance on using Bay-friendly landscaping and integrated pest management to avoid the use of pesticides and quick-release synthetic fertilizers. Stormwater runoff from the self-treating areas should be kept separate from the runoff from paved and roofed areas of the site, which requires treatment.

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

Even vegetated areas will generate some runoff. ***If the runoff from the self-treating area commingles with the C.3.d amount of runoff*** from impervious surfaces, your stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating areas and the impervious areas. 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 HM treatment measures.

***Figure 4-2*** 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***.

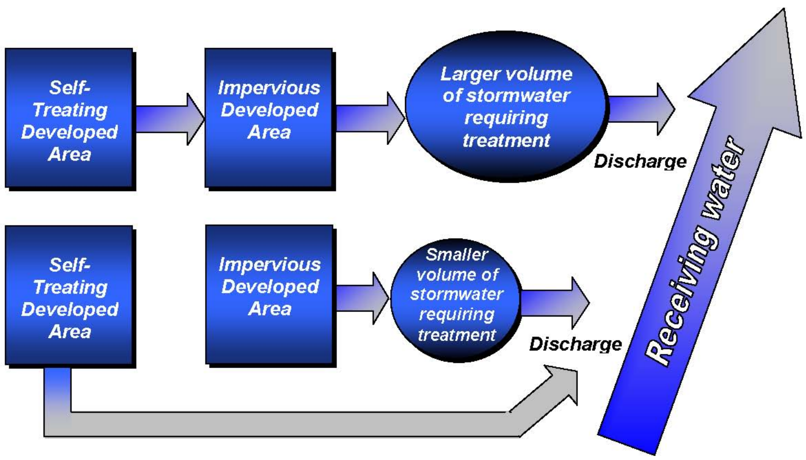



Figure 4-2: Self-Treating Area Usage (Source, BASMAA, 2003)

***Figure 4-3*** 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 appropriately designed and maintained landscaped areas directly to the storm drain system. In this approach, the treatment measure is sized to treat only the runoff from impervious areas.

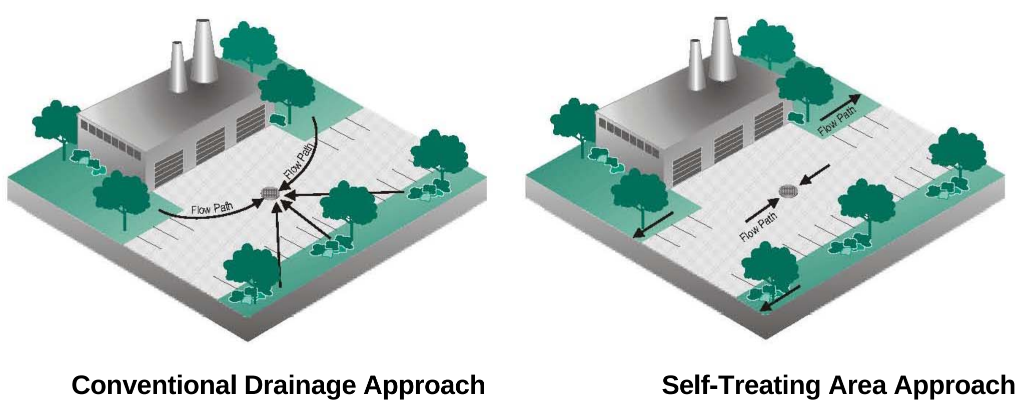



Figure 4-3: Commercial/Industrial Site Compared to Same Site with Self-Treating Areas (Source, BASMAA 2003)

***Figure 4-4*** (below) 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 areas*** on the site.

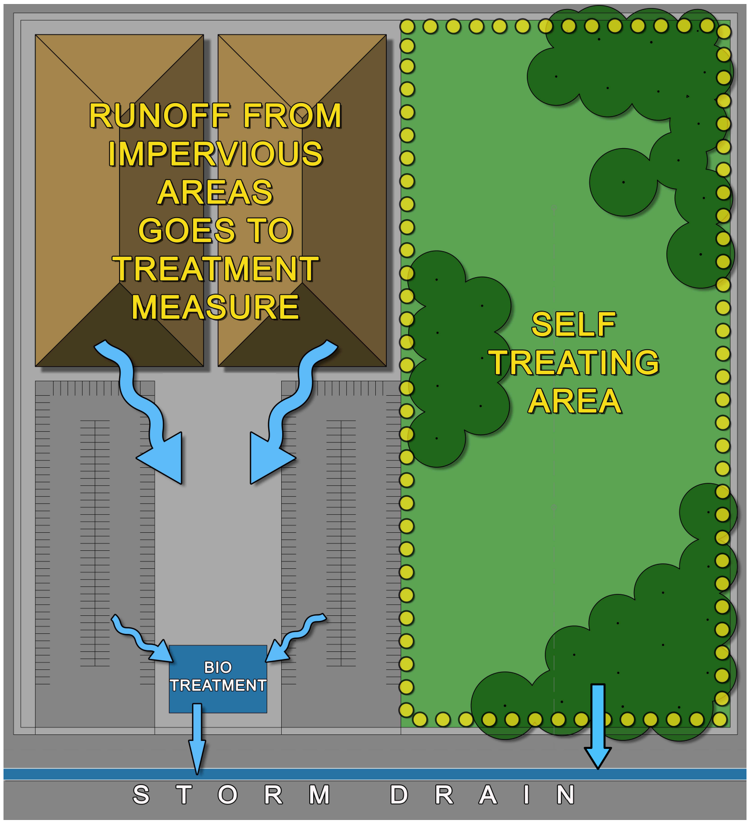



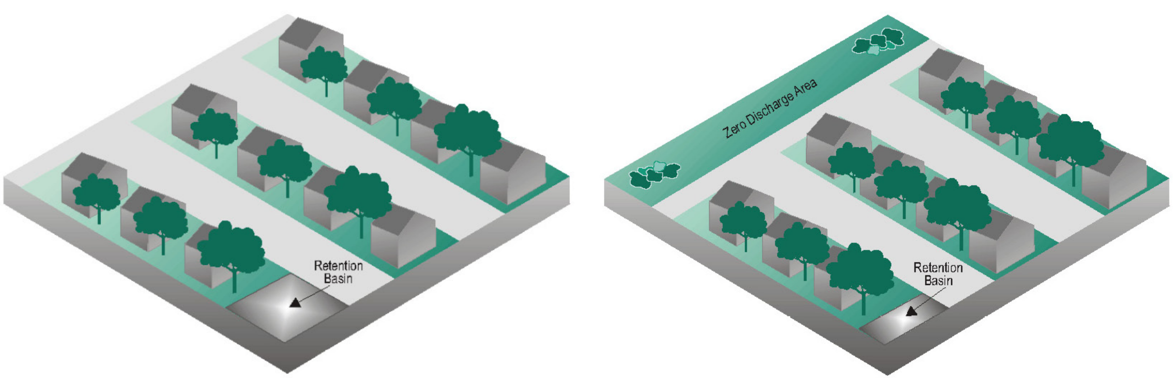

Figure 4-4: Schematic Diagram of a Site with a Self-Treating Area (Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

## 4.3 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 4-5 and 4-6). ***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. The following design considerations apply to self-retaining areas:

- 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. Modeling conducted for the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report) 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 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 hydraulic conductivity. 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 the self-retaining area (e.g., a sidewalk through a landscaped area) cannot exceed 5 percent of the total 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 4-5: 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)

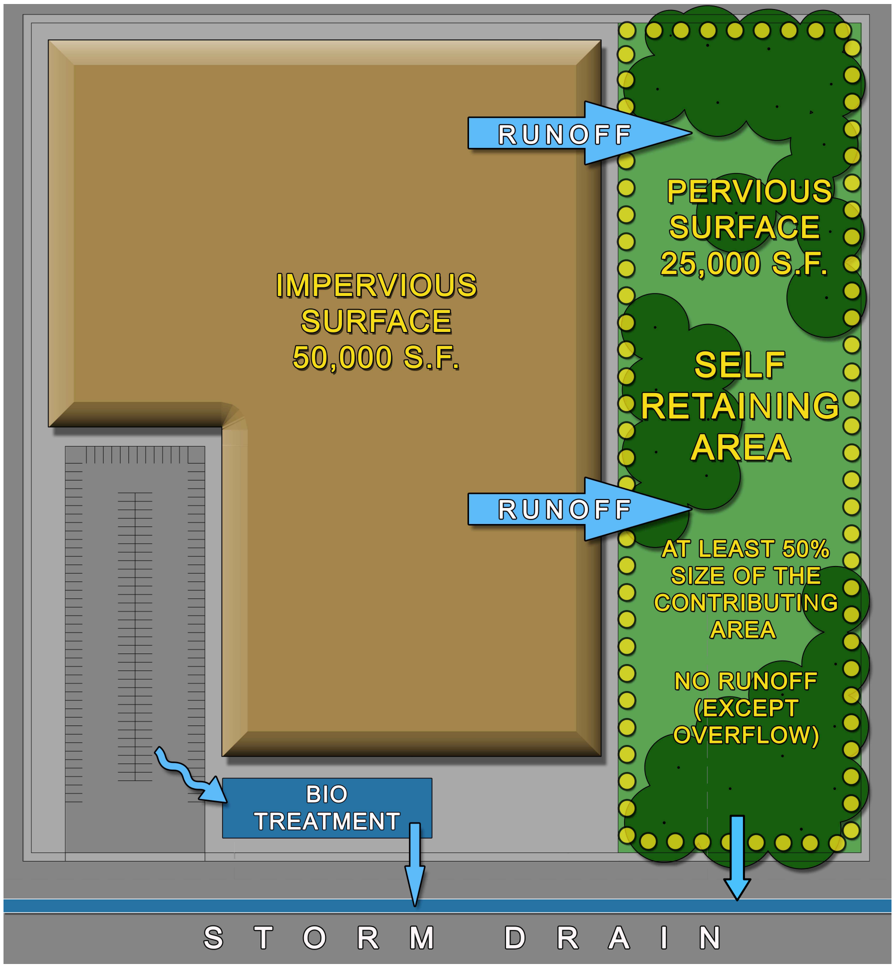



Figure 4-6: Schematic Drainage Plan for Site with a Self-Retaining Area
(Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

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 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). See Chapter 7.

## 4.4 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.

> Site designs that reduce the size of impervious area generally need to be incorporated very early in the project

### Alternative Site Layout Techniques

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

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

### Minimize Surface Parking Areas

A variety of techniques can be used to minimize surface parking areas, in terms of the number and size of parking spaces, as allowed by the local jurisdiction. These solutions focus on either reducing the demand for parking, maximizing efficient use of parking space, 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 efficient use of parking space 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.
- ***Parking structures*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings that also house office or residential space, or include ground-floor retail lining the street. Shared parking strategies can work very well with structured parking.
- ***Parking lifts*** are another way to reduce the amount of impervious surface needed for parking. A parking lift stacks two to three cars using a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. With proper training for residents, employers, or parking attendants, this strategy can be a practical way to double or triple the parking capacity given a set amount of land.

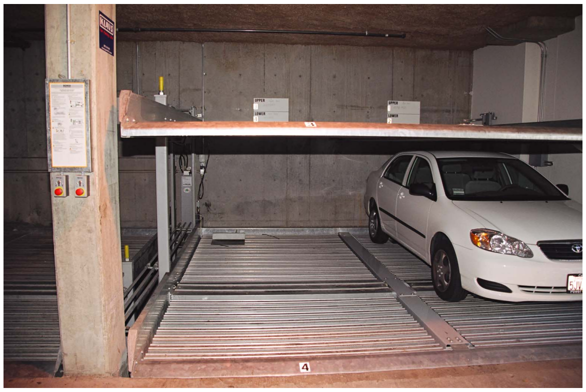


Figure 4-7: Parking Lifts in Parking Garage, Berkeley (photograph courtesy of City of Berkeley)

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

## 4.5 Rainwater Harvesting and Use

Technical guidance for rainwater harvesting and use is provided in Section 6.9 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 6.9, with the exception of meeting the C.3.d stormwater treatment sizing criteria.

Figure 4-8: Installation of notched unit pavers in Portland, Oregon. Water infiltrates through notches between pavers. (Photo courtesy of City of Portland)

## 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 one of six site design measures listed below:

- 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 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.

To help select site design measures appropriate for small projects that meet the thresholds described above, the Countywide Program collaborated regionally through the Bay Area Stormwater Management Agencies Association (BASMAA) and developed 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.

Chapter

5

# General Technical Guidance for Treatment Measures

### *This Chapter contains guidance on:*

- *Hydraulic sizing criteria,*
- *Applicability of non-landscape based treatment measures,*
- *Using Manufactured Treatment Measures*
- *"Treatment trains,"*
- *Infiltration guidelines,*
- *Low-flow systems,*
- *Plant selection and maintenance,*
- *Mosquito control,*
- *Incorporating treatment with hydromodification management,*
- *Treatment measures in areas of Bay fill,*
- *Treatment measures in seismic hazard areas,*
- *Getting water into stormwater treatment measures, and*
- *Underdrains.*

This general technical information in this section applies to the full range of stormwater treatment measures for all types of new development and redevelopment projects. See Chapter 6 for technical guidance on specific types of stormwater treatment measures.

## 5.1 Hydraulic Sizing Criteria

Stormwater treatment measures must be sized to treat runoff from ***relatively small sized storms*** that comprise the vast majority of storms. The intent is to treat most of the stormwater runoff, recognizing that it would be infeasible to size stormwater treatment measures to treat runoff from 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 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 4.2, and "self-retaining areas" designed to store and infiltrate runoff from rooftops or paved areas as described in Section 4.3. Other than "self-treating areas" and "self-retaining areas," ***ALL AREAS AT A PROJECT SITE*** must receive stormwater treatment.


Treating runoff from driveway entrances can be challenging. Consider using pervious pavement in these areas, or using interceptor tree credits (see Section 4.1) to account for the amount of impervious surface created and/or replaced by driveway entrances.

## 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 through filtration, infiltration or biological processes, 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 time to allow treatment through settling and/or infiltration processes or use of stormwater for irrigation or indoor non-potable demands. 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.

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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 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[2] | 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 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 Countywide Program recommends using the "California BMP Handbook Approach," or "80 percent capture method," shown in the text box.

***Volume-Based Sizing Criteria***

Design volume-based treatment measures to treat stormwater runoff equal to the volume of annual runoff required to achieve ***80 percent or more capture***, determined in accordance with methodology set forth in Appendix D of the California Stormwater BMP Handbook, using local rainfall data.


The ***80 percent capture method*** should be used when sizing volume based treatment measures. The 80 percent runoff value is determined by running a continuous simulation hydrologic model to convert rainfall to runoff based on a long-term local rainfall record[3]. . This method for sizing volume-based stormwater treatment measures is described in the California Stormwater Quality Association's 2003 Stormwater BMP Handbook New Development and Redevelopment available at www.cabmphandbooks.com, and is the basis for the method described below.

[2] In order to be considered self-treating areas or self-retaining areas, as described in Sections 4.2 and 4.3, pervious pavements and grid pavements need to be sized to store and infiltrate/evapotranspirate the water quality design volume in the pore space of supporting media.

[3] The Storage, Treatment, Overflow, Runoff Model (STORM) developed by the U.S. Army Corps of Engineers was used to generate the 80 percent runoff values in this guidance manual.

***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. Identify Rainfall Region***

Determine which rainfall region the project site is located in using the figure in Appendix C. San Mateo County has been divided into seven different regions based on local rainfall patterns.

***2. Determine the Effective Impervious Area for Each 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 4.2 and 4.3 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 5 percent or more of 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. Then add the product obtained in the previous step to the area of impervious surface, to obtain the "effective impervious area". For DMAs with less than 5 percent pervious area, use the entire DMA area as the effective impervious area.

***3. Unit Basin Storage Volume***

- Refer to Table 5-2 to determine the ***unit basin storage volume*** that corresponds to your rainfall region. When using the effective impervious area method, use the unit basin storage volume corresponding to a runoff coefficient of 1.0.
- Adjust the unit basin storage volume to the appropriate value for your project site by applying the following correction factor based on the ratio of the mean annual precipitation (MAP) of the project site to the MAP of the reference rain gage:

  Correction factor = $MAP_{site} \div MAP_{gage}$

  For example, if the MAP of the site is 23 inches, and the site is in Region 5 (San Francisco) with a reference gage MAP of 21 inches, the correction factor would be 23/21 inches, or 1.095.

  Multiply the unit basin storage volume by the correction factor to get the ***adjusted unit basin storage volume***.
- Calculate the ***water quality design volume ("C.3.d volume")*** by multiplying the effective impervious area of the drainage management area, determined in step 2, by the adjusted unit basin storage volume (in units of inches converted to feet). 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 Volumes in Inches for 80 Percent Capture Using**
**48-Hour Drawdown Time**

| | | **Unit Basin Storage Volume for Effective Impervious Area of Drainage Management Area** |
|---|---|---|
| **Region[1]** | **Meteorological Station, and Mean Annual Precipitation (Inches)** | **Coefficient of 1.00** |
| 1 | Boulder Creek, 55.9” | 2.04 |
| 2 | La Honda, 24.4” | 0.86 |
| 3 | Half Moon Bay, 25.9 | 0.82 |
| 4 | Palo Alto, 14.6” | 0.64 |
| 5 | San Francisco, 21.0” | 0.73 |
| 6 | San Francisco airport, 20.1” | 0.85 |
| 7 | San Francisco Oceanside, 19.3” | 0.72 |

Source: CDM memo dated May 14, 2004
[1] See Appendix C to locate the applicable Treatment Measure Design Criteria Region.

### *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 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 (below the underdrain), 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 Permit specifies three alternative methods for hydraulically sizing flow-based stormwater treatment control measures. These three methods are described in Table 5-3.

**Table 5-3**
**Flow-based Sizing Criteria Included in MRP Provision C.3.d**

| Flow-based Sizing Criteria | Description | Practice Tips |
|---|---|---|
| Percentile Rainfall Intensity | Ranks the hourly depth of rainfall from storms over a long period, determines the 85$^{th}$ percentile hourly rainfall depth, and multiplies this value by two. | This approach requires hydrologic studies that have not been conducted in San Mateo County. |
| 0.2 Inch-per-Hour Intensity ***(Recommended Method)*** | Simplification of the Percentile Rainfall Intensity Method: the flow of runoff resulting from a rainfall intensity equal to 0.2 inches/hour | The 4 percent sizing method, which is recommended for use throughout San Mateo 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. |

The percentile rainfall intensity method is based on ranking the hourly depth of rainfall from storms over a long period, determining the 85$^{th}$ percentile hourly rainfall depth and multiplying by two. For rain gages in the Bay Area at lower elevations, the resulting value is generally around 0.2 inches/hour. The permit also allows the use of 0.2 inches/hour as one of the three alternative methods regardless of the results from calculating values from local rainfall depths.

> The Countywide Program ***recommends the use of the 4% method*** (which is based on a rainfall of 0.2 inches/hour) to hydraulically size bioretention areas.

### *Sizing Bioretention Areas*

For design of bioretention areas, the 0.2 inches/hour criteria can be simplified to the "4 percent method," which assumes a runoff inflow of 0.2 inches per hour, and an infiltration rate through 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 ***Countywide Program recommends using the 4 percent method to design bioretention areas*** and other LID treatment systems that may use flow-based hydraulic sizing criteria.

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 surface" (as described 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 one 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 4.2 and 4.3 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 5 percent of more of the area that will contribute runoff to the treatment measure consists of 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 area of "effective impervious surface."
5. 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.

Appendix B 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 <u>acres</u> 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[4]

[4] 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

The Countywide Program recommends the use of the 4 percent method for sizing flow-based LID treatment facilities wherever possible, in order to maximize infiltration of treated runoff from these facilities. The 4 percent method, in which the surface area of the treatment measure is designed to be 4 percent of the impervious area that drains to the treatment measure, is conservative in that it does not account for any storage provided in the surface ponding area of the treatment facility.

For projects on sites where infiltration should be avoided, or that are planned to maximize density at redevelopment or infill[5] sites, municipal staff may allow the use of the combination flow and volume design basis for bioretention areas and flow-through planters. 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 design surface loading rate of 5 inches per hour required by MRP Provision C.3.c(2)(b)(vi).

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,

[5] For the purpose of selecting hydraulic sizing criteria, this manual defines infill sites as properties served by existing roadways and other infrastructure, for which all adjacent properties are occupied by existing development or have previously been developed. Redevelopment sites are defined as properties occupied by existing development that will be removed, or partially removed, to construct the proposed project. Individual municipalities may have stricter definitions for the purpose of selecting hydraulic sizing criteria.

compliance with C.3.d. can be demonstrated by showing how the treatment system design meets both the flow-based and volume-based criteria.

Where allowed by the municipality, lined bioretention areas and flow-through planters in locations where infiltration should be avoided or on redevelopment or infill sites (as defined above) may use the approach described below to take into consideration both the flow of stormwater through the planting media and the volume of stormwater in the surface ponding area. This approach will allow for a reduction in the surface area of the treatment measure, which may be appropriate for projects that are planned to maximize density at redevelopment or infill sites, and therefore offer environmental benefits such as reduced disturbance of previously undeveloped land and reduced vehicle miles traveled, when compared with comparable development projects in areas with little or no prior development.

***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 referred to in Appendix B. Note the first three steps below are the same as the first three steps to size volume-based treatment measures on page 48.

1. ***Identify Rainfall Region***

   - Determine which rainfall region the project site is located in using the figure in Appendix C. San Mateo County has been divided in to seven different regions based on local rainfall patterns.

2. ***Determine the Effective Impervious Area for Each 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 4.2 and 4.3 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 5 percent or more of 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. Then add the product obtained in the previous step to the area of impervious surface, to obtain the "effective impervious area". For DMAs with less than 5 percent pervious area, use the entire DMA area as the effective impervious area.

3. ***Unit Basin Storage Volume***

   - Determine the ***unit basin storage volume*** from Table 5-2 based on the composite effective impervious area runoff coefficient of 1.0 and the rain gauge area.

- Adjust the unit basin storage volume to the appropriate value for your project site by applying the following correction factor based on the ratio of the mean annual precipitation (MAP) of the project site to the MAP of the reference rain gage:

  Correction factor = $MAP_{site} \div MAP_{gage}$

  For example, if the MAP of the site is 23 inches, and the site is in Region 5 (San Francisco) with a reference gage MAP of 21 inches, the correction factor would be 23/21 inches, or 1.095.

  Multiply the unit basin storage volume by the correction factor to get the adjusted unit basin storage volume.

- Calculate the ***water quality design volume ("C.3.d volume")*** by multiplying the effective impervious area of the DMA, calculated in step 2, by the adjusted unit basin storage volume (in units of inches converted to feet). 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.

### *4. Estimate the Duration of the Rain Event*

- Assume that the rain event that generates the required design 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 adjusted 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. *Make a Preliminary Estimate of the Surface Area of the Facility*

- Make a ***preliminary estimate of the surface area*** of the bioretention facility by multiplying the DMA's area of impervious surface (or equivalent impervious surface from step 4, 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 standard. Using the example above, 280 – (0.25 × 280) = 210 square feet.
- ***Calculate the volume of runoff that filters through the treatment 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 5. For example, for a bioretention surface 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.

### 6. *Initial Adjustment of Depth of Surface Ponding Area*

- Calculate the portion of the water quality design 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 6 and Step 9 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 range for ponding in a bioretention facility or flow-through planter.

### 7. *Optimize the Size of the Treatment Measure*

- If the ponding depth is less than 6 inches, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 6 and 7 with a smaller area). If the ponding depth is greater than 12 inches, a larger surface area will be required. (In the above example, the recommended size of the bioretention area is 190 square feet with a ponding depth of 6 inches.)

Appendix B 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 Measures

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. Specifically, 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 that have a high flow rate and with tree well filters that have a high flow rate. See Appendix J for additional guidance on Special Projects.


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, many underground vault systems lack the detention time required to remove ***pollutants associated with fine particles.*** See Appendix D for more information regarding non-LID treatment measures.

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

## 5.3 Using Manufactured Treatment Measures

In the limited cases (Special Projects) where a municipality does approve the use of one or more manufactured treatment measures in a development project, the project applicant is responsible for installing the unit(s) so that they will function as designed and for following the manufacturer's instructions for maintenance. When installed and maintained properly, manufactured media filters (see Section 6.10) may have adequate pollutant removal levels for fine particles and their attached pollutants. Media filters typically include two chambers: the first chamber allows coarse solids to settle, and the second contains the filters that consist of a proprietary media. When installed and maintained properly, hydrodynamic separators may be effective in removing trash and coarse sediment, but not dissolved pollutants, and they may be installed upstream of other treatment measures.

The ***applicant is responsible*** for ensuring that the manufactured treatment measures used in the project are sized in accordance with the Provision C.3.d hydraulic sizing criteria to treat the amount of runoff that will flow to these treatment measures. The surface loading rate of the media filter should be based on the Washington State TAPE approved rate (see Section 6.10).

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

## 5.4 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 pretreat stormwater 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.

## 5.5 Infiltration Guidelines

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

- ***Site design measures*** -- such as clustering development or otherwise laying out the site to reduce impervious area, routing drainage from building roofs to landscaped areas, and using pervious pavement.
- ***Indirect infiltration*** methods, which allow stormwater runoff to percolate ***into surface soils***. Runoff may reach groundwater indirectly, or it may be underdrained into subsurface pipes. Examples of indirect infiltration methods include bioretention areas and shallow infiltration trenches or basins. Unless geotechnical considerations preclude it, all projects should maximize infiltration of stormwater runoff through methods such as bioretention (see Section 6.1).
- ***Direct infiltration*** methods***,*** which are designed to ***bypass surface soils*** and transmit runoff directly to subsurface soils for groundwater recharge. These types of devices must be located and designed to limit the potential for stormwater pollutants to reach groundwater. Examples of direct infiltration methods include deep infiltration trenches and dry wells.


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 essential to prevent damage from infiltrated water to surrounding properties, structures and/or public improvements.

***Appendix I*** provides instructions for determining the feasibility and infeasibility of treating the entire C.3.d amount of runoff from a project with infiltration. ***Appendix E*** provides guidelines to help you determine whether your project site is suitable for using site design and/or stormwater treatment measures that increase stormwater infiltration. Appendix E also describes regulatory requirements that apply to direct infiltration methods, as well as practical tips for design and construction.

## 5.6 Bypassing High Flows

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

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

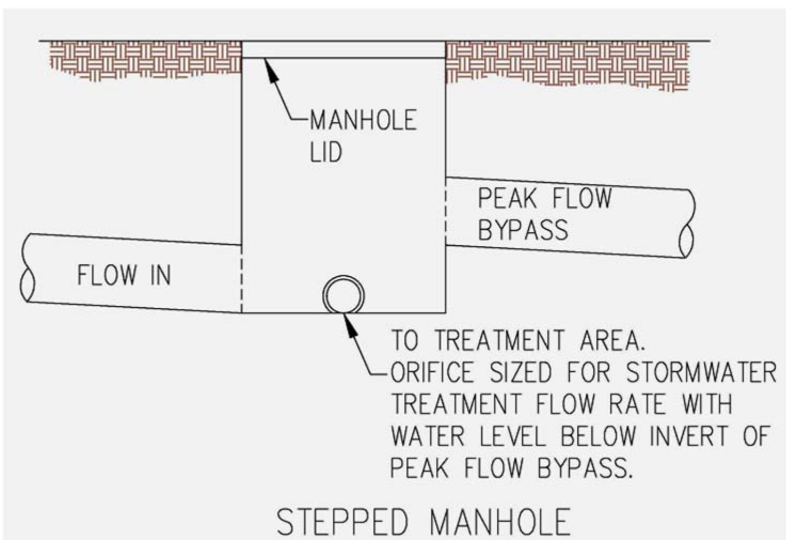


Figure 5-1: Stepped manhole design directs low-flows to treatment measure and diverts high flows to storm drain system. (BKF Engineers)

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. These systems have to include an alternative flow path for high flows, otherwise stormwater would back up and flood the project area. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards for high-flow bypasses.

For some types of stormwater treatment measures that are designed as low-flow systems, it is often necessary to restrict stormwater flows and ***bypass the flows around***

***the facility.*** In these instances the stormwater treatment measures are designed to treat only the water from small storm events. Bypassing larger flows helps prevent hydraulic overload and resuspension of sediment, and it can 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 designed to handle high flows. This can be accomplished using a stepped manhole (Figure 5-1) or a proprietary flow splitter. As illustrated in Figure 5-3, 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.

## 5.7 Plant Selection and Maintenance

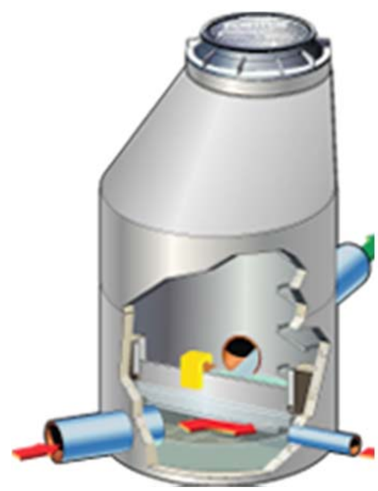

Figure 5-2: StormGate™ proprietary flow splitter structure. Source: Contech Construction Products Inc. The use of this illustration is for general information only and is not an endorsement of this or any other proprietary device.

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

### Plant Selection Guidance


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

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

### Bay Friendly Landscaping

Figure 5-3: Beneficial insects can help control pests.

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 local watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly (and ocean-friendly) Landscaping practices from the initial plant selection through the long-term maintenance of the site. Appendix A summarizes Bay Friendly Landscaping practices that may be implemented to benefit water quality of the bay, ocean and their tributaries, based on the Bay-Friendly Landscaping Guidelines (available at www.bayfriendlycoalition.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. As a last resort some pesticides with low levels of toxicity may be used. More information on IPM is included in Appendix A.

> Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** from the Vector Control Plan, which are included in Appendix F.

### Wetland Regulations and Treatment Measures

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

### Water Efficient Landscaping Requirements

The California Water Conservation in Landscaping Act of 2006 requires municipalities to adopt, by January 1, 2010, landscape water conservation ordinances that are at least as effective with regard to water conservation as the Model Water Efficient Landscape Ordinance prepared by the Department of Water Resources. The Model Ordinance automatically went into effect, on January 1, 2010, in municipalities that have not adopted a local water efficient landscape ordinance.

***Most new and rehabilitated landscapes*** are subject to a water efficient landscape ordinance. The Model Ordinance applies to public landscapes and private development projects including developer-installed single family and multi-family residential landscapes with at least 2,500 square feet of landscape area. The model ordinance also applies to homeowner-provided landscaping if the landscape area is at least 5,000 square feet. Contact the municipality to ***determine whether your project is subject to the Model Ordinance*** or a comparable local ordinance.

## 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 have the potential to ***retain standing water*** if they are not properly designed, constructed and maintained.

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


Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** from the countywide Vector Control Plan, which are included in Appendix F. Project plans that include stormwater treatment measures (and their maintenance plans) may be routed to the San Mateo County Mosquito Abatement District for review. Project applicants may wish to consult with Mosquito Abatement District staff for guidance.

## 5.9 Incorporating Treatment with Hydromodification Management

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

Figure 5-4: This detention pond is used for hydromodification management. .

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 post-project flow durations to pre-project durations ***for a range of 10 percent of the two-year peak flow up to the ten-year peak flow.*** This is different from the sizing criteria that are used for stormwater treatment measures and the design criteria used for flood control facilities. Implementing low impact development site design and treatment measures in your project may help to reduce the size of required HM facilities.

To help applicants meet the HM requirements, the Countywide Program developed the Bay Area Hydrology Model (BAHM) with assistance from the municipal stormwater programs in Santa Clara and Alameda 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.bayareahydrologymodel.org to download the BAHM). The BAHM takes into consideration the implementation of low impact development site design and treatment measures when calculating the required size of HM facilities. Chapter 7 provides more detail on HM requirements and the BAHM.

## 5.10 Treatment Measures in Areas of Bay Fill


Extensive portions of San Mateo County's bayside consist of historic Bay wetlands that were filled long ago to accommodate development pressure. These areas typically have ***high water tables***, and the fill soils have a tendency to settle. Both of these characteristics can lead to problems with building foundations. Treatment measures that rely on direct infiltration to treat stormwater, such as infiltration trenches, are inappropriate to use on properties with a high water table. Be sure to consult the ***infiltration guidance in Appendix E*** when considering a stormwater treatment measure that relies on infiltration to treat stormwater for your site.

## 5.11 Treatment Measures in Seismic Hazard Areas


The San Andreas Fault passes through the county near the Skyline Boulevard and I-280 corridors areas before exiting the coast at Mussel Rock Park in Daly City. State law prohibits the location of developments and habitable structures across the trace of active faults, and limits the placement of these types of structures to no less than 50 feet of an active fault trace. Projects located near a fault typically need to incorporate special design features. For example, ***pipes built across a fault*** need to accommodate the gradual movement of the tectonic plates that meet at the fault line. If your project is located near a fault line, contact your local jurisdiction to obtain any special requirements for storm drain pipes or other stormwater facilities included in your project.

Steep slopes and areas of Bay fill may also be identified as seismic hazard areas, based on the damage to buildings, bridges, and other structures that may occur in these areas during a major earthquake. To date, stormwater professionals have not identified seismic-induced failure as a threat to stormwater treatment measures located in Bay fill areas or on steep slopes. There are, however, special concerns associated with stormwater treatment measures that rely on infiltration in areas with high water tables or steep slopes. These concerns are addressed in ***Appendix E.***

## 5.12 Artificial Turf and Stormwater Treatment

Artificial turf typically consists of a permeable synthetic grass layer over a permeable underlay, such as gravel, and a compacted sub-base, with a subdrain to collect water and convey it to the storm drain system. Artificial turf can be designed to allow infiltration of runoff to the underlying soils.

When calculating the total area of a project's new and/or replaced impervious surface, areas of artificial turf are considered pervious, if the underdrain is placed sufficiently high in the gravel base layer, so that the void space in the gravel below the underdrain is sufficient to store and infiltrate the amount of stormwater specified in Provision C.3.d of the MRP. Although using artificial turf in place of natural turf can help conserve water and reduce pesticide and fertilizer use, it is advisable to ***weigh the benefits against potential environmental impacts,*** such as the heating effect of artificial turf (as opposed to the cooling effect of natural turf). Concerns have also been raised regarding the potential for toxic chemicals in artificial turf to pollute stormwater; however, data on this issue are limited and inconclusive to date.

## 5.13 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 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.


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

### Standard Curb Cut: Design Guidance


Figure 5-6: This standard curb cut at parking lot rain garden has 45 degree chamfered sides.

- 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.

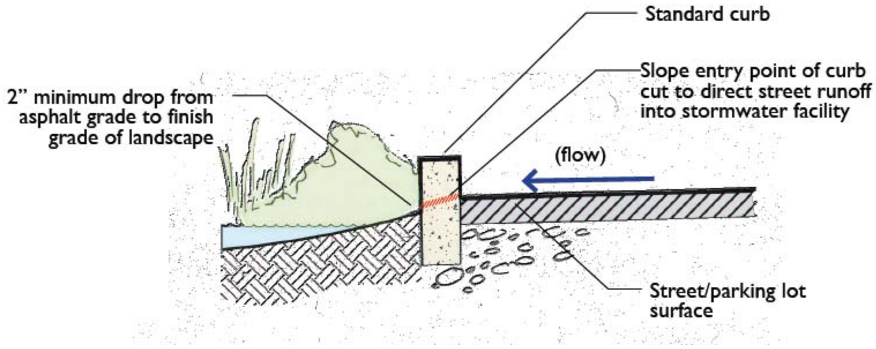


Figure 5-7: Standard curb cut: section view (Source: San Mateo Countywide Water Pollution Prevention Program [SMCWPPP] 2009)

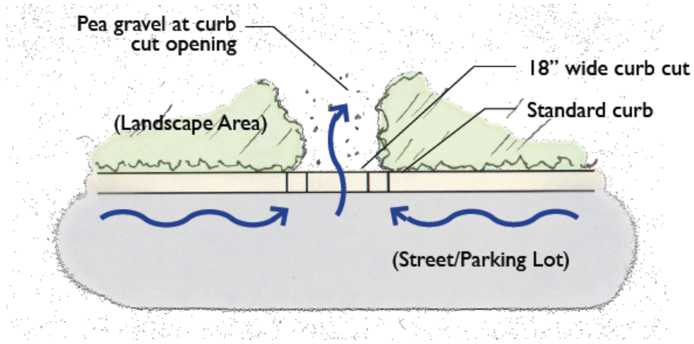


Figure 5-8: Standard curb cut: plan view (Source: SMCWPPP 2009)

## 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.


Figure 5-9: The side wings of this standard curb cut help retain the side slope grade on each side of the curb cut opening.

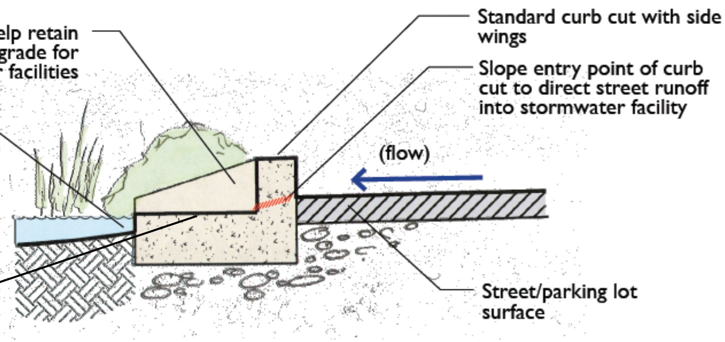


Figure 5-10: Standard curb cut with side wings:  cut section view (Source: SMCWPPP 2009)

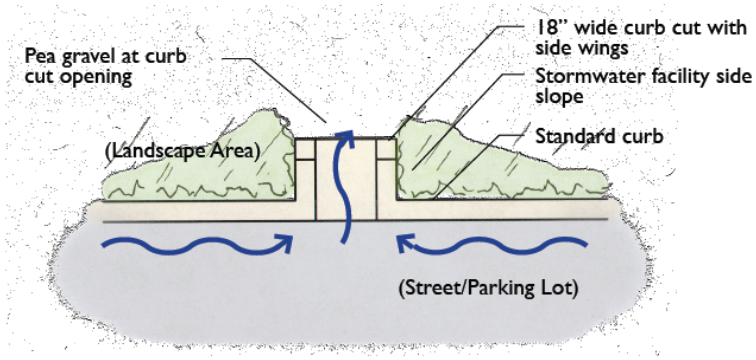


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Figure 5-11: Standard curb cut with side wings: plan view (Source: SMCWPPP 2009)

- 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.

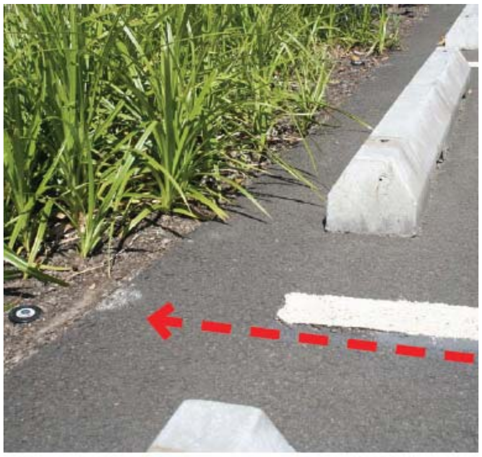


Figure 5-12: Stormwater runoff enters the stormwater facility through the 3-foot space between these wheelstops. The design could be improved by providing more of a drop in grade between the asphalt and landscape area.

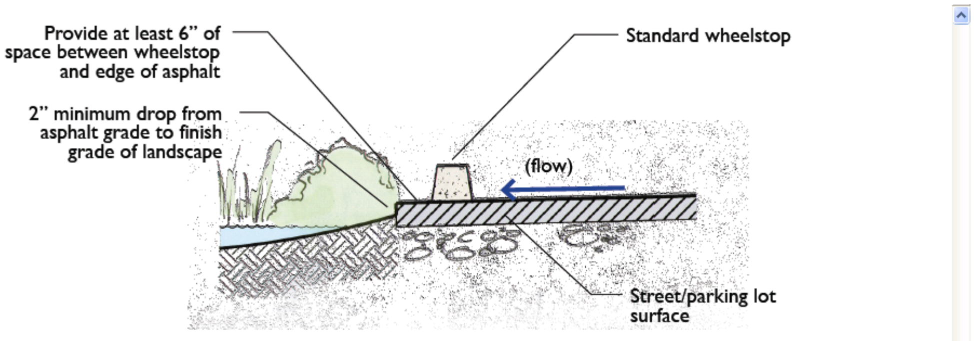



Figure 5-13: Opening between wheelstop curbs: section view (Source: SMCWPPP 2009)

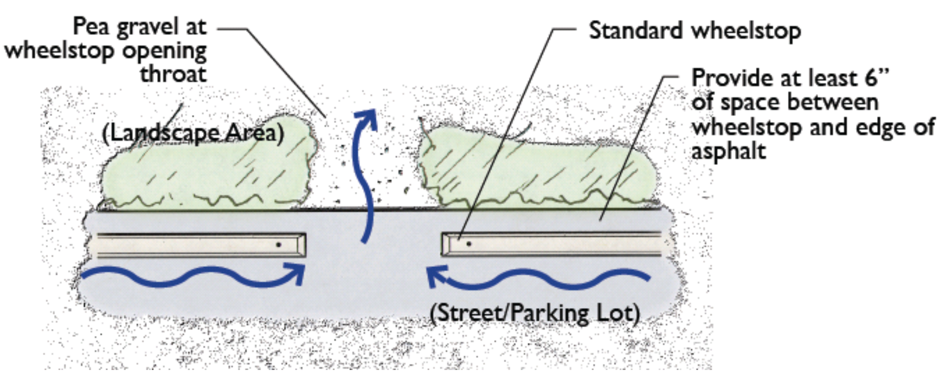



Figure 5-14: Opening between wheelstop curbs: plan view (Source: SMCWPPP 2009)

- 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 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.


*Figure 5-15: A grated curb cut allows stormwater to pass under a pedestrian egress zone to the stormwater facility.*

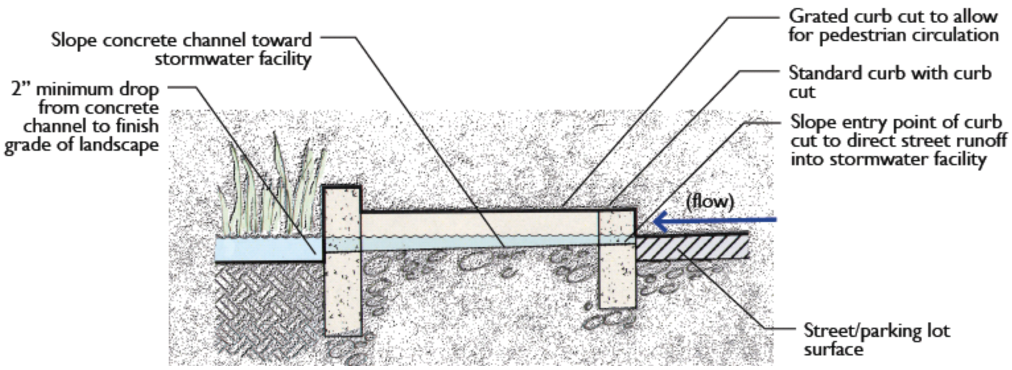



Figure 5-16: Grated curb cut: section view (Source: SMCWPPP 2009)

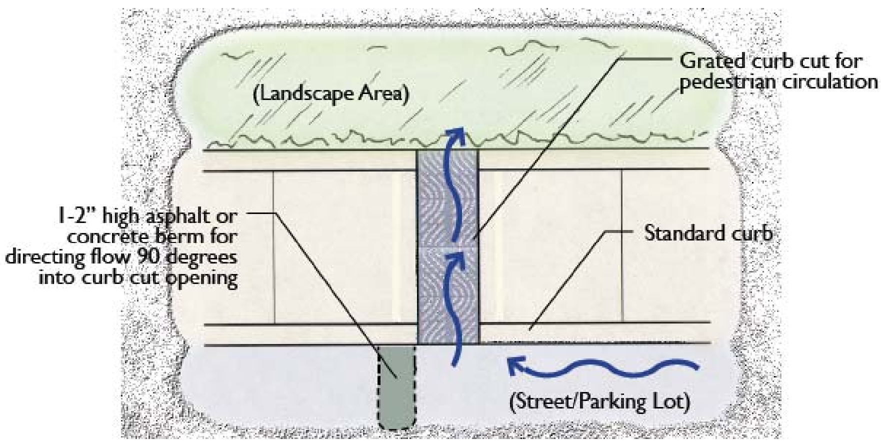



Figure 5-17: Grated curb cut: plan view (Source: SMCWPPP 2009)

# 5.14 Underdrain

Were the existing soils have a lower infiltration rate than soils specified for a landscape-based stormwater treatment 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***. In most of San Mateo County, underdrains will be required.

Underdrains are perforated pipes that allow water to enter the pipe and flow to the storm drain system. To help prevent clogging, two rows of perforation may be used along the underside of the pipe. Cleanouts should be installed to allow access to underdrains to remove debris. ***Underdrains should NOT be wrapped in filter fabric***, to avoid clogging. Underdrains are typically installed in a layer of washed drain rock or Class 2 permeable aggregate, beneath more permeable stormwater biotreatment soils. The nominal rock diameter size used in the rock layer should be larger than the diameter of the perforations in the subdrain to prohibit drain rock from entering the subdrain pipe.

The MRP requires that the full amount of stormwater runoff specified in Provision C.3.d must be infiltrated, evapotranspired, or harvested for use. Where this is infeasible, as determined using feasibility/infeasibility criteria in Appendix I, biotreatment will be allowed. Any use of underdrains will need to be consistent with the feasibility/infeasibility criteria. In a facility designed for infiltration, an underdrain is allowed as long as it is located above a section of drain rock with sufficient void space to store and infiltrate the C.3.d volume.

When designing a bioretention facility and infiltration is permitted onsite, the underdrain should be placed near the top of the drain rock layer to allow as much water to infiltration into native soils as possible before entering the underdrain and discharging to a storm drain. If infiltration is not permitted due to site conditions such as high groundwater, contaminated soils, proximity to structures, etc., the bioretention facility should be lined and the underdrain placed near the bottom of the drain rock layer. Refer to the technical guidance for specific stormwater treatment measures in Chapter 6 for more details.

Chapter

# 6

# Technical Guidance for Specific Treatment Measures

## *In this Chapter:*

- *Technical guidance for stormwater treatment measures commonly used in San Mateo County*

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

| **Table 6-1: Treatment Measures for which Technical Guidance is Provided** | |
|---|---|
| **Treatment Measures** | **Section** |
| Bioretention areas | 6.1 |
| Flow-through planter box | 6.2 |
| Tree well filter | 6.3 |
| Infiltration trench | 6.4 |
| Extended detention basin | 6.5 |
| Pervious paving | 6.6 |
| Turf block and permeable joint pavers | 6.7 |
| Green roof | 6.8 |
| Rainwater harvesting and use | 6.9 |
| Media filter | 6.10 |
| Subsurface infiltration system | 6.11 |

The technical guidance in this chapter is intended help prepare permit application submittals for your project. Municipalities will require you to prepare more specific drawings taking into consideration project site conditions, materials, plumbing connections, etc., in your application. This technical guidance was developed using best engineering judgment and based on a review of various documents and guidance from Water Board staff as available. We look forward to working with Water Board staff to continue improving this guidance.

# 6.1 Bioretention Areas

Figure 6-1. Bioretention Area.
Source: City of Brisbane

### 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 areas[1], or "rain gardens," are concave landscaped areas that function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. Bioretention areas can be any shape, including linear. Linear bioretention areas are sometimes referred to as bioretention swales. Bioretention areas normally consist of the following layers, starting from the top: a surface ponding area, a layer of mulch, planting soil and plants, and an underlying rock layer with an underdrain that connects to the municipal storm drain system.

Bioretention areas are designed to distribute stormwater runoff evenly within the surface ponding area. The water is temporarily stored in the ponding area and percolates through the planting soil, which is engineered to have a high rate of infiltration. From there, the water filters down into the underlying rock layer.

The rock layer of the bioretention area may be designed to either maximize infiltration or prevent infiltration to the underlying soils. In bioretention areas that maximize infiltration, the underdrain is raised 6 inches above the bottom of the rock layer, and there is no liner between the rock layer or planting soil and the surrounding soils. Maximizing infiltration is only allowed where conditions are suitable for infiltration – check with the geotechnical engineer. Where infiltration is precluded, the bioretention area is fully lined with waterproof material, and the underdrain is placed at the bottom of the rock layer.

## 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.

[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".

- Area draining to the bioretention area does not exceed 2 acres.
- Area draining to the bioretention area shall 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 shall have slopes more than 0.5% for pavement and more than 1% for vegetated areas.
- Bioretention areas, including linear treatment measures, shall not be constructed in slopes greater than 4%, unless constructed as a series of bioretention cells. Separate bioretention cells by check dams up to 24 inches high and at least 25 feet apart. The slope within cells shall not exceed 4%. Bioretention cells are not recommended if overall slope exceeds 8%.
- If treatment measure is designed to infiltrate stormwater to underlying soils, a 50-foot setback is needed from septic system leach field.

***TREATMENT DIMENSIONS AND SIZING***

- Bioretention area may be sized to 4% of the impervious surface area on the project site. The area of impervious surface multiplied by 0.04 sizing factor will equal the footprint of the bioretention area. Alternatively, bioretention sizing may be calculated using the flow-based treatment standard, or the combination flow- and volume-based treatment standard described in Section 5.1 based on the flow entering the basin at the treatment flow rate over the initial hours of the storm until the treatment volume is attained.
- The bioretention area shall be sized to either:
  - Percolate the design treatment flow using a rate of 5 inches per hour. No additional allowance is provided for storage or for infiltration rates in excess of 5 inches per hour; or,
  - Store the 24-hour treatment volume based on inflow at the water treatment rate for the initial hours of the storm and outflow by infiltration.
- Where there is a positive surface overflow, bioretention areas shall have freeboard of at least 0.2 feet to the lowest structural member versus the 100-year storm water level in the bioretention area, unless local jurisdiction has other requirements.
- Where the bioretention area is in a sump that depends on outflow through a catch basin, the bioretention area shall have a freeboard of at least 0.5 feet to the lowest building finished floor elevation (including garage and excluding crawl space) for conditions with the outlet 50 percent clogged, unless local jurisdiction has other requirements. Where the freeboard cannot be provided, emergency pump may be allowed on a case-by-case basis.
- Minimum 2 inches between the crest of the emergency outfall riser and elevation of the surface area.
- The elevation of the surface area may vary as needed to distribute stormwater flows throughout the surface area.
- Side slopes do not exceed 3:1; downstream slope for overflow shall not exceed 3:1.

- Surface ponding depths should vary, with a maximum depth of 12 inches. If ponding depths exceed 6 inches, landscape architect shall approve planting palette for desired depth.
- The inlet to the overflow catch basin shall be at least 6 inches above the low point of the bioretention planting area.

***INLETS TO TREATMENT MEASURE***

Flow may enter the treatment measure (see example drawings in Section 5.13):

  - 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 5-3 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.
- Cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.

***VEGETATION***

- Plant species should be suitable to well-drained soil and occasional inundation. See planting guidance in Appendix A.
- Shrubs and small trees shall be placed to anchor the bioretention area cover.
- Tree planting shall be as required by the municipality. If larger trees are selected, plant them at the periphery of bioretention area.
- Underdrain trench shall be offset at edge of tree planting zone, as needed, to maximize distance between tree roots and underdrain.
- 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 shall be provided to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

***SOIL AND DRAINAGE CONSIDERATIONS SPECIFIC TO BIORETENTION AREAS***

- Planting soil shall have a long term minimum percolation rate of 5 inches per hour (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.) Soil guidance is provided in Appendix K. Check with municipality for any additional requirements.

- Bioretention areas shall have a minimum planting soil depth of 18 inches.
- Provide 3-inch layer of mulch in areas between plantings.
- An underdrain system is generally required. Depending on the 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:
  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 constrains, 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.
  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 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.

***SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS***

- Filter fabric shall not be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- Underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2, or similar municipality-approved material. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used. There shall be adequate fall from the underdrain to the storm drain or discharge point.
- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix K), which supersede other soil specifications. The minimum percolation rate for the biotreatment soil is 5 inches per hour. The long-term desired maximum infiltration rate is 10 inches per hour, although initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.

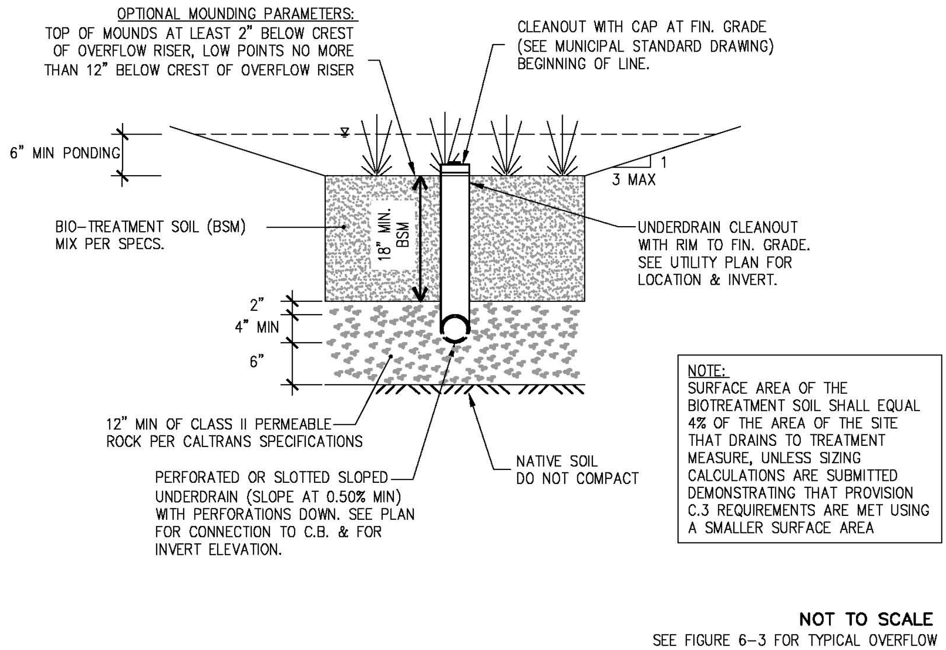
***CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS***

- 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 shall be diverted away from biotreatment facility.

***MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES***

- A Maintenance Agreement shall be provided.

- Maintenance Agreement shall state parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix




G.

Figure 6-2: Cross Section, Bioretention Area

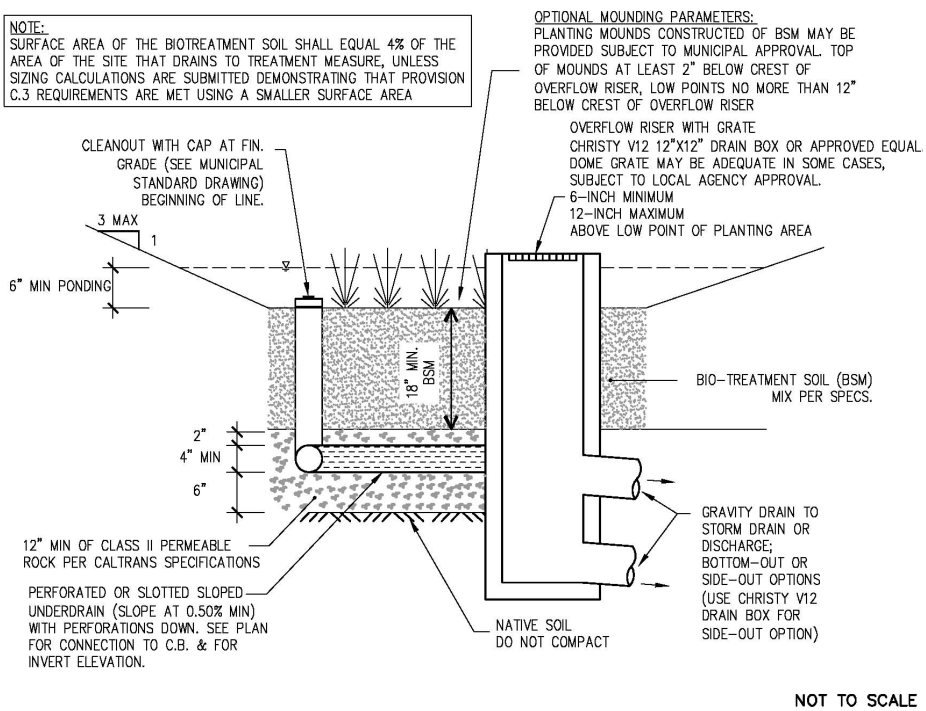



Figure 6-3: Cross Section, Bioretention Area (side view)

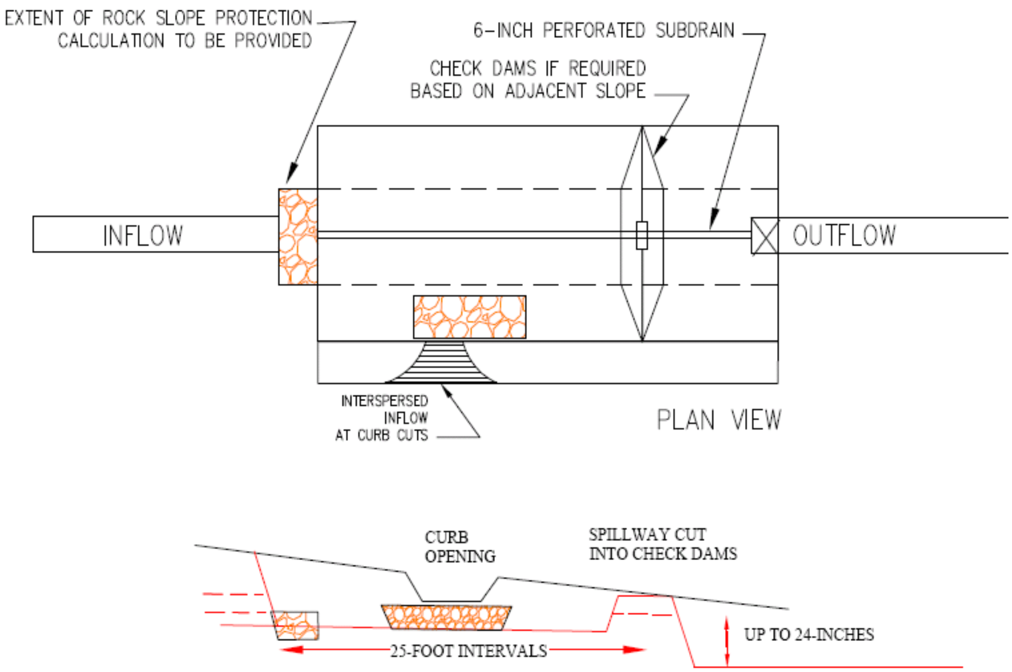



Figure 6-4: Check dam (plan view and profile) for installing a series of linear bioretention cells in sloped area

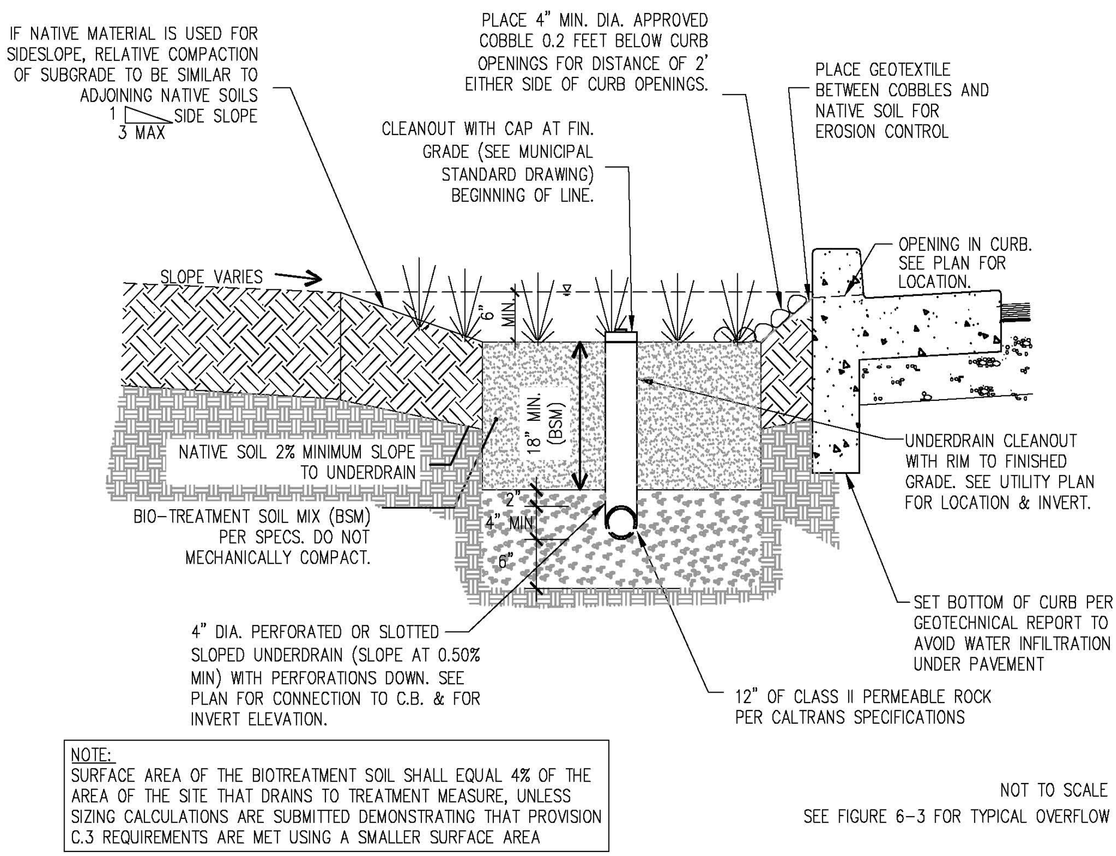



Figure 6-5: Cross section of bioretention area showing inlet from pavement.

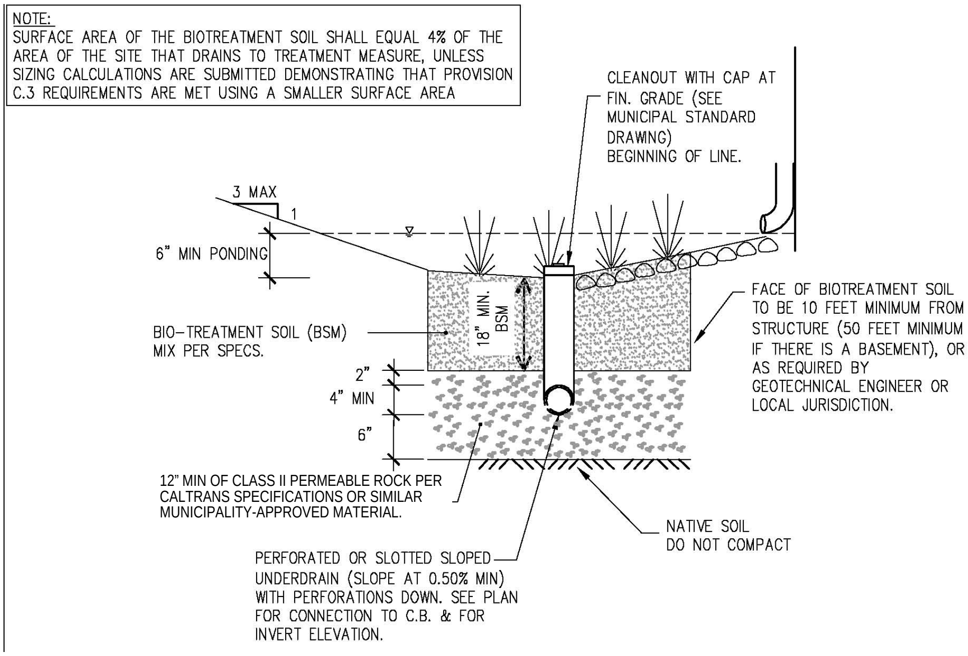



Figure 6-6: Bioretention area in landscaping to treat runoff from rainwater leaders (Not to Scale)

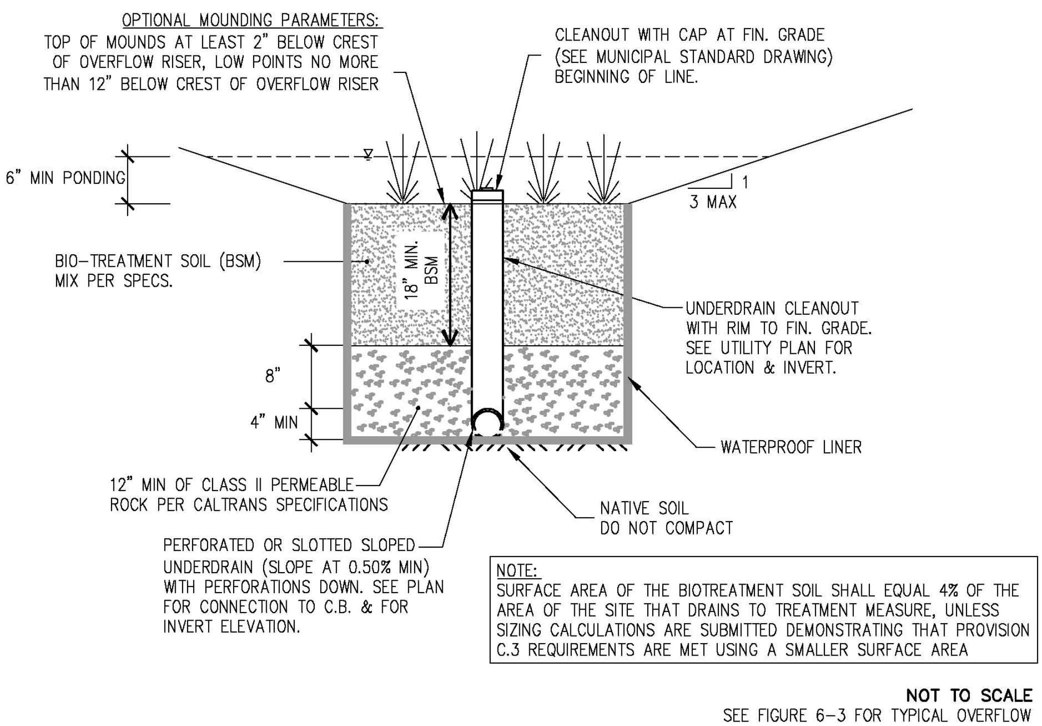



Figure 6-7: Cross section of lined bioretention area, for locations where infiltration is precluded.

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## 6.2 Flow-Through Planter

Figure 6-8: At-grade flow-through planter. Source: City of Emeryville

### Best uses

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

### Advantages

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

### Limitations

- Requires 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 must be directed to a storm drain or other discharge point. An overflow inlet conveys flows that exceed the capacity of the planter.

***TREATMENT DIMENSIONS AND SIZING***

- Flow-through planters may be designed with a 4% sizing factor (percentage of the surface area of planter compared to the surface area of the tributary impervious area). The area of impervious surface multiplied by 0.04 sizing factor will equal the footprint of the flow-through planter. Alternatively, calculations may be performed using either the hydraulic sizing criteria for flow-based treatment measures or the hydraulic sizing criteria for combination flow- and volume-based treatment measures, included in Section 5.1.
- Install an overflow weir adequate to meet municipal drainage requirements.
- Flow-through planters can be used adjacent to building and within set back area.
- Flow-through planters can be used above or below grade.
- Size overflow trap for building code design storm, set trap below top of planter box walls.
- Planter wall set against building should be higher to avoid overflow against building.

- Elevation of the surface area may vary as needed to distribute stormwater flows throughout the surface area.
- Minimum 2 and up to12 inches of water surface storage between the planting surface and crest of overflow weir.

***VEGETATION***

- Plantings should be selected for viability in a well-drained soil. See planting guidance in Appendix A.
- 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 shall be provided, as needed, to maintain plant life.
- 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 5.13):

  - 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 5-3 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.
- Splash blocks, cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.
- 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 shall be installed as required to protect adjacent building foundations.
- An underdrain system is required for flow through planters.
- The biotreatment soil shall have long term minimum percolation rate of 5 inches per hour (although the initial infiltration rate may exceed this to allow for a tendency of the infiltration rate to reduce over time.) Soil specifications are provided in Appendix K. Check with municipality for additional requirements.
- The biotreatment soil shall be at least 18 inches deep.

- Provide 3-inch layer of mulch in areas between plantings.
- To avoid excess hydraulic pressure on subsurface treatment system structures:
    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.

***SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS***

- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix K), which supersedes other soil specifications. The minimum long term percolation rate for the biotreatment soil is 5 inches per hour although initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.
- Filter fabric shall not be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground.
- The underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2, or similar municipality-approved material. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.

***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 shall be diverted away from biotreatment facility.

***MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES***

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

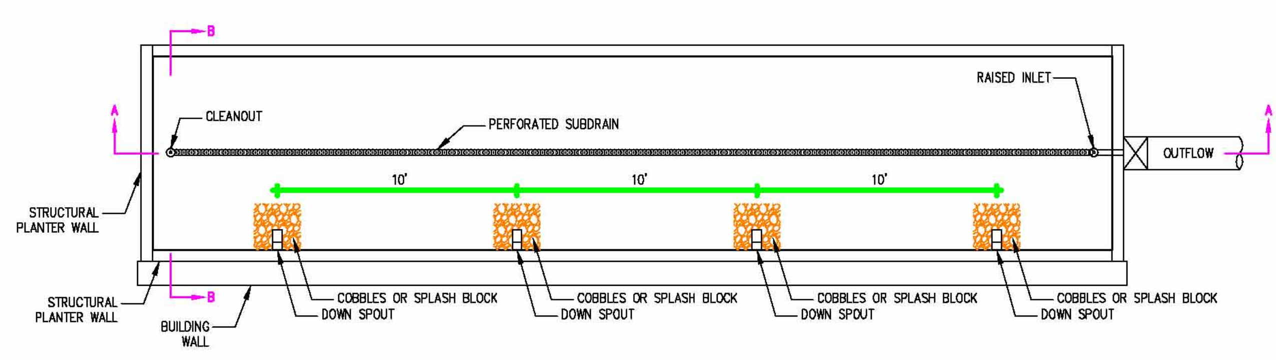


Figure 6-9: Plan view of long, linear planter, with inlets to the planter distributed along its length at 10' intervals.

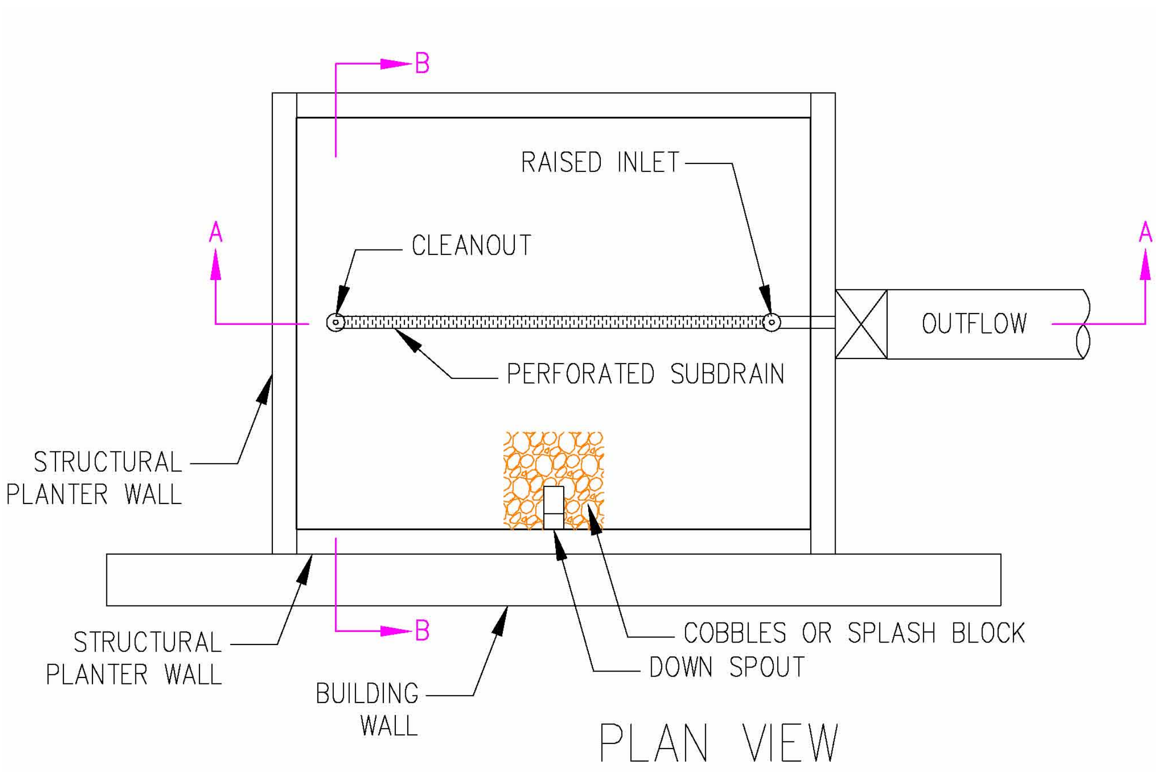


Figure 6-10: Plan view of planter designed to disperse flows adequately with only one inlet to planter

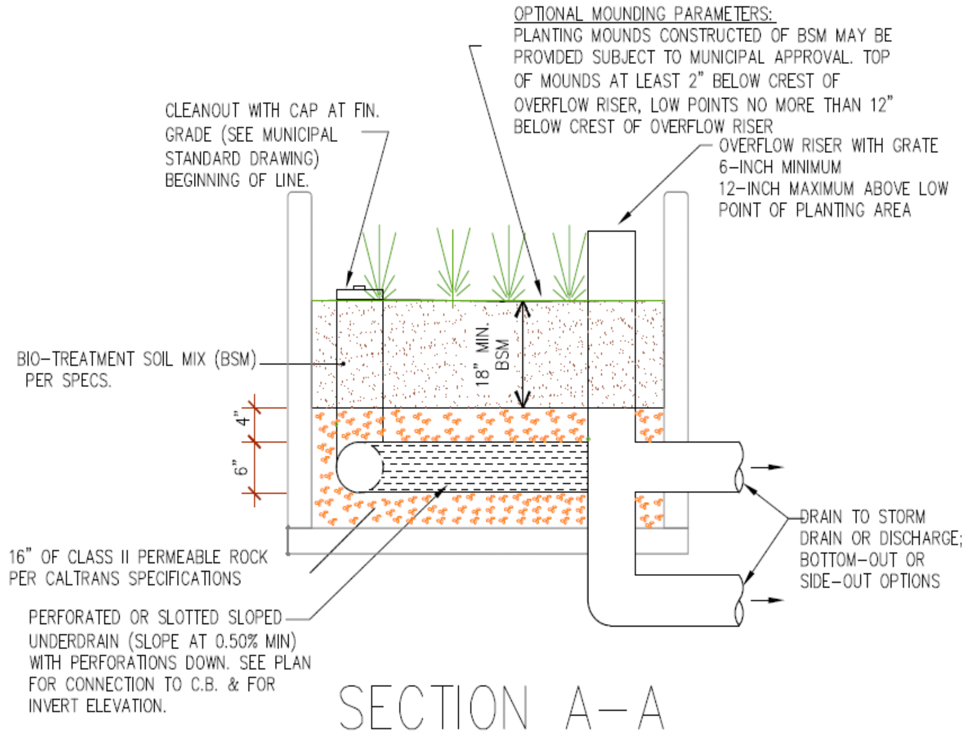


Figure 6-11: Cross section A-A of flow-through planter, shows side view of underdrain (Not to Scale)

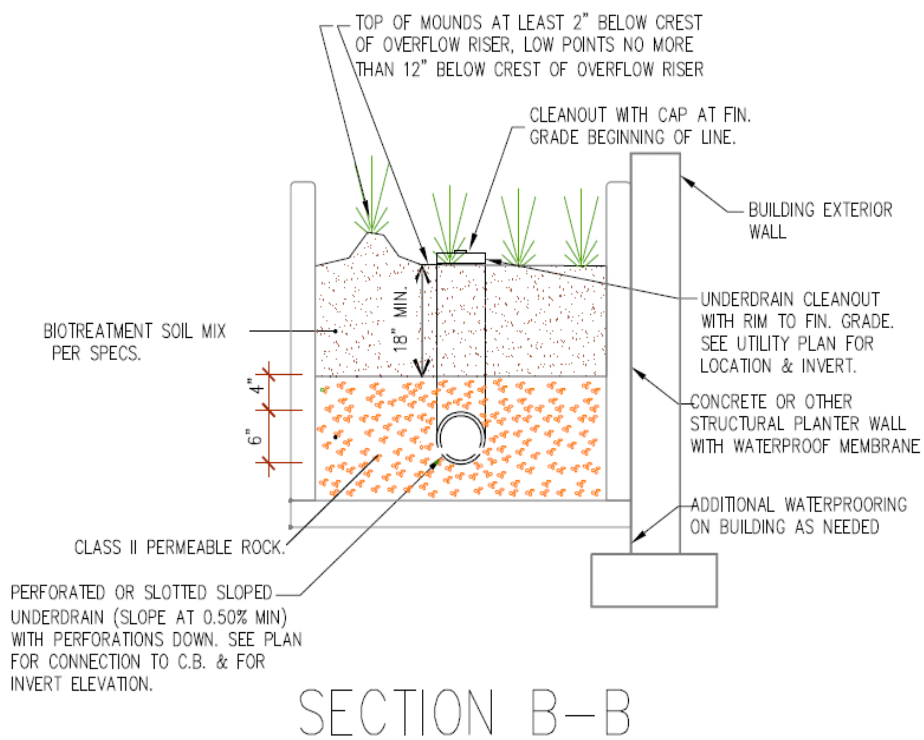


Figure 6-12: Cross section B-B of flow-through planter, shows cross section of underdrain

Figure 6-13: Above-grade planters. Source: City of Portland

Figure 6-14: Close-up of Flow Through Planter. (Source: City of Portland)

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# 6.3 Tree Well Filter

Figure 6-15: 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

- 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 beginning December 2011***

Tree filters consist of one or multiple chambered pre-cast concrete boxes or hoops with a small tree or shrub planted in a filter bed filled with engineered media or other absorptive filtering media. As stormwater flows into the chamber, large particles settle out on the mulch layer, and then finer particles and other pollutants are removed as stormwater flows through the filtering media. Underground, physical, chemical and biological processes work to remove pollutants from stormwater runoff. Stormwater flows through a specially designed filter media mixture that has a high rate of infiltration. The mixture immobilizes some pollutants, which may be decomposed and volatilized, or incorporated into the biomass of the tree filter system's micro/macro fauna and flora. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged. Tree filters are similar in concept to bioretention areas in function and applications, with the major distinction that a tree filter has been optimized for high volume/flow treatment, therefore the size of treatment area is proportionally less. A tree filter takes up little space and may be used on highly developed sites such as landscaped areas, green space, parking lots and streetscapes. A tree filter is adaptable and may be used for developments, in all soil conditions to meet stormwater treatment needs. ***Beginning December 1, 2011,*** manufactured tree well filters, and other tree well filters with long-term rates of infiltration that exceed 10 inches per hour, will be allowed only in Special Projects, as described in Appendix J.

## Design and Sizing Guidelines

- Flows in excess of the treatment flow rate shall bypass the tree filter to a downstream inlet structure or other appropriate outfall.
- Tree filters cannot be placed in sump condition; therefore tree filters shall have flow directed along a flow line of curb and gutter or other lateral structure. Do not direct flows directly to a tree filter.
- If a proprietary tree filter is used, it shall be reviewed by the manufacturer before installation.
- For proprietary tree filters, manufacturer will size the tree filter to the impervious surface of a site. The manufacturer shall certify the ratio of impervious area to treatment area for the project. For example, Filterra states that a tree filter of 6 x 6-feet can treat 0.25 acres of impervious surface.
- Proprietary tree filters are available in multi-sized pre-cast concrete drop in boxes, Sizes range from 4 x 6-feet up to 6 x 12-feet boxes.

***INLETS TO TREATMENT MEASURE***

Flow may enter the treatment measure (see example drawings in Section 5.13):

  - 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 5-3 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.
- Cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.

***VEGETATION***

- Suitable plant species are identified in Appendix A 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 shall be provided, as needed, to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

***SOIL AND DRAINAGE REQUIREMENTS SPECIFIC TO TREE WELL FILTERS***

- Filter media in tree well filter shall be specialized for expected site pollutant loads.

- Beginning December 1, 2011, if the long-term infiltration rate of media exceeds 5 inches per hour, use of the tree well filter will not be allowed, except for Special Projects (see Appendix J).
- An underdrain system is required for tree well filters.
- Consideration of groundwater level and placement of the underdrain:
  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 between the drain rock and the bottom of the facility and the underdrain placed on top of that liner.
  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 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.
- To avoid excess hydraulic pressure on subsurface treatment system structures:
  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.

***SOIL AND DRAINAGE CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS***

- Filter fabric shall not be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- Underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2, or similar municipality-approved material. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.
- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix K), which supersede other soil specifications. The minimum long term percolation rate for the biotreatment soil is 5 inches per hour - the initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.

***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 shall be diverted away from biotreatment facility.

***MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES***

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

Figure 6-16: Non-proprietary Tree Filter with Overflow Bypass. Source: University of New Hampshire Environmental Research Group, 2006

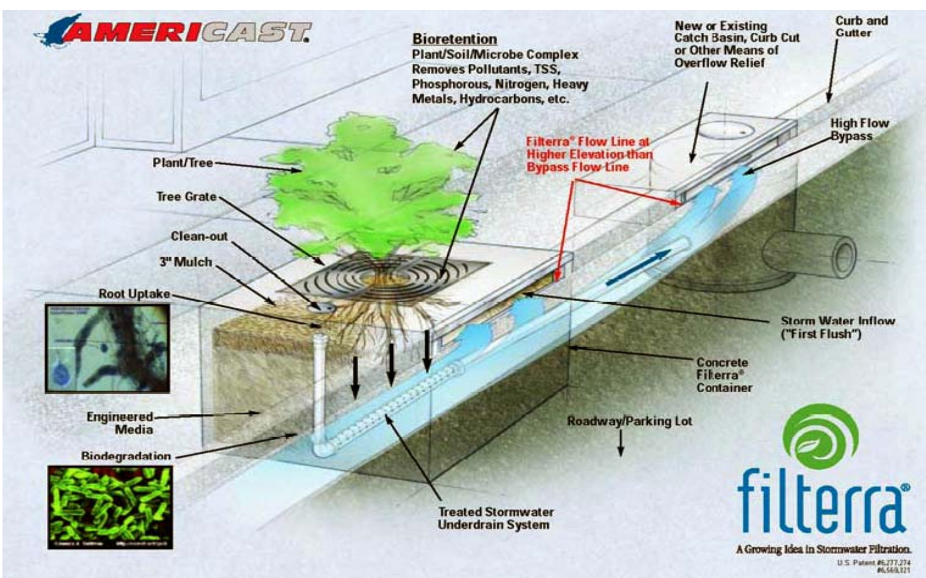


Figure 6-17: Cut Away View. Source: Americast, 2006. The use of this photo is for general information only, and is not an endorsement of this or any other proprietary stormwater treatment device.

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# 6.4 Infiltration Trench

Figure 6-18. Infiltration Trench. Source: CASQA, 2003

### Best Uses

- Limited space
- Adjacent to roadways
- Landscape buffers

### Advantages

- Increases groundwater recharge
- Removes suspended solids
- Used with other BMPs
- 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

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

## Design and Sizing Guidelines

***DRAINAGE AREA AND SETBACK CONSIDERATIONS***

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

- There shall 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 shall 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 shall be sized to store the full 48-hour water quality 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 35 to 40 percent. A minimum drainage time of 6 hours shall be provided to ensure satisfactory pollutant removal in the infiltration trench. Trenches may be designed to provide temporary storage of storm water. 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. Typically, there is about 35 to 40% void space within the rock.
- Use trench rock that is 1.5 to 2.5 inches in diameter or pea gravel to improve sediment filtering and maximize the pollutant removal in the top 1 foot of the trench.
- Place permeable filter fabric around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric shall overlap each side of the trench in order to cover the top of the stone aggregate layer. The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate. Filter fabric that is placed 1 foot below the trench surface will maximize pollutant removal within the top layer of the trench and decrease the pollutant loading to the trench bottom, reducing frequency of maintenance.
- The infiltration trench shall drain within 5 days to avoid vector generation.
- An observation well is recommended to monitor water levels in the trench. The well can be 4 to 6-inch diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench.

#### *INLET TO THE TREATMENT MEASURE*

- A vegetated buffer strip at least 5-feet wide, swale or detention basin shall be established adjacent to the infiltration trench to capture large sediment particles in the runoff 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 shall be graded with a slope between 0.5 and 15 percent so that runoff enters the trench as sheet flow. The vegetated buffer strip or detention basin shall be sized according to Sections 6.4 and 6.6 respectively.

- If runoff is piped or channeled to the trench, a level spreader shall be installed to create sheet flow.

***IF VEGETATION IS ALLOWED AT TRENCH SURFACE***

- Infiltration trenches can be modified by adding a layer of organic material (peat) or loam to the trench subsoil. This modification enhances the removal of metals and nutrients through adsorption. The modified trenches are then covered with a permeable geotextile membrane overlain with topsoil and grass or stones.
- If surface landscaping of the trench is desired, contact local municipality to determine if this is allowed.
- Plant species should be suitable to well-drained soil. See planting guidance in Appendix A.
- 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 shall be provided as needed to maintain plant life.

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

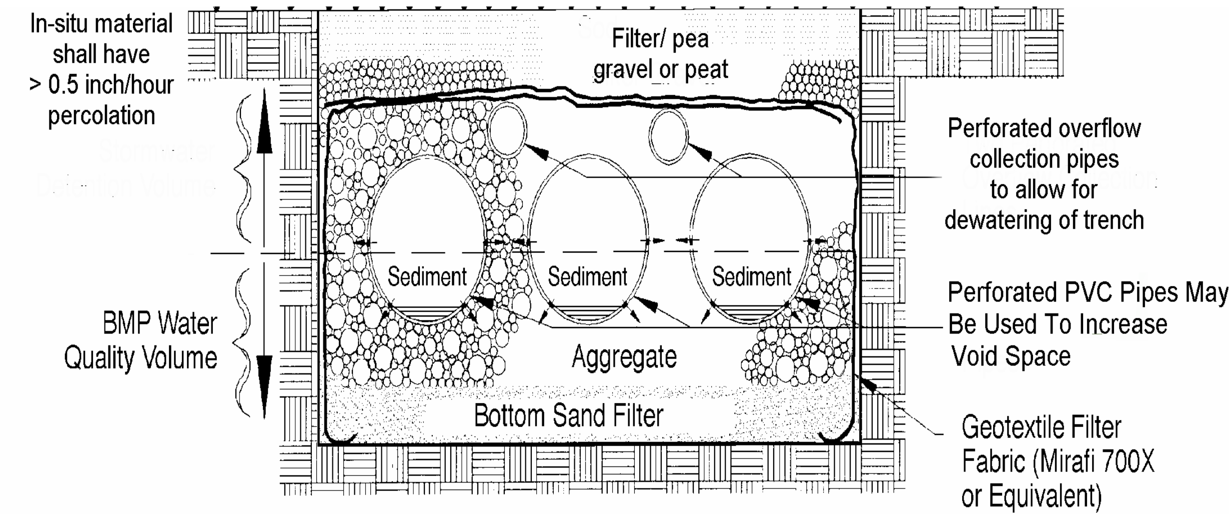


Figure 6-19: Infiltration trench cut-away view

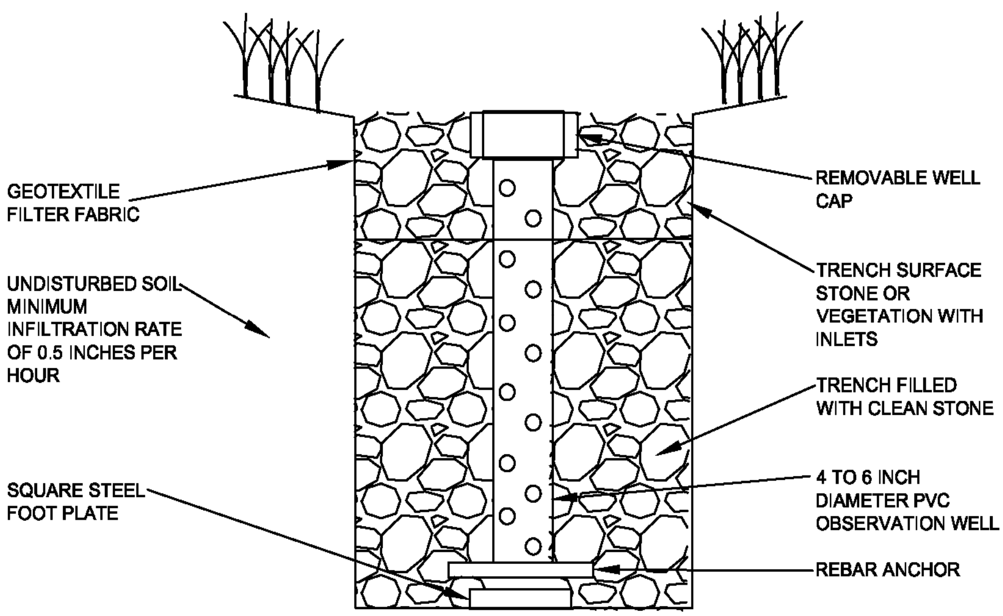


Figure 6-20: Cutaway view: Infiltration Trench with Observation Well

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# 6.5 Extended Detention Basin

Figure 6-21: Extended Detention Basin. Photograph courtesy of Bill Southard (DES Architects and Engineers)

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

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

### Limitations
- Storage area available
- Moderate pollutant removal

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

***Beginning December 1, 2011,*** projects will no longer be 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 new MRP requirements for biotreatment soils and surface loading area.

## Design and Sizing Guidelines

***TREATMENT DIMENSIONS AND SIZING***

- Extended detention basins shall be sized to capture the required water quality volume over a 48-hour period. At least 10 percent additional storage shall be provided to account for storage lost to deposited sediment.
- Extended detention basin shall have no greater than 3:1 side slopes.
- The optimal basin depth is between 2 and 5 feet.
- A safety bench shall be added to the perimeter of the basin wall for maintenance when basin is full.

- Extended detention basin shall empty within five days of the end of a 6-hour, 100-year storm event 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 shall be provided. If not paved, the ramp shall have a maximum slope of 5 percent. If paved, the ramp may slope 12 percent.
- The extended detention basin shall have a length to width ratio of at least 1.5:1.
- A fixed vertical sediment depth marker shall be installed in the sedimentation forebay. The depth marker shall have a marking showing the depth where sediment removal is required. The marking shall be at a depth where the remaining storage equals the design water quality volume.
- The detention basin is a volume-based treatment measure and requires detention time to be effective. The basin shall not empty more than 50% of its treatment volume in less than 24 hours to ensure treatment of runoff.

***INLETS TO TREATMENT MEASURE***

- The inlet pipe shall have at least 1 foot of clearance to the basin bottom.
- Piping into the extended detention basin shall have erosion protection. As a minimum, a forebay with a 6-inch thick layer of Caltrans Section 72, Class 2 rock slope protection shall be placed at and below the inlet to the extent necessary for erosion protection.
- 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***

- The outlet shall be sized with a drawdown time of 48 hours for the design water quality volume. The outlet shall have two orifices at the same elevation sized using the following equation:

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

  Where:

  a = area of each orifice in square feet
  A = surface area of basin at mid-treatment storage elevation (square feet)
  H = elevation of basin when filled by water treatment volume (feet)
  Ho = final elevation of basin when empty (bottom of lowest orifice) (feet)
  C = orifice coefficient (0.6 typical for drilled orifice)
  T = drawdown time of full basin (hours)

  (Caltrans Method, Appendix B, Stormwater Quality Handbook, September 2002)

- The orifices shall each be a minimum diameter of 1 inch. Extended detention basins are not practical for small drainage areas because the minimum orifice diameter cannot be met.
- Each orifice shall be protected from clogging using a screen with a minimum surface area of 50 times the surface area of the openings to a height of at least 6 times the diameter. The screen shall protect the orifice openings from runoff on all exposed sides.

- For each outlet, documentation shall be provided regarding adequacy of outlet protection, and a larger stone size may be necessary depending on the slope and the diameter of the outfall.

***VEGETATION***

- Plant species should be adapted to periods of inundation. See planting guidance in Appendix A.
- 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 shall be provided as needed to maintain plant life.
- If vegetation is not established by October 1st, sod shall 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***

- 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.

***EXTENDED DETENTION BASINS ARE NOT DESIGNED TO INFILTRATE THE ENTIRE VOLUME OF WATER CAPTURED, BUT THEY MAY INFILTRATE SOME WATER IF CONDITIONS ALLOW***
***MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES***

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

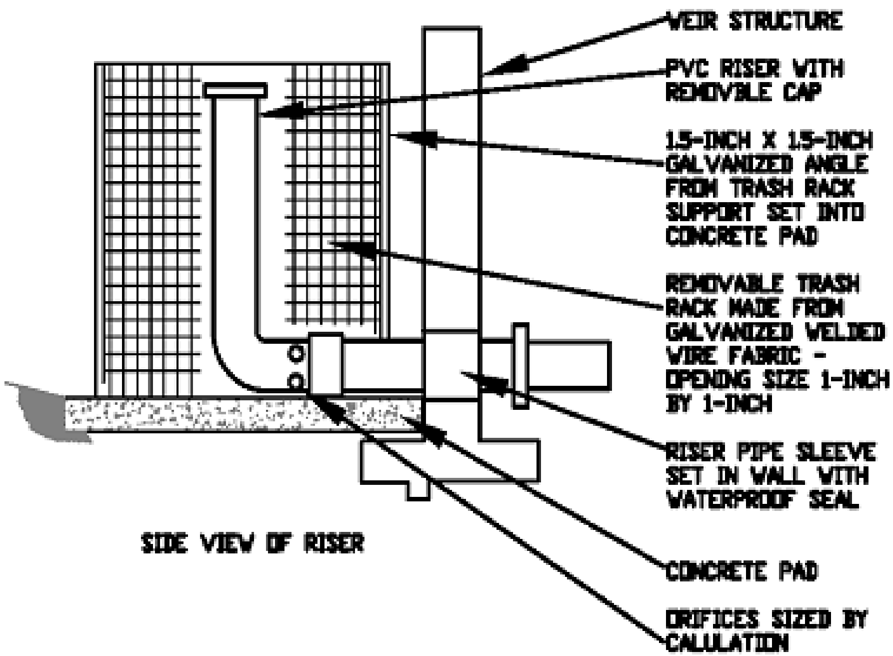



Figure 6-22. Side View of Riser

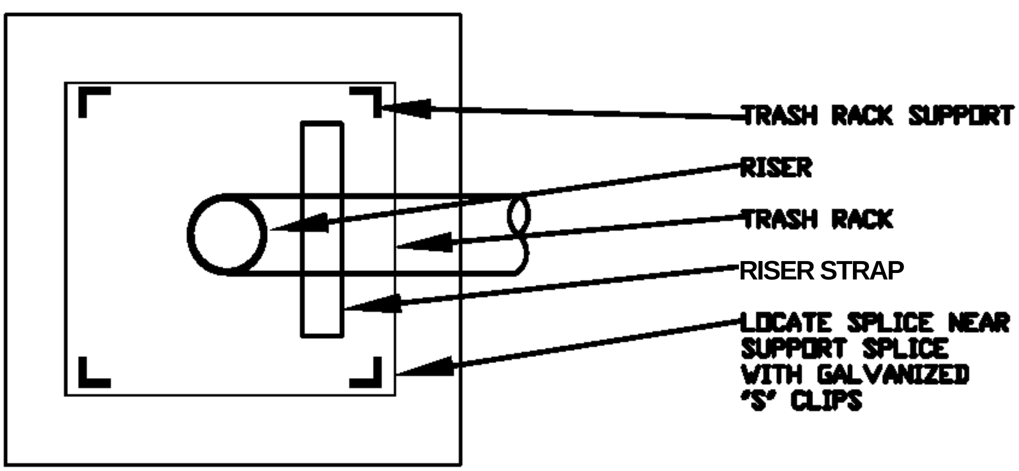
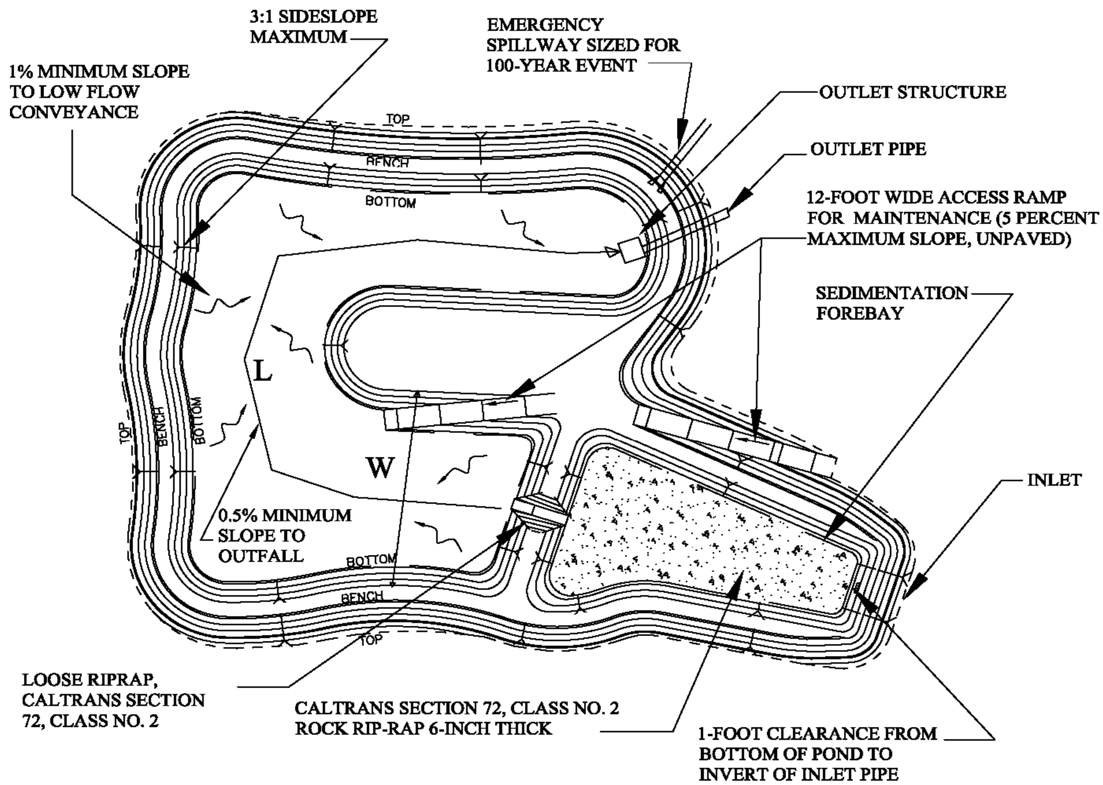



Figure 6-23. Top View of Riser (Square Design)




NOTES:
LENGTH (L) SHALL BE AT LEAST 1.5 TIMES THE WIDTH (W)

Figure 6-24. Plan View, Typical Extended Detention Basin

# 6.6 Pervious Paving

Figure 6-25: The City of Menlo Park used pervious concrete for parking stalls and standard paving in the drive aisles in this public parking lot.

Best uses

- Low-speed residential roads and alleys
- Parking lots
- Driveways
- Sidewalks & Plazas

Advantages

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

Limitations

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

Pervious pavement types include pervious concrete, porous asphalt, pervious concrete pavers and permeable interlocking concrete pavement (PICP). Except for PICP, pervious paving is used for areas with light vehicle loading and lightly trafficked areas, such as automobile parking areas. Crushed aggregate is sometimes used as pervious pavement as well. Table 6-2 shows possible applications for different types of pervious paving. 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 such that water infiltrates across the entire surface of the material at a high rate. If an area of pervious paving is underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, it is not considered an impervious surface and can function as a self-treating area, as described in Section 4. 2.

Please note that the CALGreen Building Code does not define pervious paving in the same way as the MRP. Projects that include pervious paving per CALGreen requirements must also verify that the pervious paving meets the MRP definition of pervious pavement.

*The Countywide 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.*

**Table 6-2:**
**Types of Pervious Paving and Possible Applications**

| Paver Type | Description | Possible Applications |
|---|---|---|
| Porous Asphalt | Open-graded asphalt concrete over an open-graded aggregate base, over a draining soil. Contains very little fine aggregate (dust or sand) and is comprised almost entirely of stone aggregate and asphalt binder; surface void content of 12-20%. | Low traffic use, such as parking lots, travel lanes, parking stalls. Surface may be too rough for bicycle path. |
| Pervious Concrete | A discontinuous mixture of coarse aggregate, hydraulic cement and other cementitious materials, admixtures, and water which have a surface void content of 15-25% allowing water to pass through. | Sidewalks and patios, low traffic volume and low speed (less than 30 mph limit) bikeways, streets, travel lanes, parking stalls, and residential driveways. |
| Permeable Interlocking Concrete Pavers (PICP) | Discrete units set in a pattern on a prepared base. Typically made of precast concrete in shapes that form interlocking patterns. Solid unit pavers are made of impermeable materials, but are spaced to expose a permeable joint filled with permeable aggregates and set on a permeable base. | Parking stalls and lots, private driveways, walkways, patios, alleys, travel lanes, low volume streets. |
| Pervious Concrete Pavers | Discrete units set in a pattern on a prepared base. Constructed of pervious concrete. | Lighter traffic pedestrian and vehicle areas. |
| Source: Design Guidelines for Permeable Pavements, Redwood City | | |

## Design and Sizing Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and the layer's required operational life. The thickness of the base layer is also affected by hydrologic sizing considerations. To provide satisfactory performance, the following criteria shall be considered.

***SUBGRADE AND SITE REQUIREMENTS***

- The soil sub-grade shall be able to sustain anticipated traffic loading without excessive deformation while temporarily saturated.
- The sub-grade shall be either ungraded in-situ material with an infiltration rate that allows detained flows to infiltrate within 72 hours, or the paving system can be installed with an underdrain that will remove detained flows within the pervious paving and base.
- 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***

- To allow for subsurface water storage, the base must be open graded, crushed stone (not pea gravel), meaning that the particles are of a limited size range, with no fines, so that small particles do not choke the voids between large particles.
- 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.
- If the subbase/base layer is sized to hold 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 (see Section 4. 2).
- If the subbase/base layer has sufficient capacity in the void space to store the C.3.d amount of runoff for both the area of pervious paving and the area that drains to it, it is not considered an impervious surface and can function as a self-retaining area, described in Section 4.2.
- Pervious paving designed to function as a self-retaining area may accept runoff from an area of impervious surface that has a surface area of up to two times the surface area of the properly-designed 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 shall 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 shall 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 Traffic Index = 9.
    - Drainage routing of detained flows within the open graded subbase/base as well as expected infiltration into in-situ soils, or collection in a raised underdrain if infiltration rate cannot meet design criteria.

***PAVEMENT MATERIALS***

- The pavement materials shall 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 shall 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* $4^{th}$ 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 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.
- All new pavements should have a minimum surface infiltration rate of 100 in./hr when tested in accordance with ASTM C1701.
- Protect excavated area from excessive compaction due to construction traffic and protect the finished pavement from construction traffic.

### Maintenance

A maintenance plan shall be provided.
Standards for Ongoing Maintenance and Upkeep:

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

As needed maintenance:

- If routine cleaning does not restore infiltration rates, then reconstruction of part of the pervious surface may be required.
- The surface area affected by hydraulic failure should be lifted, if possible, for inspection of the internal materials to identify the location and extent of blockage.
- Lift and replace surface materials as needed to restore infiltration.

  Geotextiles may need complete replacement.
- Sub-surface layers may need cleaning and replacing.
- Removed silts may need to be disposed of as controlled waste.

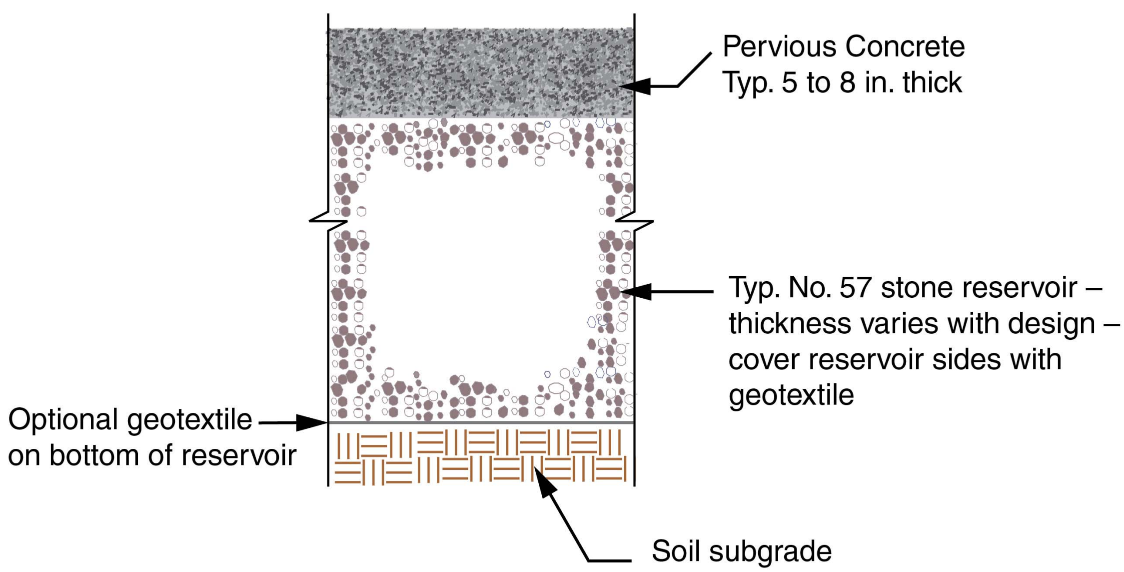



Figure 6-26. Typical Pervious Concrete Pavement (Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

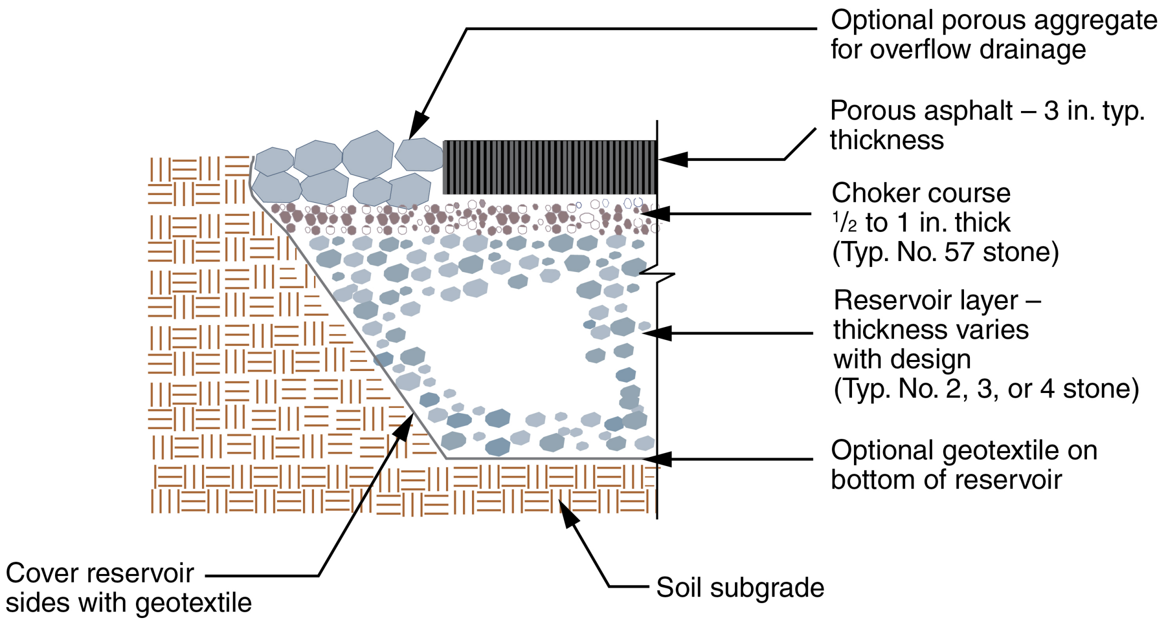



Figure 6-27. Typical Porous Asphalt Pavement

Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone. (Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

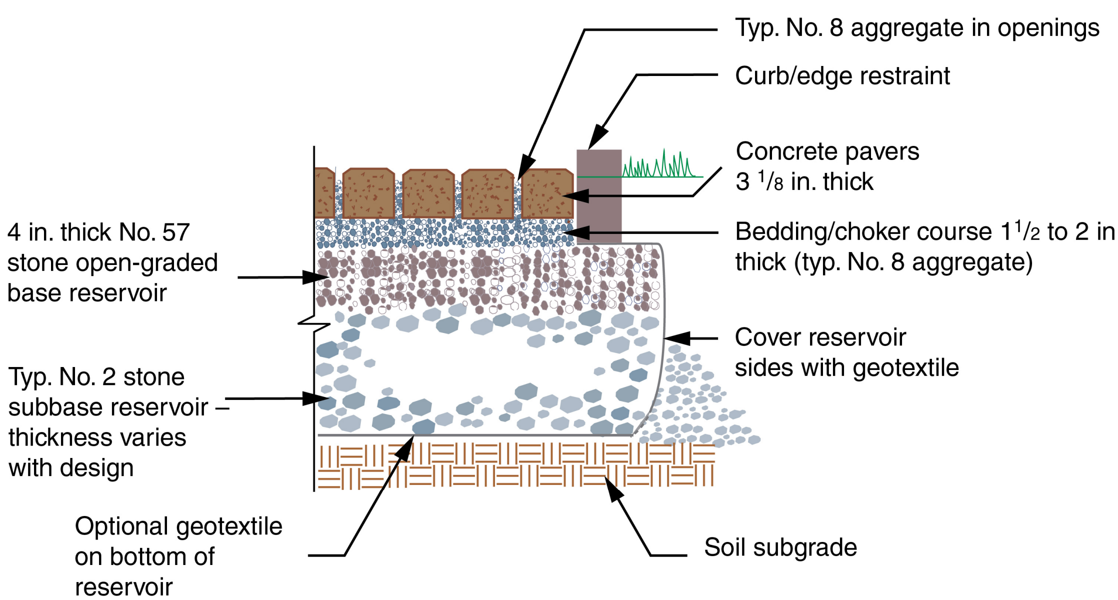



Figure 6-28. Profile of Porous Concrete Installation

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# 6.7 Turf Block and Permeable Joint Pavers

Figure 6-29: Turf Block and Pave Mat (Source: Georgia Stormwater Handbook)

### 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 6-33 and 6-34). 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.

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. Grid pavements with dense-graded bases are not generally designed to accept runoff from adjacent areas.

*The Countywide 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.*

**Table 6-3:**
**Grid Pavement Types and Possible Applications**

| Type | Description | Possible Applications |
|---|---|---|
| Brick | Solid unit paver laid on a permeable base with sand joints. | Driveways, walkways, patios, public sidewalks, plazas, low volume streets |
| Natural Stone | Laid on pervious surface area in random pattern with wide sand, gravel, or soil joints (from 1/2 to 4 inches). | Driveways, walkways, patios, sidewalks, plazas, low-use parking stalls |
| Turf Blocks | Open celled unit paver filled with soil and planted with turf. Sometimes the cells are filled with crushed rock only. | Areas of low flow traffic and infrequent parking, residential driveways and overflow parking areas, emergency access roads, utility roads, street shoulders, and outer edges of commercial and retail parking lots where low-use spaces are located. |
| Permeable Interlocking Concrete Pavers (PICP) | Discrete units set in a pattern on a prepared base. Typically made of precast concrete in shapes that form interlocking patterns, some unit paver shapes form patterns that include an open cell to increase permeability. Solid unit pavers are made of impermeable materials, but can be spaced to expose a permeable joint set on a permeable base. | Parking stalls, private driveways, walkways, patios, low volume streets, and travel lanes, and bikeways. |
| Source: Design Guidelines for Permeable Pavements, Redwood City | | |

## 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.
- 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.
- 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
    - Drainage routing of detained flows within the aggregate base as well as expected infiltration into in-situ soils, or collection in underdrain if infiltration rate cannot meet design criteria

***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 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.

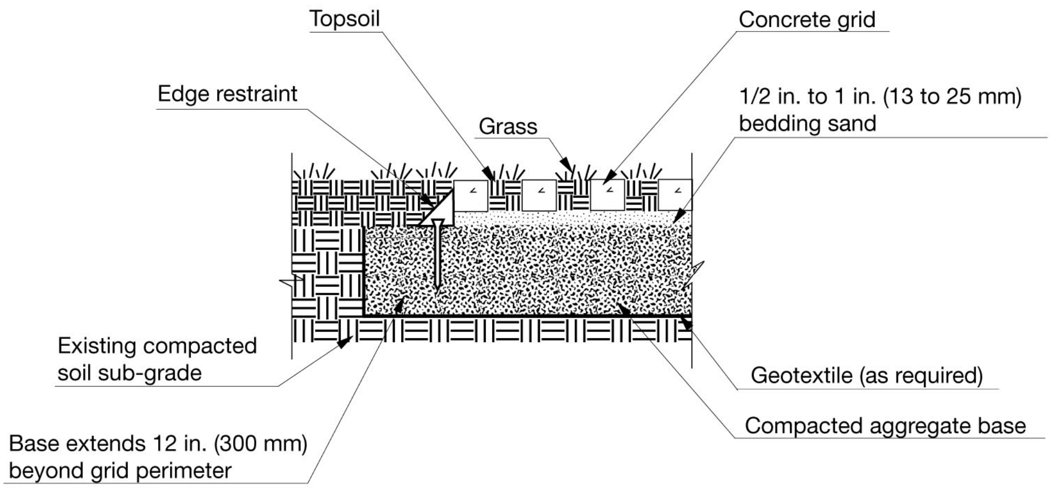


Figure 30: Concrete Grid Pavement for Occasional Vehicular Use or for Emergency Access Lanes(Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

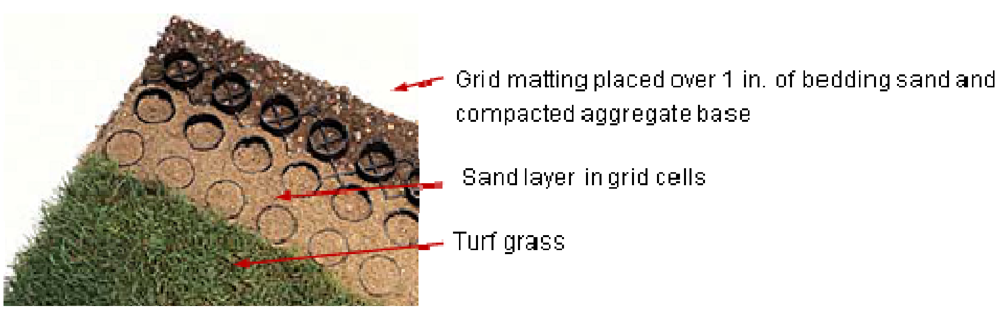


Figure 6-31: Plastic Grid Pavement for Occasional Vehicular Use or for Emergency Access Lanes. Note: Sand and turf grass can be replaced with ASTM No. 8 aggregate in cell openings. (Source: Santa Clara Valley Urban Runoff Pollution Prevention Program)

***MAINTENANCE***

A maintenance plan shall be provided.

Standards for Ongoing Maintenance and Upkeep :

- Keep landscaped areas well maintained
- The surface of the unplanted turf block and permeable joint pavers shall be vacuum cleaned using commercially available sweeping machines at the following times:
    - End of winter (April)
    - Mid-summer (July / August)
    - After autumn leaf-fall (November)
- Planted turf block can be mowed, as needed.
- Inspect outlets yearly, preferably before the wet season. Remove trash and debris.
- When vacuum cleaning is conducted, inspect turf block and pavers for any signs of hydraulic failure.

Figure 6-32: Unit Pavers, Redwood City

As needed maintenance:

- If routine cleaning does not restore infiltration rates, reconstruct the part of pervious surface that is not infiltrating.
- 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.
- Deposits may need to be disposed of as controlled waste.
- Replace permeable joint materials as necessary.

Figure 6-33: Notched pavers (Source: Unigroup-usa.org). Photo for example purposes only; it is not an endorsement of any proprietary product.

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# 6.8 Green Roof

Figure 6-34: Parking Lot with Turf-Covered Roof, Google building, Mountain View

**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 (Figure 6-39), 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:
  - The green roof system planting media shall 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 shall 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.
- Design and installation is typically completed by an established vendor.
- Extensive green roof systems contain layers of protective materials to convey water away from 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, engineered growing medium or soil substrate, and 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.


Figure 6-35: Green roof cross-section. Source: American Wick Drain Corp.

- 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 A for planting guidance.
- Green roof shall be free of gullies or rills.
- Irrigation is typically required.
- Beginning December 1, 2011, green roofs will need to meet green roof specifications (to be included in Appendix L) approved by the Regional Water Board in order to be considered biotreatment measures.

## 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 A for alternatives to quick release fertilizers.

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

Figure 6-36: Extensive Green Roof at Gap Headquarters, San Bruno (William McDonough & Partners)

Figure 6-37: Intensive Green Roof, Kaiser Center Parking Garage, Oakland

Figure 6-38: Plants selected to support endangered butterflies (California Academy of Sciences, San Francisco)

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# 6.9 Rainwater Harvesting and Use

Figure 6-39: 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

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. As indicated in Appendix I, the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report) identified toilet flushing as the use that is most likely to generate sufficient demand to use the C.3.d amount of runoff. 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, and (3) a distribution system to get the water to where it is intended to be used. 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.

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.

#### *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 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 rainwater harvesting system will be designed to 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.
- If the project's completed Rainwater Harvesting Feasibility Worksheet (or other project-specific calculation) indicates that there is sufficient demand, size the cistern (or other storage device) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves.

#### *DESIGN GUIDELINES FOR ALL SYSTEMS*

- Equip water storage facilities covers with tight seals, to reduce mosquito-breeding risk. Follow mosquito control guidance in Appendix F.
- 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/reuse 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.

- 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 shall 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 shall be provided and shall 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.

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# 6.10 Media Filter

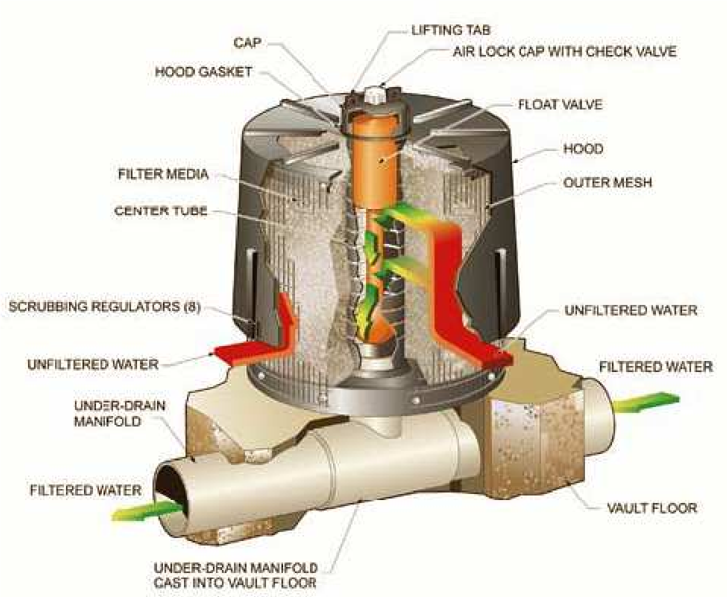


Figure 6-40. System C Filter Cartridge, Typically Used as Part of Treatment Train. Source: CONTECH Stormwater Solutions, 2006. (Note: The proprietary media filters shown are for general information only and are not endorsed by the Countywide Program. An equivalent filter may be used.)

### Best Uses
- Limited space
- Underground
- 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 non-vegetated[1] media filters include: 1) bed filters, such as Austin or Delaware sand filters; 2) proprietary modular cartridge filters; 3) powered filtration systems; and 4) catch basin inserts, also known as inlet filters.

Under current Municipal Regional 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

[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 Technical Guidance.

(such as processed leaves). The media are designed to remove certain types of pollutants. The media cartridges are placed in vaults, manholes, or catch basins. In the unit shown in Figure 6-36, 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

- It is recommended that the selected media filter product be 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 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 6-38 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 produce must have TAPE GULD certification, 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.

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[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

- To avoid excess hydraulic pressure on subsurface treatment system structures:
    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***

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

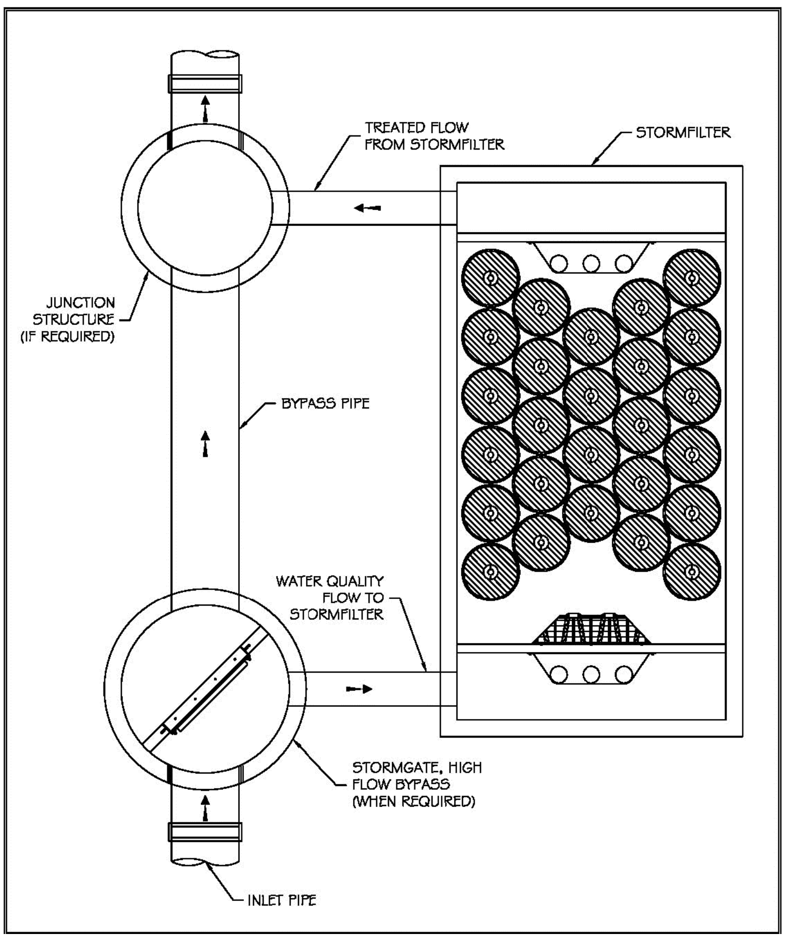


Figure 6-41. Profile View, Typical Cartridge System Filter Array. Source: CONTECH Stormwater Solutions, 2006. (Note: The proprietary media filters shown are for general information only and are not endorsed by Countywide Program.

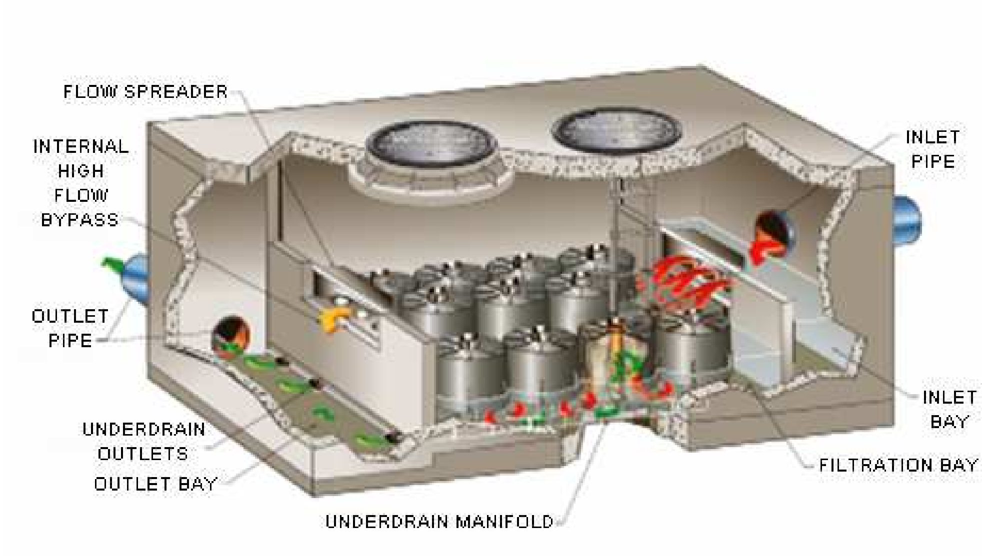


Figure 6-42. Plan View, Typical Cartridge System Filter Array. Source: CONTECH Stormwater Solutions, 2006. (Note: The proprietary media filters shown are for general information only and are not endorsed by Countywide Program.

# 6.11 Subsurface Infiltration System

Figure 6-43: Photo of subsurface retention/infiltration system installation under a parking lot. Source: Contech.

Best uses
- Residential or commercial projects with large parking lots or common areas
- Large drainage areas

Advantages
- Can be located beneath at-grade features
- Systems are modular, allowing flexible design

Limitations
- Not recommended for poorly infiltrating soils or highly polluted runoff
- Requires pretreatment
- Potential for standing water and mosquito

Subsurface infiltration systems, also known as infiltration galleries, are underground vaults or pipes that store and infiltrate stormwater. 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” and do not require a permit if they do not endanger underground sources of drinking water and comply with federal UIC requirements (see Appendix E).

## 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.
- Refer to Infiltration Guidelines (Appendix E) for additional setback and separation requirements.

#### *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 48-72 hours.
- 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.

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

#### *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.
- The trench depth should maintain the required separation from seasonal high groundwater, and the depth should be less than the widest surface dimension.
- 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 as swales, 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 discussion of 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 G for specific maintenance requirements.

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Chapter

# 7

# Hydromodification Management Measures

*In this Chapter*

- *Explanation of hydromodification*
- *Description of hydromodification management controls*
- *Summary of requirements for reducing erosive flows from development projects*

## 7.1 What is Hydromodification?

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.

In watersheds with large amounts of impervious surface, the larger volumes, faster rates and 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.

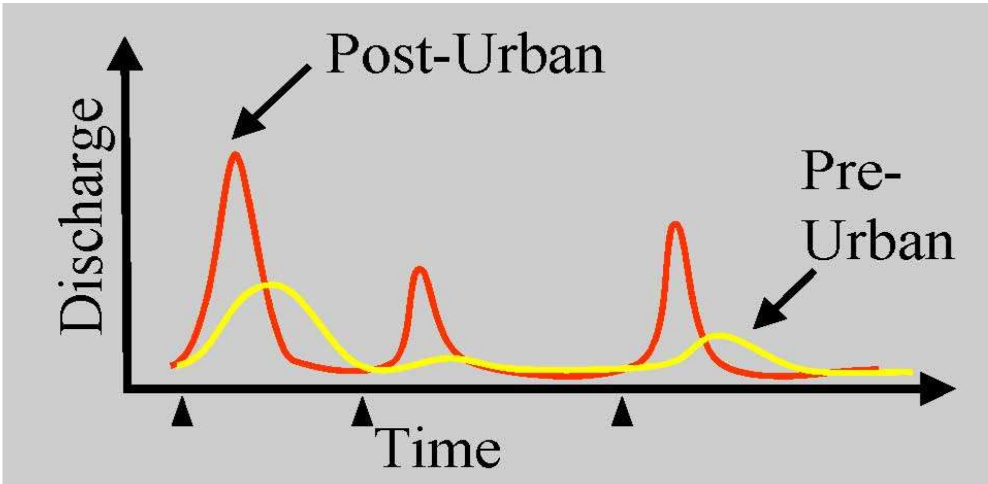



Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

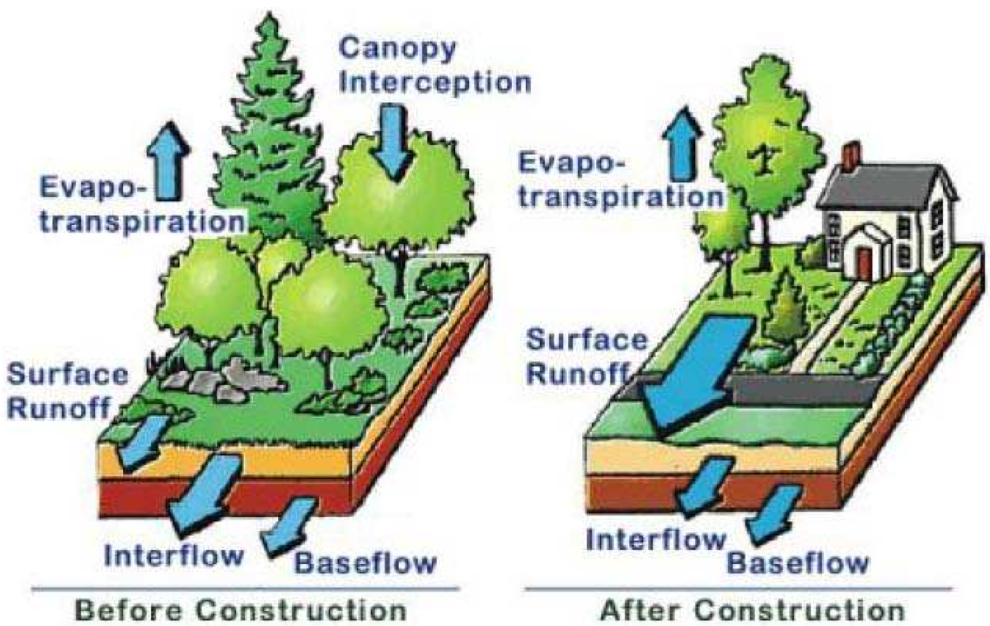



Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

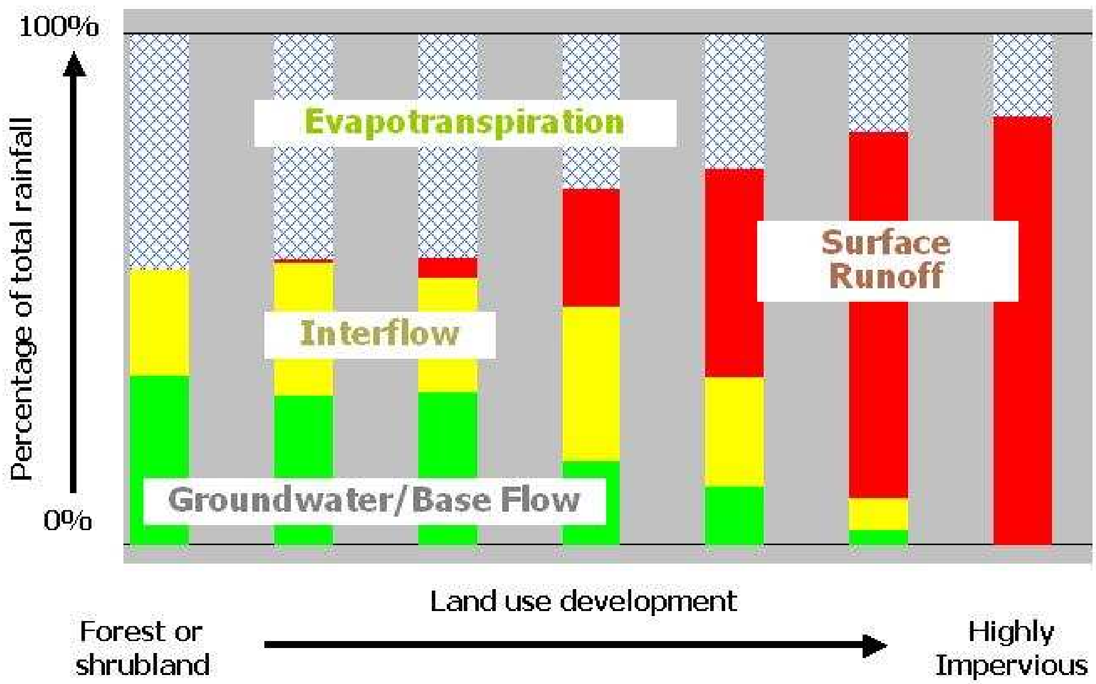



Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek Solutions.)

## 7.2 Hydromodification Management (HM) Controls

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

Since 2007, new 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 San Mateo 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. HM measures can be grouped into three types:

- ***Integrated management practices***, or IMPs, which are small-scale, stormwater management techniques that are generally distributed throughout a project site. IMPs are designed to minimize directly-connected impervious areas, slow runoff, and maximize infiltration (where appropriate) as described in *Start at the Source* (BASMAA, 1999, www.flowstobay.org – click on Business, then New Development). IMPs may also include the use of bioretention areas, vegetated buffer strips, roofs that detain water, and multi-functional landscape areas.

- ***Flow duration control measures*** are used to manage excess runoff from the site after IMPs are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes from stormwater collected in pipes and channels before the runoff is discharged to a natural channel that could suffer adverse effects. Examples include extended detention basins, wet ponds and constructed wetlands. Please note that there is a difference between the design approach for sizing measures to remove pollutants from stormwater and the approach for designing flow duration controls 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. Flow duration controls must be sized to control the statistical duration of a wide range of flow levels under simulated runoff conditions. Depending on pre-project and post project conditions, the required detention volume is ***likely to be greater*** than the capture volume required for treatment. Flow duration controls are typically used on-site, but larger facilities, such as detention basins, may be sized to control runoff from a regional drainage area.

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


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

## 7.3 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 HM Control Area Map.

Appendix H shows the Countywide HM Control Area Map. The boundary between areas that are subject to HM requirements and areas that are not generally follows major roadways, such as El Camino Real and Alameda de Las Pulgas. Appendix H includes a series of maps that show more detail for locations in which the boundary does not follow major roadways. Areas exempt from HM requirements tend to be ***heavily developed areas of the bayside***, while the more open and residential hillside, and coastside areas are subject to the HM requirements. Four municipalities -- East Palo Alto, Foster City, Daly City, and Colma – are totally exempt (except for some small areas of parkland in which no development is expected to occur). All of the other municipalities have some portions of their jurisdictions where development may occur that would be subject to HM requirements.

Please note that Attachment E of the MRP allows for the ***following exceptions to the HM control area boundary*** shown on the map:

- A project located on one or more parcels in the exempt area that drain into the HM control area would be subject to HM requirements.
- A project in the HM Control Area from which runoff drains only through a hardened channel and/or enclosed pipe along its entire length before directly discharging into a waterway in the exempt area or into tidal waters would be exempt from HM requirements, if the project applicant demonstrates, in a statement signed by an engineer or qualified environmental professional, that this condition is met.

Also 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.***

# 7.4 Hydromodification Management HM) Requirements

The HM objective is to control stormwater discharges from non-exempt development projects so that these discharges do ***not increase the erosion potential*** of the receiving creek over the pre-project (existing) condition. This is accomplished by implementing four performance criteria:

- Projects shall ***provide hydromodification management (HM) controls*** as needed to maintain the pre-project creek erosion potential. These controls may include a combination of on-site or off-site (regional drainage area and/or in-creek) control measures. An erosion potential (Ep) of up to 1.0 shall be maintained for creek segments downstream of the discharge point. Ep can be expressed as the ratio of post-project to pre-project erosive "work" done on the creek.
- On-site stormwater controls that are designed to provide ***flow duration control*** to the pre-project condition shall comply with the HM requirements. Flow duration controls shall be designed so that the post-project stormwater discharge rates and durations match those of the pre-project condition, from 10 percent of the pre-project two-year peak flow up to the pre-project 10-year peak flow.
- Projects may use ***off-site control measures*** in lieu of or in combination with on-site controls, where an approved plan – including an appropriate funding mechanism – is in place and accounts for the creek changes expected to result from changes in project runoff conditions. The off-site control measures or combination of controls shall be designed to achieve the management objective of keeping the erosion potential (Ep)

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

at 1.0 or less, from the point of discharge to the creek as far down stream as potential impacts will occur.

# 7.5 How to Implement HM Requirements

Projects subject to HM requirements need to consider HM at every stage of project development, following the step-by-step instructions for C.3 submittals in Chapter 3. The most effective use of land and resources may require a combination of IMPs, flow duration control facilities and in-creek measures, which are described in Section 7.2. In general, the strategy for designing HM measures should:

- ***Start with site design*** to minimize the amount of runoff to be managed (see Chapter 4).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration is limited by site constraints such as slope stability concerns, low-permeability soils or groundwater protection constraints.
- Use ***flow duration controls*** 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.

## 7.5.1 Flow Duration Control


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

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.

## 7.5.2 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.

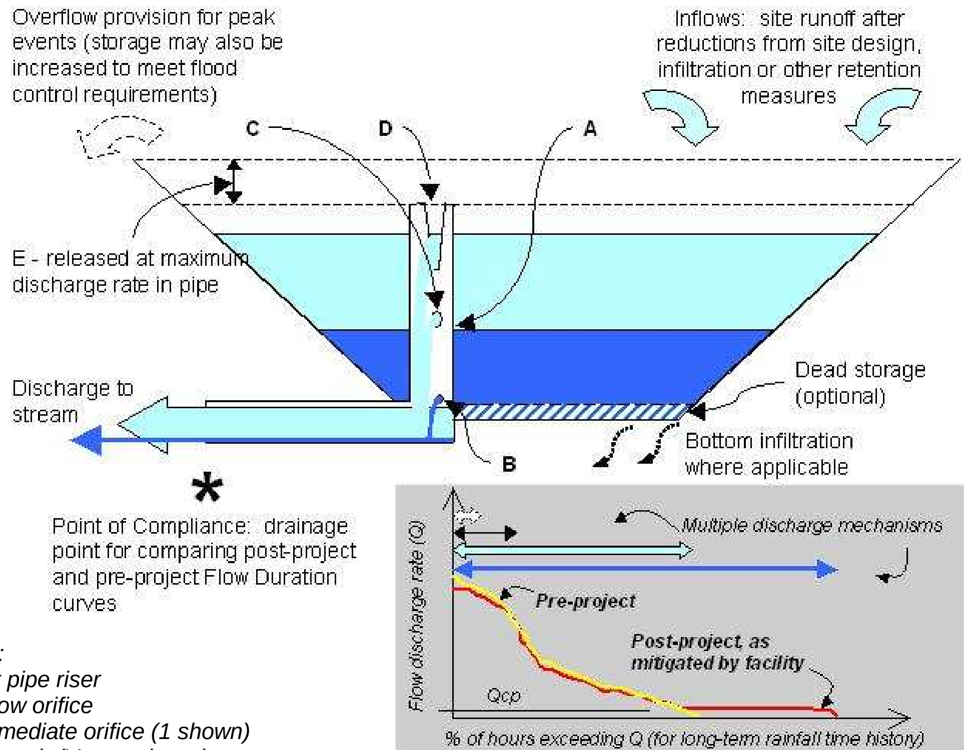
This is done with a combination of site design, infiltration and detention. Typically the post-project increase in surface runoff volume is routed through a ***flow duration control basin*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4).

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

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.

Adequate maintenance of the low-flow orifice or notch is critical to proper performance. The outlet may be in a protective enclosure to reduce risk of clogging. Please note that Flow Duration facilities are subject to Operations and Maintenance verification requirements similar to those for numerically sized treatment measures.




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

Figure 7-4: Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume. (Source: ACCWP, 2006)

### 7.5.3 Bay Area Hydrology Model (BAHM)

To facilitate the simulation modeling aspect of FDC for project applicants and their engineers, the Countywide Program collaborated with the Santa Clara and Alameda counties' stormwater programs to develop a Bay Area Hydrology Model ***software package*** that is adapted from 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.

Key Point

The BAHM, which may be downloaded from the Program's website together with county-specific data, 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.
- Simulation of ***LID site design and treatment measures***, to estimate the reduction in runoff flow and volume achieved by these measures.

- 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.

## 7.6 HM Control Design Process

If the project is not exempt from HM requirements, it has the potential to cause hydromodification impacts on the receiving stream and must use the HM standards to determine how it will meet the management objective. Implement the following steps to design HM controls for non-exempt projects.

1. ***Compare pre- and post-development runoff patterns.*** Use the BAHM to perform a detailed analysis comparing pre-project and post-project runoff patterns for the project site. If you wish to conduct a more detailed or site-specific approach, as an alternative to using the BAHM, you must generate flow duration curves illustrating the distribution of flows resulting from a continuous rainfall record for the pre- and post-project conditions. This is accomplished using a continuous simulation hydrology model or a sizing tool based on a continuous simulation model. ***The input data and results of the BAHM or other model analyses and the flow duration matching curves must be submitted to the municipality as part of the project’s Stormwater Management Plan.***
2. ***Incorporate the flow duration control measures into the project design.*** Use the BAHM to design flow control facilities to meet the flow duration control criteria, so that the discharge pattern produced by the proposed flow duration control measures matches the pre-development flow duration curve. As an alternative to using the BAHM, you must use a continuous simulation hydrology model or sizing tool based on a continuous simulation model, preferably the same model or tool used in step 1, above. Achieving the flow duration control criteria generally requires some type of above- or below-ground detention and/or infiltration facilities that reduce the volume and control the rate of post-project discharge.
3. ***If necessary, consider alternatives to on-site HM control.*** On-site stormwater detention and infiltration facilities may not be suitable for the project site due to space limitations, soil conditions, depth to groundwater, and other factors. If the on-site HM control alternatives are constrained for your project, you may need to consider a combination of on-site, off-site, and/or in-stream measures to meet HM requirements. Remember that site design measures and LID treatment measures will help meet HM requirements by reducing post-project runoff volumes and peak flows.
4. ***Optimize the orifice of the HM facility***. The diameter of the low-flow (bottom) orifice is an important design parameter for flow duration facilities, since flows discharged from this outlet must be at or below the critical flow rate for the project (Qcp). However, maintenance and/or other considerations may dictate a practical limit to how small this orifice may be. In Western Washington, which has been

implementing HM control requirements since 2001, the minimum orifice diameter specified in its Stormwater Management Manual is 0.5 inches, for orifices that have protective screens and a sump below that collects sediment[1]. If the BAHM or other model indicates that the flow duration matching criteria cannot be achieved with an orifice diameter of 0.5 inches, design options include:

a. Increasing the drainage area to the HM facility (e.g. combining flows from two or more drainage management areas);

b. Reducing the depth of the detention facility (that is, increase the surface area) to reduce the head on the orifice;

c. Adding a flow throttling device such as an elbow restrictor; and/or

d. Add an infiltration measure downstream of the detention facility to further mitigate flows from the low-flow orifice.

The BAHM User Manual, Appendix D, provides more information on how to size a flow duration facility with a specified minimum orifice size[2]. The Western Washington Manual provides more detail on orifice design.

5. ***Design for maintenance of the HM facility.*** HM facilities, like treatment measures, should be designed with maintenance considerations in mind. Design guidance for detention basins is provided in Chapter 6. Detention basins and underground vaults need safe access for personnel and equipment to perform required maintenance. Detention basins typically require a maintenance ramp leading to the bottom of the basin and a perimeter access road. Underground vaults require sufficient manhole openings and spacing with appropriate railings and ladders for access.

   ***Adequate maintenance of the low-flow orifice*** is critical to proper performance. Outlet protection, such as a screen, is recommended to reduce risk of clogging. For example, Caltrans detention basin design standards call for a welded stainless steel wire mesh attached to a frame that wraps around the outlet riser[3]. Note that HM facilities are subject to the MRP operations and maintenance verification requirements and will be inspected by municipal staff. Property owners should be familiar with maintenance requirements and perform activities routinely. More information on maintenance of detention basins is provided in Chapter 8.

# 7.7 HM Control Submittals for Review

Determine the potential applicability of the HM requirements to the proposed project, using the guidelines in Section 7.3 and the applicability maps in Appendix H, and indicate HM applicability on the municipality's C.3 and C.6 Development Review

[1] Washington State Department of Ecology, Feb. 2005. *Stormwater Management Manual for Western Washington*, Volume III – Hydrologic Analysis and Flow Control Design. http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

[2] Clear Creek Solutions, July 2007. *Bay Area Hydrology Model User Manual*. Prepared for the Alameda Countywide Clean Water Program, the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program. http://www.bayareahydrologymodel.org/downloads.html

[3] Clear Creek Solutions, July 2007. *Bay Area Hydrology Model User Manual*. Prepared for the Alameda Countywide Clean Water Program, the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program. http://www.bayareahydrologymodel.org/downloads.html

Checklist (or equivalent form). Then prepare an HM Control Plan as part of the project's Stormwater Management Plan.

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, along with any modeling analyses. Check with the local jurisdiction to determine the specific requirements for your project.

**Table 7-1: HM Control Plan Checklist**

| Required ?* | | Information on Plan Sheets |
|---|---|---|
| Yes | No | |
| ❑ | ❑ | 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 controls |
| ❑ | ❑ | Stormwater treatment measure and HM control 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 the model, input and output data |
| ❑ | ❑ | Description of any changes to standard parameters (for example, scaling factor, duration criteria) |
| ❑ | ❑ | Comparison of HM facility sizing per modle 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 |
| ❑ | ❑ | Preliiminary 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.

## 7.8 Area-Specific HM Provisions


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

> Some municipalities may have special policies or ordinances for ***creek protection.***

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

## 7.9 When On-site HM is Impracticable

Under specific conditions, the MRP allows projects to meet HM requirements by providing for or contributing financially to an off-site alternative HM project.

### 7.9.1 Determining Impracticability

In order to use an off-site alternative HM project, you would need to demonstrate the following:

- Due to onsite conditions (such as extreme space limitations) the ***total cost to comply with both HM and stormwater treatment requirements*** exceeds two percent of the project construction cost, excluding land costs. (When calculating costs of HM and stormwater treatment measures, do NOT include land costs, soil disposal fees, hauling, contaminated soil testing, mitigation, disposal, or other normal site enhancement costs such as landscaping or grading that are required for other development purposes.)
- There is ***no available regional HM measure*** to which runoff from your project can be directed. A regional HM measure is considered available if there is a planned location from the regional HM measure AND if an appropriate funding mechanism for the regional HM measure is in place by the time of your project's construction.
- Meeting the HM requirements by constructing ***an in-stream measure is not practicable***. An in-stream measure is considered practicable if an in-stream measure for your project's watershed is planned, and an appropriate funding mechanism for the in-stream measure is in place by the time of project construction.

### 7.9.2 Requirements for Using an Alternative HM Project

If you have demonstrated that on-site HM is impracticable for your project, you will need to implement the following requirements to use an alternative HM project.

- Include site designs in your project that ***provide hydrologic source control***. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention.
- Include in your project stormwater treatment measures that collectively ***minimize, slow and detain runoff*** to the maximum extent practicable. (This generally includes bioretention areas, flow-through planters, and other stormwater treatment measures that filter runoff through soil or other media.)
- ***Contribute financially*** to an alternative HM project, such as a stormwater treatment retrofit, HM retrofit, regional HM control, or in-stream measure that is not otherwise required by the Water Board or other regulatory agency. The contribution shall consist of the difference between two percent of the project construction costs and the cost of the treatment measures at the site (based on calculations described in Section 7.6.1).

Chapter

# 8

# Operation and Maintenance

***In this Chapter:***

- *Operation & maintenance requirements for stormwater treatment and flow duration control measures,*
- *Preparing documentation for maintenance agreements,*
- *Common maintenance concerns for frequently-used treatment measures*

## 8.1 Summary of O&M Requirements

Maintenance is essential for assuring that stormwater treatment and flow duration control (FDC) 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 FDC measures*** included in your project. The operation and maintenance (O&M) process can be organized into five phases, as described below:

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

> O&M requirements for treatment measures also apply to ***flow duration control measures*** where and when they are implemented.

### 8.1.1. Responsibility for Maintenance

Key Point

The responsibility for the maintenance of stormwater treatment and FDC 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 FDC 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 San Mateo County Mosquito Abatement 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 what is required for normal landscaped areas.

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.

For a list of ***landfills in San Mateo County*** that accept sediment ("soil"), contaminated or otherwise, visit www.ciwmb.ca.gov/SWIS/Search.asp.

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.

***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. Except for certain treatment measures designed to hold permanent pools of standing water, treatment measures should ***drain completely within five days*** to effectively suppress mosquito production. The Countywide Program's Vector Control Plan includes mosquito control design guidance

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

and maintenance guidance for treatment measures. This guidance is included in Appendix F.

***CONSIDER ACCESS***


The maintenance agreement for your project will need to guarantee access permission for local municipality staff, the San Mateo 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 FDC measures are ***readily accessible to the inspectors***, and contact municipal staff to determine whether easements will be needed. Stormwater treatment and FDC measures must also be accessible to equipment needed to maintain them. Maintenance needs vary by the type of treatment measure that is used. Review the maintenance requirements described in Section 8.2 to identify the accessibility needs for maintenance equipment. By nature, it is more difficult to provide adequate access for below-ground treatment measures than above-ground treatment measures.

### 8.1.3 Documentation Required with Permit Application


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

- A legible conceptual plan of the site, clearly showing the locations of stormwater treatment measures. Letter-sized plans are preferred; legal-sized plans may be accepted.
- Detailed maintenance plan for stormwater treatment and FDC 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 municipal staff if there are any additional requirements. Appendix G 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 FDC 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:

- 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 San Mateo 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.

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

## 8.2 Preparing Maintenance-Related Documents

This section provides instructions for preparing the following documents that are typically required as parts of the building permit application, if your project includes stormwater treatment measures and/or FDC 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 G. ***Check with the local jurisdiction*** for an electronic version of the template. When using the template to prepare your report form, please insert project-specific information where you find highlighted prompts such as the following:

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


### 8.2.2 Maintenance Plan

The maintenance plan must be sufficiently detailed to demonstrate to the municipality that stormwater treatment measures and/or FDC 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/FDC measures on the site.
- A list of specific, routine maintenance tasks that will be conducted, and the intervals at which they are conducted. (For example, "Inspect treatment measure once a month, using the attached checklist.")
- An inspection checklist, specific to the treatment/FDC measure(s) included in your project, which indicates the items that will be reviewed during regular maintenance inspections. Completed inspection forms may be required as part of the annual Stormwater Treatment Measure O&M Report, described in Section 8.2.1.

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

- Maintenance plan templates included in Appendix G.
- A list of common maintenance concerns for frequently-used stormwater treatment measure (see the following pages).

When using a template to prepare your report form, insert project-specific information where you find prompts such as: [[== insert name of property owner/responsible party ==]]. The templates include sample inspection checklists for some treatment measures. If your project includes different treatment/FDC measures, you will need to customize the template. Refer to the ***treatment measure-specific maintenance information*** on the following pages to prepare your maintenance plan.

> Refer to the ***treatment measure-specific maintenance information*** to prepare your maintenance plan.

***BIORETENTION AREAS – COMMON MAINTENANCE CONCERNS:***

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

- Conduct monthly inspections as follows:
- Inspect bioretention area for obstructions and trash.
- Inspect bioretention area for ponded water. If ponded water does not drain within five days, remove surface soils and replace with sand. If mosquito larvae are observed, contact the San Mateo County Mosquito Abatement District at 650/344-8592.
- Inspect inlets for channels, exposure of soils, or other evidence of erosion. Clear any obstructions and remove any accumulation of sediment.
- Conduct a biannual (twice yearly) evaluation of the health of any plants, and remove any dead or diseased vegetation.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible, and replace any dead plants.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed, as needed, to keep the bioretention area neat and orderly in appearance.

Inspect and, if needed, replace mulch before the wet season begins. Mulch should be replaced when erosion is evident or when the bioretention area begins to look unattractive. The entire area may need mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas.

Figure 8-1: Bioretention Area in Daly City

***FLOW-THROUGH PLANTERS – COMMON MAINTENANCE CONCERNS:***

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

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

Figure 8-2: Flow through planter (Source: City of Portland, 2004)

***TREE WELL FILTERS – COMMON MAINTENANCE CONCERNS:***

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

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

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

***VEGETATED BUFFER STRIPS – COMMON MAINTENANCE CONCERNS:***

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

- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where six-inch high grasses are used, the grass height shall be at least three inches after mowing. Where mowed grasses are shown on the plans, the grass shall be mowed when the height exceeds three inches. Dispose of grass clippings properly.
- Remove obstructions and trash from the vegetated buffer strip.
- Conduct monthly inspections as follows:
- Inspect vegetated buffer strip for and remove obstructions and trash,

- Confirm that any ponded flow drains within five days after a rainfall event. If ponding is observed for longer than five days, grading is required to improve positive drainage.
- Confirm that grasses are in good condition.
- Identify and correct any erosion problems.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

Figure 8-4: Vegetated Buffer Strip (Source: California Stormwater Quality Association, 2003)

***INFILTRATION TRENCHES – COMMON MAINTENANCE CONCERNS:***
The primary maintenance objective is to prevent clogging, which may lead to trench failure. Typical inspection and maintenance tasks are as follows:

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

the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

- Routinely remove trash, grass clippings and other debris from the trench perimeter and dispose of these materials properly. Trees or other large vegetation should be prevented from growing adjacent to the trench to prevent damage to the trench.

Figure 8-5: Infiltration Trench (Source: California Stormwater Quality Association)

***EXTENDED DETENTION BASINS – COMMON MAINTENANCE CONCERNS:***

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

- Harvest vegetation annually, during the summer.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and mosquito control reasons.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Conduct a biannual (twice yearly) evaluation of the health of the vegetation and remove and replace any dead or dying plants.
- Conduct semiannual inspection as follows
- Inspect the outlet, embankments, dikes, berms, and side slopes for structural integrity and signs of erosion.
- Examine outlets and overflow structures and remove any debris plugging the outlets. Identify and minimize any sources of sediment and debris. Check rocks or other erosion control and replace, if necessary.
- Check inlets to make sure piping is intact and not plugged. Remove accumulated sediment and debris near the inlet.

- Inspect for standing water and correct any problems that prevent the extended detention basin from draining as designed.
- If mosquito larvae are observed, contact the San Mateo County Mosquito Abatement District at 650/344-8592.
- Check for slope stability and the presence of rodent burrows. Fill in any holes detected in the side slopes.
- Maintenance activities at the bottom of the basin shall not be performed with heavy equipment, which would compact the soil and limit infiltration.
- Remove sediment from the forebay when the sediment level reaches the level shown on the fixed vertical sediment marker.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume.
- Remove accumulated trash and debris from the extended detention basin at the middle and end of the wet season (January and April), or as needed.
- Inspect for and remove any trash and debris.
- Confirm that any fences around the facility are secure.
- Check for sediment accumulation.

Figure 8-6: Extended Detention Basin, Palo Alto

***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.

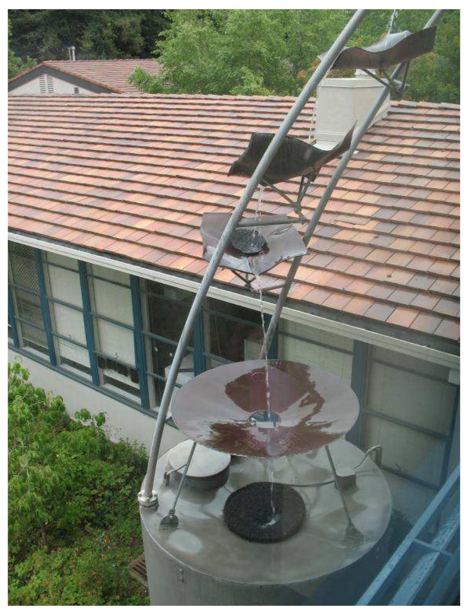


Figure 8-7: Rainwater harvesting system, Mills College, Oakland

- Maintenance requirements specific to rain barrels
  - Inspect rain barrels four times per yearand after major storms
  - Remove debris from screens as needed.
  - Replace screens, spigots, downspouts, and rain leaders as needed.

***MEDIA FILTERS – COMMON MAINTENANCE CONCERNS:***

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

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

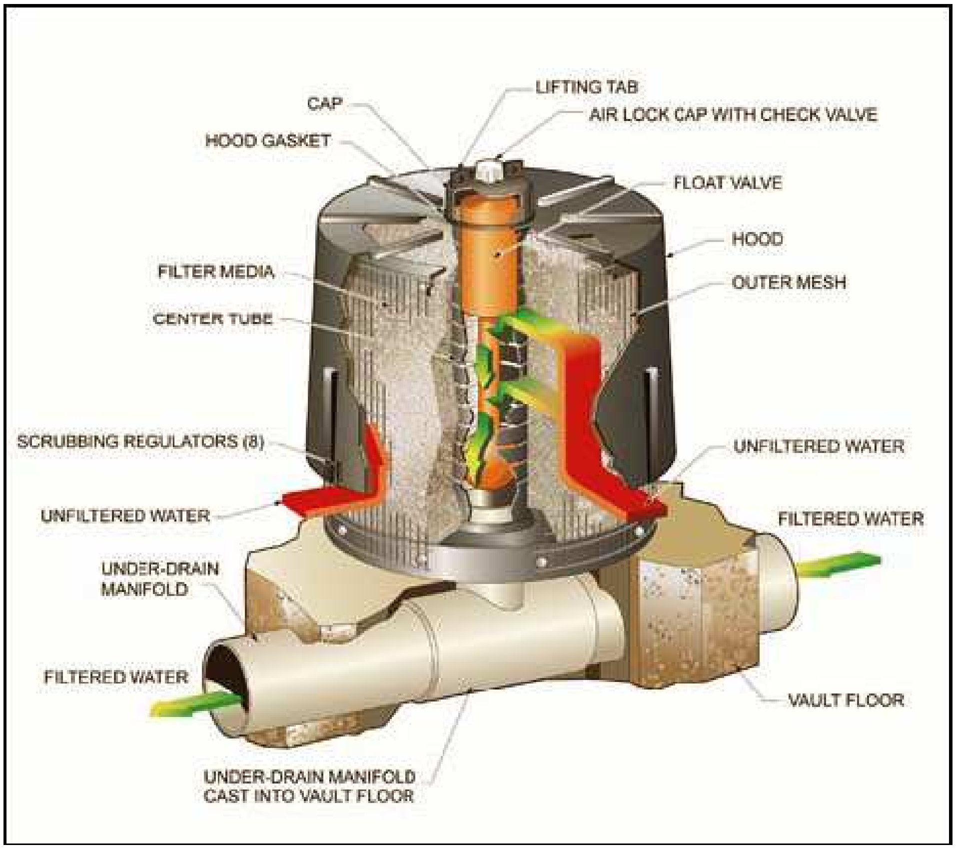



Figure 8-8: Example of a media filter cartridge (Type C, as described in Section 6.10), which is typically used as part of an array. Source: www.stormwaterinc.com. This drawing is shown for general information only; its use is not an endorsement of any proprietary product.

Chapter

9

# Alternative Compliance

*In this Chapter:*

- *Information on using Alternative Compliance for options on where LID treatment is provided.*

## 9.1 What Is Alternative Compliance?

Provision C.3.e of the Municipal Regional Stormwater 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 and ***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 runoff from multiple sites*** at a nearby, offsite 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 treat an equivalent quantity of stormwater runoff and pollutant loading with hydraulically-sized LID treatment measures at a Regional Project ***and*** the monetary amount necessary to share a proportionate amount of the operation and maintenance costs of the Regional Project.

***REGIONAL PROJECT***

A regional project is a regional or municipal stormwater treatment facility located in the same watershed as the project seeking alternative compliance.

## 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 by the time the subject project is completed. If the offsite project is not completed in time, the offsite project must, for each additional year up to three years, provide additional treatment of 10% of the required amount of stormwater runoff and pollutant loads. For example, an offsite project completed two years after the subject project would be required to provide LID treatment for 20% more stormwater runoff and pollutant loads than if the offsite project had been completed in time.

### 9.3.2 Timeline for construction of a Regional Project

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

## 9.4 Alternative Compliance Effective Date

The Alternative Compliance provision and the LID treatment requirements both go into effect December 1, 2011. Projects deemed complete after this date may use alternative compliance to meet the LID treatment requirements for LID treatment. Projects deemed complete before December 1, 2011 do not have to use LID for stormwater treatment if the project has been diligently pursued[1] by the project applicant. The Alternative Compliance provision does not apply to public projects for which funding has been committed and construction is scheduled to begin by December 1, 2012.

[1] Diligent pursuance may be demonstrated by the project applicant's submittal of supplemental information to the original application, plans, or other documents required for any necessary approvals of the project.

# References

American Society of Civil Engineers. 1992. Design and Construction of Sanitary and Storm sewers, Manual of Engineering Practice No. 77.

Atlanta Regional Commission (ARC) / Georgia Department of Natural Resources-Environmental Protection Division. 2003. Georgia Stormwater Management Manual.

Bay Area Stormwater Agencies Association (BASMAA). 1999. Start at the Source.

BASMAA. 2003. Using Site Design Techniques to Meet Development Standards for Stormwater Quality: A Companion Document to Start at the Source.

BASMAA. 2011. Harvest and Use, Infiltration and Evapotranspiration Feasbility/Infeasibility Criteria Report.

Beyerlein, Douglas. May/June 2005. "Flow Duration-Based Stormwater Mitigation Modeling," in *Stormwater*. http://www.stormh2o.com/sw_0505_flow.html

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

Caltrans. 2002. Stormwater Quality Handbook: Project Planning and Design Guide.

Cities of Citrus Heights, Elk Grove, Folsom, Galt, Rancho Cordova, Roseville and Sacramento, and the County of Sacramento. 2007. Stormwater Quality Design Manual for Sacramento and South Placer Regions.

City of Emeryville. 2005. Stormwater Guidelines for Green, Dense Development: Storwmater Quality Solutions for the City of Emeryville.

City of Milpitas. 2005. Milpitas C.3 Stormwater Guidebook, 3rd Edition.

City of Portland, Oregon. 2004. Stormwater Management Manual. http://www.portlandonline.com/bes/index.cfm?c=35117

Contra Costa Clean Water Program. January 2005. Contra Costa County Stormwater Quality Requirements for Development Applications. Stormwater C.3 Guidebook, 3rd Draft.

Contra Costa Clean Water Program, November 16, 2005. Policy on the Use of Hydrodynamic Separators to Achieve Compliance with NPDES Provision C.3.

Contra Costa Clean Water Program. March 2005. C.3 Stormwater Guidebook, 2nd Edition.

County of Sonoma and City of Santa Rosa. 2005. Santa Rosa Area Standard Urban Stormwater Management Guidelines.

Decker, Thomas R. January/February 2006. "Specifying and Permitting Alternative MTDs", in *Stormwater.*

Maryland Department of Environment. 2000. Maryland Stormwater Design Manual.
Metzger, M.E., Messer, D.F., Beitia, C.L, Myers, C.M., Kramer, V.L. April 8, 2003. The Dark Side of Stormwater Runoff Management: Disease Vectors Associated with Structural BMPs. [Online] http://www.forester.net/sw_0203_dark.html.

Northeast Georgia Regional Development Center (NGRDC) and Georgia Department of Natural Resources (GDNR). 2005/06. Aquatics Study Materials.

Prince George's County (Maryland) Department of Environmental Resources (PGDER). 1993. Design Manual for Use of Bioretention in Stormwater Management.

San Francisco Bay Regional Water Quality Control Board (RWQCB). 1994. "Policy on the Use of Constructed Wetlands for Urban Runoff Pollution Control" (Resolution No. 94-102).

San Francisco Bay RWQCB. 2004. Basin Plan.
http://www.waterboards.ca.gov/sanfranciscobay/basinplan.htm

San Francisco Bay RWQCB. October 2009. Order No. R2-2009-0074 Issuing NPDES Permit No. CAS612008, Municipal Regional Stormwater Permit.

San Francisco Bay RWQCB. November 28, 2011. Order Amending NPDES Permit No. CAS612008, Municipal Regional Stormwater Permit.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP). April 2004. Developments Protecting Water Quality: A Guidebook of Site Design Examples.

SCVURPPP. May 2004. C.3 Stormwater Handbook.

Texas Water Development Board. 2005. Texas Rainwater Harvesting Manual, 3rd edition.
http://www.twdb.state.tx.us/publications/reports/rainwaterharvestingmanual_3rdedition.pdf

University of New Hampshire Environmental Research Group, 2006. Tree Box Filter Fact Sheet, www.unh.edu/erg/cstev.

US Army Corps of Engineers (US ACOE). 1977. Storage, Treatment, Overflow, Runoff Model (STORM) Users Manual.

US Environmental Protection Agency (US EPA). 2003. Protecting Water Quality from Urban Runoff [fact sheet]. www.epa.gov/npdes/pubs/nps_urban-facts_final.pdf

USEPA. No Date. Stormwater Frequently Asked Questions.
http://cfpub.epa.gov/npdes/faqs.cfm?program_id=6

Water Environment Federation (WEF) Manual of Practice No. 23/ American Society of Civil Engineers (ASCE) Manual and Report on Engineering Practice No. 87. 1998. Urban Runoff Quality Management.

Wolfe, Bruce H., Executive Officer of the San Francisco Bay Regional Water Quality Control Board.

Appendix

# A

# Plant List and Planting Guidance for Landscape-Based Biotreatment Measures

Table of Contents



## A.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 San Mateo County, including Sunset's *Western Garden Book* and the East Bay Municipal Utility District's *Plants and Landscapes for Summer-Dry Climates of the San Francisco Bay Region.*

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

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

## A.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.

## A.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 that 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 A-1, which lists the plants in alphabetical order by Latin name, in the categories described above. The columns in Table A-1 indicate stormwater treatment measures for which each plant species may be suitable. Following Table A-1 are brief descriptions of the stormwater measures for which technical guidance is included in this handbook, including the suitable plantings from Table A-1.

**Table A-1 Plant List for Stormwater Measures**

| Species | Common name | Bioretention Area - including bioretention swale | Flow-Through Planters | Tree Well Filters[2] | 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** | | | | | | | | | | | | | |
| *Artemisia douglasiana* | mugwort | | | | | | ✓ | ✓ | | | | ✓ | |
| *Carex barbarae* | Santa Barbara sedge | | | | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| *Carex densa* | dense sedge | | | | | | ✓ | ✓ | | | | ✓ | |
| *Carex obnupta* | slough sedge | | | | | | ✓ | ✓ | | | | ✓ | |
| *Eleocharis macrostachya* | creeping spikerush | | | | | ✓ | ✓ | ✓ | | | | ✓ | |
| *Hydrocotyle ranunculoides* | marsh pennywort | | ✓ | | | | | ✓ | | | | ✓ | |
| *Juncus balitcus* [1] | baltic rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Juncus bufonius* | toad rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Juncus effusus* [1] | Pacific rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Juncus leseurii* | common rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Juncus mexicanus* | Mexican rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Juncus patens* | blue rush | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| *Juncus xiphioides* | iris-leaved rush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Limonium californicum* | marsh rosemary | | | | | | ✓ | ✓ | | | | ✓ | ✓ |
| *Phragmites spp.* | common reeds | | | | | | ✓ | ✓ | | | | | |
| *Scirpus actutus* | Tule | | | | | | ✓ | ✓ | | | | ✓ | |
| *Scirpus americanus* [1] | three square | | | | | | ✓ | ✓ | | | | ✓ | |
| *Scirpus californicus* [1] | california bulrush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Spartina foliosa* | California cordgrass | | | | | | ✓ | ✓ | | | | ✓ | |
| *Typha angustifolia* | narrowleaf cattail | | | | | | ✓ | ✓ | | | | ✓ | |
| *Typha latifolia* | cattail | | | | | | ✓ | ✓ | | | | ✓ | |
| **Grass Species** | | | | | | | | | | | | | |
| *Agrostis exarata* | spike bentgrass | | | | | | ✓ | ✓ | ✓ | | | ✓ | |
| *Alopecurus aequalis* | shortawn foxtail | | | | | | ✓ | ✓ | | | | ✓ | |
| *Alopecurus saccatus* | Pacific foxtail | | | | | | ✓ | ✓ | | | | ✓ | |
| *Aristida purpurea* | Purple three-awn | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Calamagrostis X acutiflora* | Reed grass | | | | | | | ✓ | | | ✓ | | |
| *Carex pansa* | California meadow sedge | | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| *Carex praegracilus* | clustered field sedge | | ✓ | | | | ✓ | ✓ | | | | ✓ | |
| *Carex tumulicola* | Berkeley sedge | | ✓ | | ✓ | | | ✓ | | | | ✓ | |
| *Chondropetalum tectorum* | cape rush | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ |
| *Danthonia californica* | California oatgrass | | | | | | ✓ | ✓ | | | | ✓ | |
| *Deschampsia cespitosa* [1] | tufted hairgrass | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| *Deschampsia cespitosa ssp. holciformis* | Pacific hairgrass | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| *Deschampsia danthonioides* | annual hairgrass | | | | | | ✓ | ✓ | | | | ✓ | |
| *Distichlis spicata* | salt grass | | | | | | ✓ | ✓ | | | | ✓ | |
| *Eleocharis palustris* | creeping spikerush | | | | | | ✓ | ✓ | | | | ✓ | |
| *Elymus glaucus* | blue wild rye | ✓ | | | ✓ | | | ✓ | | | | ✓ | |
| *Festuca californica* | California fescue | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Festuca idahoensis* | Idaho fescue | | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Festuca rubra*[1] | red fescue | | ✓ | ✓ | ✓ | | | | ✓ | | | ✓ | ✓ |
| *Festuca rubra 'molate'* | Molate fescue | | ✓ | ✓ | ✓ | | | | ✓ | | | ✓ | ✓ |
| *Leymus triticoides* | creeping wildrye | ✓ | | | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ |
| *Linum usitatissimum* [1] | flax | ✓ | ✓ | | | | | | | | | | ✓ |
| *Melica californica* | California melic | | | | ✓ | | | | | | | ✓ | ✓ |
| *Melica imperfecta* | coast range melic | ✓ | ✓ | | ✓ | | | | | | | ✓ | ✓ |
| *Muhlenbergia rigens* | deergrass | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| *Nasella pulchra* | purple needlegrass | ✓ | | | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ |
| *Nassella lepida* | foothill needlegrass | | | | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ |
| *Sisyrinchium bellum* | blue-eyed grass | | ✓ | | ✓ | ✓ | | | | ✓ | | ✓ | ✓ |

** Denotes riparian species with limited drought tolerance*
*[1] Denotes species with phytoremediation capabilities*
*[2] Non-tree species to be used only with adequate planting surface and when infiltration rates are 5-10 inches/hour*

## Table A-1 Plant List for Stormwater Measures

| Species | Common name | Bioretention Area - including bioretention swale | Flow-Through Planters | Tree Well Filters[2] | 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** | | | | | | | | | | | | | |
| *Achillea millefolium* [1] | common yarrow | | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Allium spp.* | wild onion | ✓ | ✓ | | ✓ | | | | | ✓ | ✓ | | |
| *Anthemis nobilis (Chamaemelum nobile)* | chamomile | | | ✓ | | | | | ✓ | | | | ✓ |
| *Armeria maritima* | sea pink | | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Clarkia spp.* | Clarkia | ✓ | | | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Epilobium densiflorum* | dense spike-primrose | ✓ | ✓ | | ✓ | ✓ | | | | | | ✓ | ✓ |
| *Eriogonum latifolium* | coast buckwheat | | | ✓ | ✓ | | | | | | | ✓ | ✓ |
| *Eriogonum fasciculatum* | flattop buckwheat | | | ✓ | ✓ | | | | | | | ✓ | ✓ |
| *Eschscholzia californica* | California poppy | ✓ | ✓ | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Layia platyglossa* | tidy tips | | | | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Limonium californicum* | marsh rosemary | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| *Linanthus spp.* | Linanthus | ✓ | | | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Lotus scoparius* | deerweed | ✓ | | | ✓ | | | | | ✓ | ✓ | ✓ | ✓ |
| *Mimulus aurantiacus* | common monkeyflower | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Mimulus cardinalis* | scarlet monkeyflower | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | |
| *Monardella spp.* | coyote mint | ✓ | | | ✓ | | | | | | | ✓ | ✓ |
| *Nepeta spp.* | catmint | ✓ | | ✓ | ✓ | | | | | | ✓ | | ✓ |
| *Penstemon spp.* | bearded tongue | ✓ | | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Sedum spp.* | stonecrop | | | | ✓ | | | | | ✓ | ✓ | | ✓ |
| *Sempervivum spp.* | hen and chicks | | | | ✓ | | | | | ✓ | ✓ | | ✓ |
| *Solidago spp.* [1] | goldenrod | | ✓ | | ✓ | | | | | ✓ | ✓ | | |
| *Thymus pseudolanuginosus* | woolly thyme | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | | |
| *Vigna unguiculata* [1] | cowpea | | ✓ | | ✓ | | | | | | ✓ | | |
| **Shrub Species** | | | | | | | | | | | | | |
| *Adenostoma fasciculatum* | chamise | | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Arctostaphylos densiflora 'McMinn'* | manzanita 'McMinn' | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Arctostaphylos manzanita* | common manzanita | | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Arctostaphylos uva-ursi 'Emerald Carpet'* | manzanita 'Emerald Carpet' | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Baccharis pilularis 'Twin Peaks'* | coyote brush prostrate | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Baccharis salicifolia* | mulefat | | | | ✓ | | ✓ | ✓ | | | | ✓ | |
| *Berberis thunbergii* | Japanese barberry | | ✓ | | ✓ | | | | | | ✓ | | ✓ |
| *Buddleia spp.* | butterfly bush | ✓ | | | ✓ | | | | | | | | ✓ |
| *Calycanthus occidentalis* | spicebush | ✓ | ✓ | | ✓ | ✓ | | | | | | ✓ | ✓ |
| *Carpenteria californica* | bush anemone | ✓ | ✓ | | ✓ | | | | | | | ✓ | ✓ |
| *Ceanothus hearstiorum* | ceanothus | ✓ | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Ceanothus spp.* | ceanothus | ✓ | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Cercocarpus betuloides* | mountain mahogany | | | | ✓ | | | | | | | ✓ | ✓ |
| *Cistus spp.* | rockrose | | | | ✓ | | | | | | | | ✓ |
| *Cornus sericea (same as C. stolonifera)* | western dogwood | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Dietes spp.* | fortnight lily | | ✓ | | ✓ | | | | | | | | ✓ |
| *Garrya elliptica* | coast silk tassle | | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Echium candicans* | pride-of-Madeira | | ✓ | | ✓ | | | | | | ✓ | | ✓ |
| *Heteromeles arbutifolia* | toyon | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Holodiscus sp.* | oceanspray | ✓ | | | ✓ | | | | | | | ✓ | ✓ |
| *Lavandula spp.* | lavender | | ✓ | ✓ | ✓ | | | | | | ✓ | | ✓ |
| *Lavatera spp.* | tree mallow | | | | ✓ | | | | | | | | ✓ |
| *Lepechina calycina* | pitcher sage | | | | ✓ | | | | | | | ✓ | ✓ |
| *Lupinus albifrons* | bush lupine | | | | ✓ | | | | | | | ✓ | ✓ |
| *Mahonia aquifolium* | Oregon grape | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Mahonia repens* | creeping Oregon grape | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |

** Denotes riparian species with limited drought tolerance*

*[1] Denotes species with phytoremediation capabilities*

*[2] Non-tree species to be used only with adequate planting surface and when infiltration rates are 5-10 inches/hour*

**Table A-1 Plant List for Stormwater Measures**

| | | Bioretention Area - including bioretention swale | Flow-Through Planters | Tree Well Filters[2] | 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** | | | | | | | | | | | | | |
| *Myrica californica* | Pacific wax myrtle | | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Physocarpus capitatus* | Pacific ninebark | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | |
| *Pittosporum tobira* | mock orange | | ✓ | | ✓ | | | | | | | | ✓ |
| *Prunus ilicifolia* | holleyleaf cherry | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| *Rhamnus Californica* | coffeeberry | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Rhus integrifolia* | lemonade berry | | | | ✓ | | | | | | | ✓ | ✓ |
| *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 brandegii* | 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 | ✓ | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Zauschneria californica (Epilobium c.)* | California fuchsia | | | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |
| **Tree Species** | | | | | | | | | | | | | |
| *Acer circinatum* | vine maple | ✓ | | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | |
| *Acer macrophyllum** | big leaf maple | ✓ | | | ✓ | | | | | | | ✓ | |
| *Acer negundo* v. Californicum* | box elder | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Aesculus californica* | buckeye | | | | ✓ | | | | | | | ✓ | ✓ |
| *Alnus rhombifolia ** | white alder | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | | ✓ | |
| *Alnus rubra** | red alder | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Arbutus menziesii* | madrone | | | | ✓ | | | | | | | ✓ | ✓ |
| *Arbutus unedo* | strawberry tree | | | | ✓ | | | | | | ✓ | | ✓ |
| *Betula nigra* | river birch | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| *Calocedrus decurrens* | incense cedar | | | | ✓ | | | | | | | ✓ | |
| *Celtis occidentalis* | common hackberry | | | | ✓ | | | | | | | | ✓ |
| *Cercidium floridum* | blue palo verde | | | | ✓ | | | | | | | ✓ | ✓ |
| *Cercis occidentalis* | redbud | | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| *Chilopsis sp.* | desert willow | ✓ | | | ✓ | | | | | | ✓ | | |
| *Chionanthus retusus* | Chinese fringe tree | | | | ✓ | | | | | | | | |
| *Corylus cornuta v. Californica* | California hazelnut | ✓ | | ✓ | ✓ | | | | | | | ✓ | ✓ |
| *Crataegus* | Hawthorn | | | ✓ | | | | | | | ✓ | | ✓ |
| *Fraxinus latifolia* | Oregon ash | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Geijera parviflora* | Australian willow | | | | ✓ | | | | | | | | |
| *Lagerstroemia spp.* | crepe myrtle | | | | ✓ | | | ✓ | | | ✓ | | ✓ |
| *Lyanothamnus floribundus asplendifolius* | Catalina Ironwood | | | | ✓ | | | | | | | ✓ | ✓ |
| *Morus alba (fruitless var.)[1]* | white mulberry | | | | ✓ | | | | | | | | |
| *Platanus acerifolia* | london plane tree | | | ✓ | ✓ | | | | | | | | ✓ |
| *Platanus racemosa** | sycamore | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | | ✓ | |

** Denotes riparian species with limited drought tolerance*

*[1] Denotes species with phytoremediation capabilities*

*[2] Non-tree species to be used only with adequate planting surface and when infiltration rates are 5-10 inches/hour*

**Table A-1 Plant List for Stormwater Measures**

| | | Bioretention Area - including bioretention swale | Flow-Through Planters | Tree Well Filters[2] | 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** | | | | | | | | | | | | | |
| *Populus fremontii** [1] | Fremont's cottonwood | ✓ | | ✓ | ✓ | ✓ | | | | | | ✓ | |
| *Prunus, spp.* | plum | | | | ✓ | | | | | | | | ✓ |
| *Quercus agrifolia* | California live oak | | | | ✓ | | | | | | | ✓ | ✓ |
| *Quercus kellogii* | California Black Oak | | | | ✓ | | | | | | | ✓ | ✓ |
| *Quercus lobata* | valley oak | ✓ | | | ✓ | | | | | | | ✓ | ✓ |
| *Quercus palustris* | pin oak | | | | ✓ | | | | | | | | |
| *Quercus virginiana* | southern live oak | | | ✓ | | | | | | | | | |
| *Salix laevigata*[1] | red willow | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Salix lasiolepis*[1] | arroyo willow | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Salix lucida ssp. lasiandra* [1] | shining willow | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | |
| *Sequoia sempervirens* | coast redwood | | | | ✓ | | ✓ | ✓ | | | | ✓ | |
| *Umbellularia californica* | California bay | | | | ✓ | | | | | | | ✓ | |

** Denotes riparian species with limited drought tolerance*
*[1] Denotes species with phytoremediation capabilities*
*[2] Non-tree species to be used only with adequate planting surface and when infiltration rates are 5-10 inches/hour*

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

## Bioretention Area – Including Bioretention Swale

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

***EMERGENT/GRASS SPECIES***

| | |
|---|---|
| Juncus patens*[2] | blue rush |
| Aristida purpurea*[2] | Purple three-awn |
| Chondropetalum tectorum | Cape rush |
| Deschampsia cespitosa*[1, 2] | tufted hairgrass |
| Deschampsia cespitosa ssp. Holciformis*[2] | Pacific hairgrass |
| Elymus glaucus[2] | blue wild rye |
| Festuca californica*[2] | California fescue |
| Leymus triticoides*[2] | creeping wildrye |
| Linum usitatissimum[1] | flax |
| Melica imperfecta*[2] | Coast range melic |
| Muhlenbergia rigens*[2] | deergrass |
| Nasella pulchra*[2] | purple needlegrass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Alliums spp. | wild onion |
| Clarkia spp.*[2] | Clarkia |
| Epilobium densiflorum[2] | dense spike-primrose |
| Eschscholzia californica*[2] | California poppy |
| Limonium californicum[2] | Marsh rosemary |
| Linanthus spp.*[2] | Linanthus |
| Lotus scoparius*[2] | deerweed |
| Mimulus aurantiacus*[2] | common monkeyflower |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Monardella spp.*[2] | coyote mint |
| Nepeta spp.* | catmint |
| Penstemon spp.*[2] | bearded tongue |
| Thymus pseudolanuginosus | woolly thyme |

***SHRUB SPECIES***

Shrubs and trees are recommended to be planted at a rate of 2,500 shrubs and trees per hectare (1,000 per acre). The shrub-to-tree ratio should be 2:1 to 3:1 (California Stormwater Quality Association, 2003).

| | |
|---|---|
| Arctostaphylos densiflora ‘McMinn’*[2] | manzanita ‘McMinn’ |
| Arctostaphylos uva-ursi ’Emerald Carpet’*[2] | manzanita ‘Emerald Carpet’ |
| Baccharis pilularis ‘Twin Peaks’*[2] | coyote brush prostrate |
| Buddleia spp.* | Butterfly bush |
| Calycanthus occidentalis*[2] | Spicebush |
| Carpenteria californica*[2] | Bush anemone |
| Ceanothus hearstiorum*[2] | ceanothus |
| Ceanothus spp.*[2] | ceanothus |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Heteromeles arbutifolia*[2] | toyon |
| Holodiscus sp.*[2] | oceanspray |
| Mahonia aquifolium*[2] | Oregon grape |
| Mahonia repens*[2] | creeping Oregon grape |
| Physocarpus capitatus[2] | Pacific ninebark |
| Rhamnus californica*[2] | coffeeberry |
| Ribes aureum*[2] | Golden currant |
| Rosa californica*[2] | California wild rose |
| Rubus parviflorus[2] | thimbleberry |
| Rubus spectabilis[2] | salmonberry |
| Rubus ursinus[2] | California blackberry |
| Salvia brandegii*[2] | black sage |
| Salvia clevelandii*[2] | Cleveland sage |
| Salvia leucophylla*[2] | purple sage |
| Salvia melifera*[2] | black sage |
| Salvia sonomensis*[2] | creeping sage |
| Sambucus mexicana*[2] | elderberry |
| Santolina spp. *[2] | santolina |
| Stachys spp.* | lambs ear |
| Styrax officinalis redivivus*[2] | California snowdrop |
| Trichostema spp. *[2] | wooly blue curls |

***TREE SPECIES***

| | |
|---|---|
| Acer circinatum[2] | vine maple |
| Acer macrophyllum[2, 3] | big leaf maple |
| Acer negundo v. Californicum[2, 3] | box elder |
| Alnus rhombifolia *[2, 3] | white alder |
| Alnus rubra[2, 3] | red alder |
| Betula nigra | river birch |

| | |
|---|---|
| Chilopsis sp. | desert willow |
| Corylus cornuta v. Californica*[2] | California hazelnut |
| Fraxinus latifolia[2] | Oregon ash |
| Platanus racemosa[2, 3] | sycamore |
| Populus fremontii[1, 2, 3] | Fremont's cottonwood |
| Quercus lobata*[2] | valley oak |
| Salix laevigata[1, 2] | red willow |
| Salix lasiolepis[1, 2] | arroyo willow |
| Salix lucida ssp. lasiandra[1, 2] | shining willow |

[1] denotes species with phytoremediation capabilities
[2] Denotes native species
[3] Denotes species with limited drought tolerance
* Denotes drought tolerant species

## 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". Trees are generally not included in flow-through planters, but if they are used, minimum soil depth must be 36". Plant species should be adapted to well-drained soils. Irrigation is typically required, but selecting plants adapted to extended dry periods can reduce irrigation requirements.

***EMERGENT***

| | |
|---|---|
| Hydrocotyle ranunculoides[2] | Marsh pennywort |
| Juncus patens*[2] | blue rush |

***GRASS SPECIES***

| | |
|---|---|
| Aristida purpurea*[2] | Purple three-awn |
| Carex praegracilus* | Clustered field sedge |
| Carex tumulicola[2] | Berkeley sedge |
| Chondropetalum tectorum* | cape rush |
| Festuca californica*[2] | California fescue |
| Festuca idahoensis[2] | Idaho fescue |
| Festuca rubra[1, 2] | red fescue |
| Festuca rubra 'molate'[2] | Molate fescue |
| Linum usitatissimum[1] | flax |
| Melica imperfecta*[2] | coast range melic |
| Muhlenbergia rigens*[2] | deergrass |
| Sisyrinchium bellum*[2] | blue-eyed grass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Achillea millefolium*[1, 2] | common yarrow |
| Allium spp. | wild onion |
| Armeria maritima[2] | sea pink |
| Epilobium densiflorum[2] | dense spike-primrose |
| Eschscholzia californica*[2] | California poppy |
| Limonium californicum[2] | Marsh rosemary |

| | |
|---|---|
| Mimulus aurantiacus*[2] | common monkeyflower |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Solidago spp.[1] | goldenrod |
| Thymus pseudolanuginosus | woolly thyme |
| Vigna unguiculata[1] | cowpea |

***SHRUB SPECIES***

| | |
|---|---|
| Arctostaphylos densiflora 'McMinn'*[2] | manzanita 'McMinn' |
| Arctostaphylos manzanita*[2] | common manzanita |
| Arctostaphylos uva-ursi 'Emerald Carpet'*[2] | manzanita 'Emerald Carpet' |
| Baccharis pilularis 'Twin Peaks'*[2] | coyote brush prostrate |
| Berberis thunbergii | Japanese barberry |
| Calycanthus occidentalis*[2] | Spicebush |
| Carpenteria californica*[2] | Bush anemone |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Dietes spp. | Fortnight lily |
| Garrya elliptica*[2] | coast silk tassle |
| Echium candicans | Pride-of-Madera |
| Heteromeles arbutifolia*[2] | toyon |
| Lavandula spp.* | lavender |
| Mahonia aquifolium*[2] | Oregon grape |
| Mahonia repens*[2] | creeping Oregon grape |
| Pittosporum tobira* | mock orange |
| Rhamnus Californica*[2] | coffeeberry |
| Ribes aureum*[2] | Golden currant |
| Rosa californica*[2] | California wild rose |
| Rubus parviflorus[2] | Thimbleberry |
| Rubus spectabilis[2] | Salmonberry |
| Sambucus mexicana*[2] | elderberry |
| Symphoricarpos albus*[2] | snowberry |

***TREE SPECIES***

| | |
|---|---|
| Fraxinus latifolia[2] | Oregon ash |

[1] denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance

## Tree Well Filter

Trees and shrubs planted in tree well filters should be an appropriate size for the space provided. Because plant roots are confined to the container, it is recommended that small trees and shrubs with shallow, fibrous roots be planted in the tree well filter. Provided that site conditions allow, it may be possible to work with the manufacturer to design a container that would allow for the planting of larger trees or shrubs. Plants for tree well filters should be tolerant of frequent, but temporary periods of inundation as well as adapted to extremely well-drained soils. Species with the ability to neutralize contaminants are preferred. Proprietary designs typically would not include grass or herbaceous species; however, non-proprietary designs may allow for grass and/or herbaceous species when there is adequate planting surface. Grass and herbaceous species identified below are identified for tree well filters in which the infiltration rate is 5 to 10 inches per hour.

***GRASS/HERBACEOUS SPECIES*** (NOTE: These species are to be used only with adequate planting surface and when infiltration rates are 5 to 10 inches per hour.)

| | |
|---|---|
| Carex pansa*[2] | California meadow sedge |
| Festuca californica*[2] | California fescue |
| Festuca idahoensis*[2] | Idaho fescue |
| Festuca rubra*[1,2] | red fescue |
| Festuca rbra 'molate'*[2] | Molate fescue |
| Achillea millefolium*[1,2] | common yarrow |
| Anthemis nobilis* (Chamaemelum nobile) | chamomile |
| Armeria maritime*[2] | sea pink |
| Erigonum latifolium*[2] | coast buckwheat |
| Erigonum fasciculatum*[2] | flattop buckwheat |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Nepeta spp.* | catmint |
| Penstemon spp.*[2] | bearded tongue |
| Thymus pseudolanuginosus | woolly thyme |

***SHRUB SPECIES***

| | |
|---|---|
| Baccharis pilularis 'Twin Peaks'*[2] | coyote brush prostrate |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Physocarpus capitatus[2] | Pacific ninebark |
| Prunus ilicifolia*[2] | hollyleaf cherry |

***TREE SPECIES***

| | |
|---|---|
| Acer circinatum[2] | vine maple |
| Acer negundo v. Californicum[2, 3] | box elder |
| Alnus rhombifolia*[2, 3] | white alder |
| Alnus rubra*[2, 3] | red alder |
| Betula nigra | river birch |
| Corylus cornuta v. Californica*[2] | California hazelnut |
| Crataegus* | Hawthorn |
| Fraxinus latifolia[2] | Oregon ash |
| Platanus acerifolia* | London Plane Tree |
| Platanus racemosa[2,] | sycamore |

| | |
|---|---|
| Populus fremontii[1, 2, 3] | Fremont's cottonwood |
| Quercus virginiana | Southern Live Oak |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance

### Vegetated Buffer Strips

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

***EMERGENT SPECIES***

| | |
|---|---|
| Carex barbarae*[2] | Santa Barbara sedge |
| Juncus patens*[2] | blue rush |

***GRASS SPECIES***

| | |
|---|---|
| Aristida purpurea*[2] | purple three-awn |
| Carex pansa[2, 3] | California meadow sedge |
| Carex tumulicola[2] | Berkeley sedge |
| Chondropetalum tectorum | Cape rush |
| Deschampsia cespitosa *[1, 2] | tufted hairgrass |
| Deschampsia cespitosa*[2] ssp. holciformis | Pacific hairgrass |
| Elymus glaucus[2] | blue wild rye |
| Festuca californica*[2] | California fescue |
| Festuca idahoensis[2] | Idaho fescue |
| Festuca rubra[1, 2] | red fescue |
| Festuca rubra 'Molate'[2] | Molate fescue |
| Leymus triticoides*[2] | creeping wildrye |
| Melica californica *[2] | California melic |
| Melica imperfecta*[2] | coast range melic |
| Muhlenbergia rigens*[2] | deergrass |
| Nasella pulchra*[2] | purple needlegrass |
| Nassella lepida*[2] | Foothill needlegrass |
| Sisyrinchium bellum*[2] | blue-eyed grass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Achillea millefolium*[1, 2] | common yarrow |
| Alliums pp. | wild onion |
| Armeria maritima[2] | sea pink |
| Clarkia spp. *[2] | Clarkia |
| Epilobium canum*[2] (Zauschneria) | California fuchsia |
| Epilobium densiflorum[2] | dense spike-primrose |
| Eriogonum latifolium*[2] | Coast buckwheat |

| | |
|---|---|
| Eriogonum fasciculatum*[2] | flattop buckwheat |
| Eschscholzia californica*[2] | California poppy |
| Layia platyglossa*[2] | tidy tips |
| Limonium californicum[2] | Marsh rosemary |
| Linanthus spp. *[2] | Linanthus |
| Lotus scoparius*[2] | deerweed |
| Mimulus aurantiacus*[2] | common monkeyflower |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Monardella spp. *[2] | coyote mint |
| Nepeta spp.* | catmint |
| Penstemon*[2] | bearded tongue |
| Sedum spp.* | stonecrop |
| Sempervivum spp.* | hen and chicks |
| Solidago spp.[1] | goldenrod |
| Thymus pseudolanuginosus | woolly thyme |
| Vigna unguiculata[1] | cowpea |

***SHRUB SPECIES***

| | |
|---|---|
| Adenostema fasciculatum*[2] | chamise |
| Arctostaphylos densiflora*[2] 'McMinn' | manzanita 'McMinn' |
| Arctostaphylos manzanita*[2] | common manzanita |
| Arctostaphylos uva-ursi*[2] 'Emerald Carpet' | manzanita 'Emerald Carpet' |
| Baccharis pilularis*[2] 'Twin Peaks' | coyote brush prostrate |
| Baccharis salicifolia[2] | mulefat |
| Berberis thunbergii | Japanese barberry |
| Buddleia spp.* | butterfly bush |
| Calycanthus occidentalis*[2] | Spicebush |
| Carpenteria californica*[2] | Bush anemone |
| Ceanothus heartiorum*[2] | ceanothus |
| Ceanothus spp.*[2] | ceanothus |
| Cercocarpus betuloides*[2] | mountain mahogany |
| Cistus spp.* | rockrose |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Dietes spp. | Fortnight lily |
| Garrya elliptica*[2] | coast silk tassle |
| Echium candicans* | Pride-of-Madera |
| Heteromeles arbutifolia*[2] | toyon |
| Holodiscus sp. *[2] | oceanspray |
| Lavandula spp.* | lavender |
| Lavatera spp. | tree mallow |
| Lepechina calycina*[2] | pitcher sage |
| Lupinus albifrons*[2] | bush lupine |
| Mahonia aquifolium*[2] | Oregon grape |
| Mahonia repens*[2] | creeping Oregon grape |

| | |
|---|---|
| Myrica californica*[2] | Pacific wax myrtle |
| Physocarpus capitatus[2] | Pacific ninebark |
| Pittosporum tobira* | mock orange |
| Prunus ilicifolia*[2] | hollyleaf cherry |
| Rhamnus Californica*[2] | coffeeberry |
| Rhus integrifolia*[2] | lemonade berry |
| Ribes aureum*[2] | Golden currant |
| Ribes malvaceum*[2] | chaparral currant |
| Ribes sanguineum*[2] | red-flowering currant |
| Rosa californica[2] | California wild rose |
| Rubus parviflorus[2] | Thimbleberry |
| Rubus spectabilis[2] | Salmonberry |
| Rubus ursinus[2] | California blackberry |
| Salvia brandegii*[2] | black sage |
| Salvia clevelandii*[2] | Cleveland sage |
| Salvia leucophylla*[2] | purple sage |
| Salvia melifera*[2] | black sage |
| Salvia sonomensis*[2] | creeping sage |
| Sambucus mexicana*[2] | elderberry |
| Santolina spp. *[2] | santolina |
| Symphoricarpos albus*[2] | snowberry |
| Stachys spp.* | lambs ear |
| Styrax officinalis redivivus*[2] | California snowdrop |
| Trichostema spp. *[2] | wooly blue curls |
| Zauschneria californica*[2] (Epilobium c.) | California fuchsia |

***TREE SPECIES***

| | |
|---|---|
| Acer circinatum[2] | Vine Maple |
| Acer macrophyllum[2, 3] | big leaf maple |
| Acer negundo[2, 3] v. Californicum | box elder |
| Aesculus californica*[2] | buckeye |
| Alnus rhombifolia[2, 3] | white alder |
| Alnus rubra[2, 3] | red alder |
| Arbutus menziesii*[2] | madrone |
| Arbutus unedo* | strawberry tree |
| Betula nigra | river birch |
| Calocedrus decurrens[2] | incense cedar |
| Celtis occidentales* | common hackberry |
| Cercidium floridum*[2] | blue palo verde |
| Cercis occidentalis*[2] | redbud |
| Chilopsis sp. | Desert willow |
| Chioanthus retusus | Chinese fringe tree |
| Corylus cornuta*[2] v. Californica | California hazelnut |
| Fraxinus latifolia[2] | Oregon ash |
| Geijera parviflora | Australian willow |

| | |
|---|---|
| Lagerstroemia spp.* | crepe myrtle |
| Lyanothamnus floribundus Asplendifolius*[2] | Catalina ironwood |
| Morus alba (fruitless var.)[1] | white mulberry |
| Platanus acerifolia* | London Plane Tree |
| Platanus racemosa[2, 3] | sycamore |
| Populus fremontii[2, 3] | Fremont's cottonwood |
| Prunus, spp.* | plum |
| Quercus agrifolia*[2] | California live oak |
| Quercus kellogii*[2] | California black oak |
| Quercus lobata*[2] | valley oak |
| Quercus palustris | pin oak |
| Salix laevigata[1, 2] | red willow |
| Salix lasiolepis[1, 2] | arroyo willow |
| Salix lucida ssp. lasiandra[1, 2] | shining willow |
| Sequoia sempervirens[2] | coast redwood |
| Umbellularia californica[2] | California bay |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance

## Infiltration Trench

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

***EMERGENT SPECIES***

| | |
|---|---|
| Eleocharis macrostachya[2] | creeping spikerush |
| Juncus patens*[2] | blue rush |

***GRASS SPECIES***

| | |
|---|---|
| Chondropetalum tectorum | Cape rush |
| Deschampsia cespitosa*[1, 2] | tufted hairgrass |
| Deschampsia cespitosa ssp. Holciformis*[2] | Pacific hairgrass |
| Leymus triticoides*[2] | creeping wildrye |
| Muhlenbergia rigens*[2] | deergrass |
| Nasella pulchra*[2] | purple needlegrass |
| Nassella lepida*[2] | Foothill needlegrass |
| Sisyrinchium bellum*[2] | blue-eyed grass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Epilobium densiflorum[2] | dense spike-primrose |
| Limonium californicum[2] | Marsh rosemary |

***SHRUB SPECIES***

| | |
|---|---|
| Calycanthus occidentalis*[2] | Spicebush |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Prunus ilicifolia*[2] | hollyleaf cherry |
| Ribes aureum*[2] | Golden currant |
| Rosa californica*[2] | California wild rose |
| Rubus parviflorus[2] | Thimbleberry |
| Rubus spectabilis[2] | Salmonberry |

***TREE SPECIES***

| | |
|---|---|
| Acer circinatum[2] | Vine Maple |
| Acer negundo[2, 3] (v. Californicum) | box elder |
| Alnus rubra[2, 3] | red alder |
| Betula nigra | river birch |
| Fraxinus latifolia[2] | Oregon ash |
| Populus fremontii[1, 2, 3] | Fremont's cottonwood |
| Salix laevigata[1, 2] | red willow |
| Salix lasiolepis[1, 2] | arroyo willow |
| Salix lucida ssp. lasiandra[1, 2] | shining willow |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance

## Extended Detention Basin (with biotreatment soil)

Extended detention basins are intended to capture and detain water for 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 basin are intended to capture and move large quantities of water, trees should not be planted in the basins; consult with the design engineer before specifying trees at the basin perimeter (top of bank). Shrubs are typically not specified for extended detention basins, but may be included only on the outer perimeter (top of bank) that they do not interfere with detention. Species should be adapted to periodic inundation and saturation and extended periods of dry conditions. Emergent, grass and herbaceous species for extended detention basins should consists of species that are able withstand extended periods of inundation. Supplemental irrigation will be necessary to maintain emergent species during extremely dry conditions. The following list includes plants appropriate for extended detention basins with biotreatment soil. Please see Table A-1 for plants suitable for extended detention basins that do not use biotreatment soil.

***EMERGENT SPECIES***

| | |
|---|---|
| Artemisia douglasiana[2] | Mugwort |
| Carex barbarae*[2] | Santa Barbara sedge |
| Carex densa[2] | dense sedge |

| | |
|---|---|
| Carex obnupta[2] | slough sedge |
| Eleocharis macrostachya[2] | creeping spikerush |
| Juncus balitcus[1, 2] | baltic rush |
| Juncus bufonius[2] | toad rush |
| Juncus effusus[1, 2] | Pacific rush |
| Juncus leseurii[2] | common rush |
| Juncus mexicanus[2] | Mexican rush |
| Juncus patens*[2] | blue rush |
| Juncus xiphioides | iris-leaved rush |
| Limonium californicum[2] | Marsh rosemary |
| Phragmites spp. | common reeds |
| Scirpus actutus[2] | Tule |
| Scirpus americanus[1, 2] | three square |
| Scirpus californicus[1, 2] | california bulrush |
| Spartina foliosa[2] | California cordgrass |
| Typha angustifolia[2] | narrowleaf cattail |
| Typha latifolia[2] | cattail |

***GRASS/HERBACEOUS SPECIES***

| | |
|---|---|
| Agrostis exarata[2] | spike bentgrass |
| Alopecurus aequalis[2] | shortawn foxtail |
| Alopecurus saccatus[2] | Pacific foxtail |
| Carex pansa*[2] | California meadow sedge |
| Carex praegracilus[2] | clustered field sedge |
| Chondropetalum tectorum | Cape rush |
| Danthonia californica[2] | California oatgrass |
| Deschampsia cespitosa*[1, 2] | tufted hairgrass |
| Deschampsia cespitosa Ssp. Holciformis*[2] | Pacific hairgrass |
| Deschampsia danthonioides[2] | annual hairgrass |
| Distichlis spicata[2] | salt grass |
| Eleocharis palustris[2] | creeping spikerush |
| Limonium californicum | Marsh rosemary |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Muhlenbergia rigens*[2] | deergrass |

***SHRUB SPECIES***

| | |
|---|---|
| Baccharis salicifolia[2] | mulefat |
| Cornus sericea[2] (same as C. stolonifera) | western dogwood |
| Physocarpus capitatus[2] | Pacific ninebark |

***TREE SPECIES***

| | |
|---|---|
| Acer negundo[2] v. Californicum | box elder |
| Alnus rhombifolia[2, 3] | white alder |
| Alnus rubra[2,3] | red alder |

| | |
|---|---|
| Fraxinus latifolia[2] | Oregon ash |
| Platanus racemosa[2,3] | sycamore |
| Salix laevigata[1, 2] | red willow |
| Salix lasiolepis[1, 2] | arroyo willow |
| Salix lucida ssp. lasiandra[1, 2] | shining willow |
| Sequoia sempervirens[2] | coast redwood |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance

### Pervious paving – Turf Block Pavers

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

***GRASS SPECIES***

| | |
|---|---|
| Agrostis exarata[2] | spike bentgrass |
| Carex pansa*[2] | California meadow sedge |
| Festuca idahoensis[2] | Idaho fescue |
| Festuca rubra[1, 2] | red fescue |
| Festuca rubra 'Molate'[2] | Molate fescue |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Anthemis nobilis[4] | chamomile |
| Eschscholzia californica*[2] | California poppy |
| Thymus pseudolanuginosus[4] | woolly thyme |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance
[4] Denotes species that cannot tolerate vehicular compaction

### Green roof

A green roof is intended to capture precipitation and roof runoff. Green roofs utilize a lightweight, porous planting substrate as a medium for plant growth. The depth and composition of this substrate is extremely important in determining types of plants that will be successful as part of a green roof system. Intensive green roofs, which can have up to 48" of substrate, can support a wider variety of plant types. The list below is only a sample of plants that could be suitable for an intensive green roof. Extensive green roofs, which have a depth of 3" to 7" of planting medium, are suitable for a limited number of grass and herbaceous species. These roofs generally require little maintenance and should be designed to succeed with minimal irrigation. In addition to the species listed below, pre-vegetated mats can be utilized on extensive green roofs. Information can be found at the following website: www.hfmgv.org/rouge/livingroof.asp

## *EXTENSIVE GREEN ROOF*

***EMERGENT SPECIES***

| | |
|---|---|
| Carex barbarae*[2] | Santa Barbara sedge |

***GRASS SPECIES***

| | |
|---|---|
| Festuca idahoensis[2] | Idaho fescue |
| Nasella pulchra*[2] | purple needlegrass |
| Nassella lepida*[2] | Foothill needlegrass |
| Sisyrinchium bellum*[2] | blue-eyed grass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Achillea millefolium *[1, 2] | common yarrow |
| Allium spp. *[2] | wild onion |
| Armeria maritima[2] | sea pink |
| Clarkia spp. *[2] | Clarkia |
| Eschscholzia californica*[2] | California poppy |
| Layia platyglossa*[2] | tidy tips |
| Linanthus spp. *[2] | Linanthus |
| Lotus scoparius*[2] | deerweed |
| Sedum spp.* | stonecrop |
| Sempervivum spp.* | hen and chicks |
| Solidago spp.[1] | goldenrod |
| Thymus pseudolanuginosus | woolly thyme |

***SHRUB SPECIES***

| | |
|---|---|
| Santolina spp. *[2] | santolina |

## *INTENSIVE GREEN ROOF*

***EMERGENT SPECIES***

| | |
|---|---|
| Carex barbarae*[2] | Santa Barbara sedge |
| Juncus patens*[2] | blue rush |

***GRASS SPECIES***

| | |
|---|---|
| Aristida purpurea*[2] | purple three-awn |
| Calamagrostis X acutiflora | reed grass |
| Chondropetalum tectorum | Cape rush |
| Festuca californica*[2] | California fescue |
| Festuca idahoensis[2] | Idaho fescue |
| Leymus triticoides*[2] | creeping wildrye |
| Muhlenbergia rigens*[2] | deergrass |
| Nasella pulchra*[2] | purple needlegrass |
| Nassella lepida*[2] | Foothill needlegrass |

***HERBACEOUS SPECIES***

| | |
|---|---|
| Achillea millefolium*[1,2] | common yarrow |
| Allium spp. | wild onion |
| Armeria maritima[2] | sea pink |
| Clarkia spp. *[2] | Clarkia |
| Eschscholzia californica*[2] | California poppy |
| Layia platyglossa*[2] | tidy tips |
| Linanthus spp. *[2] | Linanthus |
| Lotus scoparius*[2] | deerweed |
| Mimulus aurantiacus*[2] | common monkeyflower |
| Mimulus cardinalis[2] | scarlet monkeyflower |
| Nepeta spp.* | catmint |
| Penstemon spp. *[2] | bearded tongue |
| Sedum spp.* | stonecrop |
| Sempervivum spp.* | hen and chicks |
| Solidago spp [1] | goldenrod |
| Thymus pseudolanuginosus | woolly thyme |
| Vigna unguiculata [1] | cowpea |

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

| | |
|---|---|
| Adenostoma fasciculatum*[2] | chamise |
| Arctostaphylos densiflora 'McMinn'*[2] | manzanita 'McMinn' |
| Arctostaphylos manzanita*[2] | common manzanita |
| Arctostaphylos uva-ursi 'Emerald Carpet'*[2] | manzanita 'Emerald Carpet' |
| Baccharis pilularis 'Twin Peaks'*[2] | coyote brush prostrate |
| Berberis thunbergii | Japanese barberry |
| Ceanothus hearstiorum*[2] | ceanothus |
| Ceanothus spp.* [2] | ceanothus |
| Garrya eliptica*[2] | coast silk tassle |
| Echium candicans* | Pride-of-Madera |
| Heteromeles arbutifolia*[2] | toyon |
| Lavandula spp.* | lavender |
| Mahonia aquifolium*[2] | Oregon grape |
| Mahonia repens*[2] | creeping Oregon grape |
| Myrica californica*[2] | Pacific wax myrtle |
| Physocarpus capitatus[2] | Pacific ninebark |
| Rhamnus Californica*[2] | coffeeberry |
| Santolina spp. *[2] | santolina |
| Trichostema spp. *[2] | wooly blue curls |
| Zauschneria californica*[2] (Epilobium c.) | California fuchsia |

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

| | |
|---|---|
| Acer circinatum[2] | Vine Maple |
| Arbutus unedo* | Strawberry Tree |
| Cercis occidentalis*[2] | redbud |

| | |
|---|---|
| Chilopsis sp. | Desert willow |
| Crataegus* | hawthorn |
| Lagerstroemia spp.* | crepe myrtle |

[1] Denotes species with phytoremediation capabilities
[2] Denotes native species
* Denotes drought tolerant species
[3] Denotes species with limited drought tolerance
[+] Note: These species have been selected among trees suitable for stormwater. A large number of tree species are suitable for intensive green roofs, and will depend on the type and depth of soil mix, microclimate and available space.

## A.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 the Bay Friendly Landscaping Guidelines prepared by Stopwaste.Org (available at www.bayfriendly.org), which outline principles and practices to minimize waste, protect air and water quality, conserve energy and water, and protect natural ecosystems, including:

- Evaluate site and assess the soil;
- Consider potential for fire;
- Select plants for appropriate size upon maturity, do not over-plant;
- Irrigation, if required, should be designed as a high efficiency, water conserving system; and
- Utilize compost (see the specification in the Bay-Friendly Landscaping Guidelines) and mulch to build healthy soils and increase the water holding capacity of the soil.

### Propagation and Planting Methods

The propagation methods for different species will vary, depending upon type of plant and stormwater adaptation. In general, container stock will be utilized most commonly for green roofs, 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, prepare a hole slightly wider than the diameter of the plug, and place the roots system of the plug 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. 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. Plant seeds at the ratios and rates specified by the supplier. Seed should be free of weeds and diseases. The certified germination percentage should be provided by the supplier.

### Water Level Management and Irrigation for Plant Establishment

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

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

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

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

# A.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 material that resists floating with surface runoff will also help control weed growth.

## Erosion Control

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

- Keep the soil covered with vegetation to the extent possible;
- Slow water runoff by using compost berms, blanket, socks or tubes along slopes;
- Cover bare soil with a minimum of 3" mulch cover;
- Minimize the use of blowers in planting beds and on turf;
- In areas that will be inundated, use compost mulch that is not prone to washing into storms drains; wood chips may be used on slopes above area of inundation; and
- Store leaf litter as additional much in planting beds as appropriate.

## Irrigation Systems

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

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

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

### Bioretention and Extended Detention Basins

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

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

Long-term maintenance tasks on the banks of the basins will include continued control of nonnative weeds and invasive plants, and control of erosion. Erosion could include gullies, rills and sheet erosion. Actions to control erosion should include redirecting or dissipating the water source. Recontouring and subsequent mulching and/or reseeding with erosion control species may be required in bare areas. In the event of extensive die-off of the native plant species, replant the bare areas. 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.

## A.6 Bay-Friendly Landscaping and IPM

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

### Bay Friendly Landscaping

Bay-Friendly landscaping is a whole systems approach to the design, construction and maintenance of the landscape in order to support the integrity of the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly landscaping practices from the initial plant selection through the long-term maintenance of the site. This section summarizes Bay-Friendly Landscaping practices that may be implemented information that project sponsors need about how these practices canto benefit water quality of the Bay and its tributaries. Bay-Friendly landscaping is based on 7 principles of sustainable landscaping and features the following practices

1. **Landscape Locally.** Landscapes designed to be part of the larger ecosystem of the Bay Area can both protect the health, diversity and sustainability of this valuable resource while making the most of the natural processes of a well-functioning ecosystem. By selecting plants appropriate to the climate, exposure, soils, drainage and topography, plantings can be established more successfully with less consumption of resources and intensive maintenance. Landscape designers are also encouraged to use local, well-adapted plant communities as models and to consider the potential for fire when developing the plant palette for a project.

2. **Less to the Landfill.** Reducing waste –and thus conserving landfill space and fossil fuel for hauling this material to the landfill - starts with not generating it in the first place. Plant trimmings pruning can be reduced by selecting plants that can grow to their natural size is the space allotted them, by avoiding the use of sheared hedges as design elements and not specifying invasive species (see the list in Appendix A). 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 mulch, taking into account water flow and designing to avoid the loss of mulch with runoff.

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

4. **Conserve Water.** Amending the soil with compost and keeping it covered with mulch can increase soil permeability and water-holding capacity, reduce water loss through evaporation and decrease the need for irrigation. Planting appropriate, drought tolerant California natives or Mediterranean plants also reduces water consumption for irrigation, as well as consumption of other resources for mowing, fertilizing, and spraying. Minimize the use of turf grasses that require regular watering and fertilizing to remain green,

particularly on slopes or in narrow, irregular hard to water shapes. Arrange plants in "hydrozones" of low, medium or high water demand. Onsite collection systems can allow the use of rainwater, or the reuse of "graywater" – uncontaminated wastewater from sinks, bathtubs, and washing machines. Specify, install and maintain high-efficiency irrigation systems, and train landscaping staff to manage irrigation according to need.

5. **Conserve Energy.** Conventional landscapes are very fossil fuel consumptive. Selecting plantings that do not require regular mowing or pruning, fertilizing and watering can help reduce this demand and restore our landscapes to those that are more productive than consumptive. Tree plantings can be used to moderate building temperatures, and to shade paved areas and air conditioners. Trees can also intercept significant amounts of rainfall each year and thus help control stormwater runoff. Specify as large a tree as possible but be sure that it will be allowed to grow to its natural shape and size in the allotted space. Outdoor lighting should be designed to use less energy and minimize "light pollution." Choose and maintain energy-efficient landscaping equipment to conserve fuel. Specifying local products and suppliers reduces the energy needed to transport products and supports local economies.
6. **Protect Water and Air Quality.** Bay-Friendly landscaping can help protect water quality by increasing on-site infiltration and reducing runoff, reducing pollutants in runoff, and increasing the soil's ability to remove pollutants from runoff. It can help protect air quality by reducing fossil fuel consumption, recycling plant debris onsite, and planting trees to remove carbon dioxide and absorb air pollutants. Many of the practices described previously, such as minimizing high input decorative lawns, keeping soil covered with mulch and planting trees play a critical role in protecting water and air quality. An additional very important component of Bay-Friendly landscaping is reducing the use of pesticides through integrated pest management, which is described in a separate section, below.
7. **Create and Protect Wildlife Habitat.** Although we tend to rely on parks and open space to preserve wildlife habitat, developed landscapes can also provide food, water, shelter and nesting sites for birds, butterflies, beneficial insects, and other creatures. This can be accomplished by providing a diverse landscape that includes annuals, biennials and perennials of many different sizes, shapes, colors and textures; by choosing California natives first; providing appropriate water and shelter for wildlife; eliminating the use of pesticides; and planning sites to conserve or restore natural areas and wildlife corridors.

### Integrated Pest Management

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

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

- **Prevent Pest Problems.** Fostering a healthy soil and selecting appropriate plant communities for the site helps reduce the susceptibility to disease and other pests. Landscape designs should include a diversity of species that are well-suited to the site; specify resistant varieties and native species, including plants that attract beneficial insects; place plants a proper distance from buildings; avoid over-planting; and include compost in the soil specifications. Cultural methods of avoiding pests during construction and maintenance include the following:
  - Selecting plant material that is free from disease and insects;
  - Planting at the right depth;
  - Watering thoroughly but not over-watering;
  - Keeping mulch on the soil surface at all times, keeping it away from root crowns;
  - Using slow release fertilizer, if necessary, and not over-fertilizing;
  - Pruning judiciously;
  - Eliminating noxious weeds before they go to seed or spread;
  - Cleaning equipment after use on infected plants;
  - Inspecting and removing invasive plant parts or seeds from clothing, tools and vehicle before leaving an infected site; and
  - Cleaning up fruit and plant material that is infected with insects or diseases.
- **Watch for and Monitor Problems.** Landscaping firms should provide their staff with the time and resources to learn to identify both pest and beneficial organisms, and train residential clients to monitor and record pest problems. Plants should be checked often for vigor and signs of pests. Clarify which problems are the result of pests and not other environmental problems. Evaluate the results of any treatments, and check regularly with the Bio-Integral Resource Center (www.birc.org) or UC Davis (www.ipm.ucdavis.edu) for up-to-date resources and information.
- **Education is Key.** Many property owners have unrealistic standards of absolute pest control and need to learn how landscapes can tolerate a certain level of pests without resulting in significant, or even noticeable, damage. Landscape professionals should educate their clients and refer them to www.ourwaterourworld.org for fact sheets and information on alternative pest control strategies.
- **Use Physical and Mechanical Controls.** If pests are identified as the source of unacceptable levels of damage, physical barriers or mechanical techniques are the first line of control. This can include the carefully timed and conducted pruning of infested plant material or removal of whole plants, spraying aphids with a strong jet of water, using pheromone or sticky traps to keep ants and other insects away or hand-picking large adult insect pests and larvae as they appear

- **Use Biological Controls.** Living organisms can also be used to keep pest populations under control. The most important biological controls appear naturally and will be abundant in a landscape that is not heavily treated with pesticides. Encourage beneficial insects by planting a wide range of plants that flower throughout the year (see list 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.

## A.7 Planting Tips for Single-Family Homes

It is recommended that homeowners and builders follow the practices of Bay Friendly Landscaping and Integrated Pest Management (see Section A.6) to minimize pesticide usage and over-watering. Planting tips for single-family homes include:

- Avoid using invasive species such as iceplant and eucalyptus;
- Minimize turf grass areas to reduce need for fertilizer and excessive watering;
- Use appropriate species for soil and climate conditions; and
- Use compost instead of fertilizer.

Please review Section A.6 for complete information on Bay Friendly Landscaping and Integrated Pest Management.

## A.8 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. An asterisk (*) indicates a nursery with a dedicated native plant section.

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/

Golden Nursery
1122 2nd Street
San Mateo, CA 94401
(650) 348-5525
www.goldennursery.com

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

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

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

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

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

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

Redwood City Nursery
2760 El Camino Real
Redwood City, CA 94061
(650) 368-0357
www.rcnursery.com

Roger Reynolds Nursery
133 Encinal Ave
Menlo Park, CA 94025
(650) 323-5612
www.rogerreynoldsnursery.com

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

Wegman's Nursery
492 Woodside Road
Redwood City, CA 94061
(650)368-5821
www.wegmannursery.com

Yerba Buena Nursery
19500 Skyline Blvd.
Woodside, CA 94062
(650) 851-1668
www.yerbabuenanursery.com

## References

A. StopWaste.Org www.bayfriendly.org
1. Bay-Friendly Landscape Guidelines
2. A Landscaper's Guide to Grasscycling
3. A Landscaper's Guide to Mulch

B. A Guide to Estimating Irrigation of Water Needs of Landscape Plantings, California Dept of Water Resources, http://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, Watershed Council (510.231.5655), California Invasive Plant Council (510.843.3902)

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

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

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.

Appendix

# B

# Example Scenarios

Table of Contents



# B.1 Parking Lot Example

## Introduction

This example shows a proposed parking lot in San Mateo County with bioretention as the method of stormwater treatment, and demonstrates the use of the “4 percent method” (see Chapter 5, Section 5.1) for sizing bioretention facilities.

*Parking Lot in San Mateo County*

***Summary of Stormwater Controls***

**Site Design Measures**
- Some of the landscaped areas are designed to function as self-treating (S-T) areas

**Source Control Measures**
- Stenciling storm drain inlets
- Parking lot sweeping
- Landscape architect will be asked to select drought tolerant plants and specify maintenance with IPM techniques

**Treatment Measures**
- Bioretention facilities

**Example Parking Lot Site Description**

- The project site is 1.2 acres with 1% slope from edge of lot to street.
- Sidewalks will be graded toward landscaped areas.
- The parking lot will have some landscaping as an amenity (not used for stormwater treatment).
- All areas will be graded to drain to bioretention facilities along the perimeter of the site. There are two drainage management areas.

The site was divided into drainage management areas (DMAs). DMAs A and B each drain to one bioretention facility. The self-treating (S-T) areas do not need to drain to a treatment measure. The DMA data is as follows:

| DMA | Impervious Area (sf) | Pervious Area (sf) | Total Area (sf) |
|---|---|---|---|
| A | 6,788 | 7,868 | 14,656 |
| B | 24,491 | 0 | 24,491 |
| S-T Areas | 0 | 13,125 | 13,125 |
| Totals | 31,279 | 20,993 | 52,272 |

*Examples of Bioretention Areas*

**Procedure for BMP Sizing (4 Percent Method)**

Use the following procedure for sizing bioretention facilities using the 4 percent method (perform for each DMA and treatment measure):

1. List the area of impervious surface and the area of pervious surface (if any) that drains to the treatment measure.
2. Multiply the pervious area by a factor of 0.1.
3. Add the product obtained in Step 2 to the area of impervious surface to obtain the "effective impervious area."
4. Multiply the effective impervious area by a factor of 0.04. This is the required surface area of the bioretention facility.

Results of Steps 1 through 4 for the example DMAs are shown below:

| DMA | Impervious Area (sf) | Pervious Area (sf) | Pervious Area x 0.1 (sf) | 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 |

# B.2 Podium Type Building Example

## Introduction

This example consists of a proposed podium type building in San Mateo County, with flow-through planters as the method of stormwater treatment. The flow-through planters are sized using the combination flow and volume sizing method.

***Summary of Stormwater Controls***

**Site Design Measures**
- Multistory building above covered parking structure (minimized surface parking)

**Source Control Measures**
- Covered trash storage areas
- Landscape architect will be asked to select drought tolerant plants and specify maintenance with IPM techniques

**Treatment Measures**
- Flow-through planters

## Example Podium Type Development Description

- The project site is approximately 25,000 square feet.
- Lot line is assumed to be to the edge of city right-of-way (sidewalks).
- 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 ground floor is a concrete slab with buildings and a covered parking structure. There is no potential for infiltration.
- The podium building roof area is 15,000 square feet.
- There is a 9,000 square foot concrete patio on the top of the podium in the center of the building.
- Treatment will be provided using flow-through planters in the center of the building around the concrete patio and down at ground level.
- Runoff will be conveyed to the treatment measures via roof leaders and sheet flow.
- Flow-through planters will be designed per the guidelines in Section 6.2 of the C.3 Technical Guidance Manual.
- Off-site sidewalks and driveways will be graded toward street (stormwater treatment not required).

City of Portland *2004 Stormwater Manual*

*Typical Flow-Through Planter*

**Procedure for BMP Sizing (Combination Flow and Volume Method):**

For bioretention areas and flow-through planters, the following approach may be used to take into consideration both the flow of stormwater through the planting media and the volume of stormwater in the surface ponding area. This treatment system design approach meets both the flow-based and volume-based criteria in MRP Provision C.3.d. Note that 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 (contributing pervious area should be converted to effective impervious areas by multiplying by a runoff coefficient of 0.1).

The steps below describe the calculations for sizing the example podium building treatment measures, using the combination flow and volume method described in Chapter 5, Section 5.1, and the following assumptions:

- Design flow criterion: rainfall intensity = 0.2 in/hr
- Design volume criterion: capture 80% of the average annual runoff
- The project site is located in Rainfall Region 4, per the rainfall region map in Appendix C, and has a mean annual precipitation (MAP) of 16 inches
- The surface loading rate for the biotreatment soil is 5 in/hr
- Desired ponding depth is approximately 6 inches

1. List the DMAs draining to each treatment measure (note that for this example, it is assumed that all the runoff drains to one large flow-through planter):

| | |
|---|---|
| Impervious Patio Surfaces | 9,000 square feet |
| Roof Surfaces | 15,000 square feet |
| **Total Impervious Area** | **24,000 square feet** |

2. Determine the unit basin storage volume for 80 Percent Capture with 48-hour drawdown using Table 5-2 of Chapter 5 based on an effective impervious area runoff coefficient of 1.0. Adjust this volume based on the ratio of the MAP at the site to the MAP at the nearest rain gage.

   Region 4 (Palo Alto gage) has a MAP of 14.6 inches and a unit basin storage volume of 0.64 inches. The MAP at the site is 16 inches. Therefore, the unit basin storage volume at the site = (0.64 in. × 16/14.6) = **0.7 inches**.

3. Calculate the water quality design volume by multiplying the total impervious area from Step 1 times the adjusted unit basin storage volume from Step 2. (24,000 sq. ft. × 0.7" × 1/12 feet per inch = **1,403 cubic feet**.)

4. Assume that the rain event that generates the design volume of runoff determined in Step 3 occurs at a constant intensity of 0.2 in/hr from the start of the storm (i.e., assume a rectangular hydrograph). Calculate the duration of the rain event by dividing the adjusted unit basin storage volume from Step 2 by the intensity. In other words, determine the amount of time required for the adjusted unit basin storage volume to be achieved at a rate of 0.2 in/hr.

   For this example, with an adjusted unit basin storage volume of 0.7 inches, the rain event duration = (0.7 in. ÷ 0.2 in/hr) = **3.5 hours**.

5. Make a preliminary estimate of the surface area of the bioretention facility or flow-through planter by using the 4% method (i.e., multiplying the area of impervious surface in Step 1 by a sizing factor of 0.04).

   For this example, 24,000 sq. ft. × 0.04 = **960 square feet** of surface area

6. Assume a surface area that is about 25% smaller than the area calculated in Step 5. Using the example above, 960 – (0.25 × 960) = **720 square feet**.

7. Calculate the volume of runoff that filters through the treatment soil at a rate of 5 inches per hour (the design surface loading rate), for the duration of the rain event calculated in Step 4.

   For this example, with a surface area of 720 square feet and an infiltration rate of 5 in/hr for a duration of 3.5 hours, the volume of treated runoff =
   720 sq. ft. × 5 in/hr × (1 ft/12 in) × 3.5 hrs = **1,052 cubic feet**.

8. Calculate the portion of the water quality design 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 surface area assumed in Step 6.

   For this example, the amount remaining to be stored comparing Step 3 and Step 7 is 1,403 cu. ft. – 1,052 cu. ft. = **351 cubic feet**.

   If this volume is stored over a surface area of 720 square feet, the average ponding depth would be 351 cu. ft. ÷ 720 sq. ft. × 12 in/ft = **5.8 inches**.

9. The final step is to check if the average ponding depth is between 6 and 12 inches, which is the recommended range for ponding in a flow-through planter. (Check with the local municipality to determine what is allowed.) If the ponding depth is less than 6 inches, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 7 and 8 with a smaller area). If the ponding depth is greater than 12 inches, a larger surface area will be required.

   In this example, the recommended size of the flow-through planter is 715 square feet with a ponding depth of 6 inches.

## B.3 Sizing Worksheets

The Countywide Program has developed Excel-based worksheets for sizing treatment measures using the volume-based method and the combination flow and volume based method. The worksheets are available for download from the Countywide Program's website at the following link:

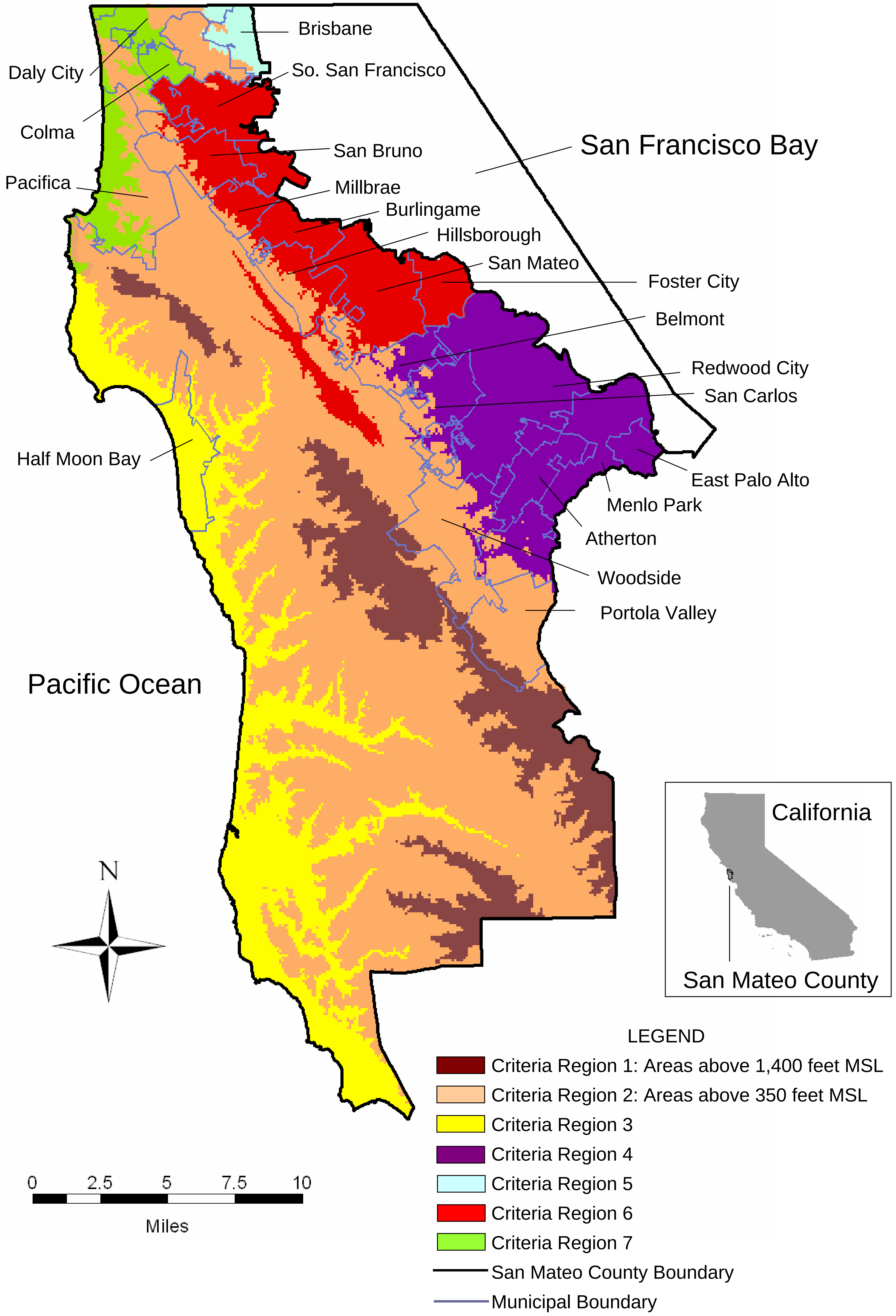
http://flowstobay.org/newdevelopment

Appendix

# C

# Treatment Measure Design Criteria Regions for San Mateo County

# Figure 1
# BMP Design Criteria Regions for San Mateo County



Appendix

# D

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

As described in Section 5.2, beginning December 1, 2011, no underground vault systems are allowed for use, 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.

## D.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 municipalities 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.

## D.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, the municipalities 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.

## D.3 Hydrodynamic Separators

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

The Contra Costa Clean Water Program 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 identified as pollutants of concern in the Contra Costa Countywide NPDES municipal stormwater permit. Contra Costa's 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.

[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, http://www.cleanwaterprogram.org/uploads/RWQCB_letter_re_inlet_filters_etc.pdf.

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

## D.4 Media Filters

A technical description of media filters is provided in Section 6.11. 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 that 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.

## D.5 Water Board Staff's Letter

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

Appendix

# E

# 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.

## E.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 E-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.

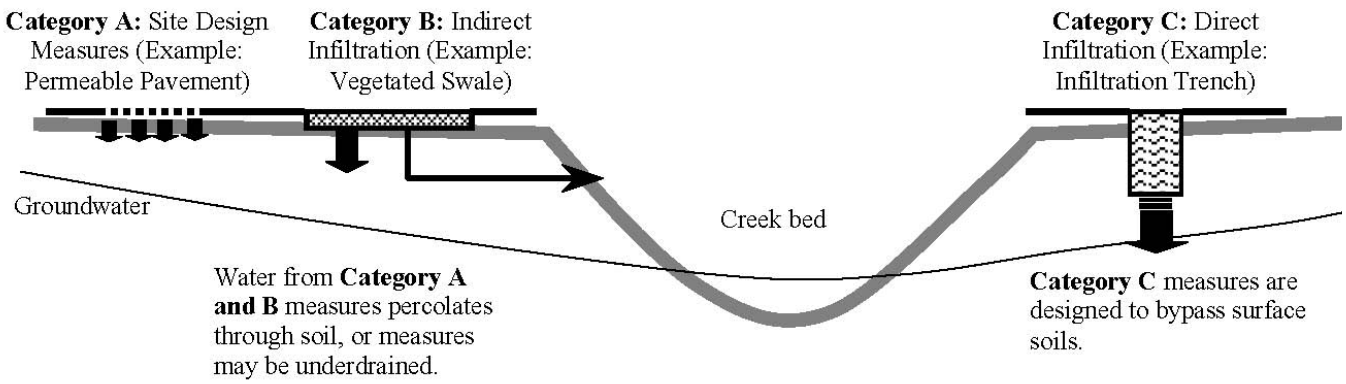



Figure E-1: Stormwater Infiltration Methods (Source: Contra Costa County Clean Water Program, 2005)

Table E-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 4 or 6 are given for stormwater controls that have specific technical guidance included in this handbook.

**Table E-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 |
| *Green Roofs* | May be “extensive” with a 3-7 inch lightweight substrate and a few types of low-profile plants; or may be “intensive” with a thicker substrate, more varied plantings, and a more garden-like appearance. | 6.8 |
| *Pervious Pavements* | Special mixes of concrete and asphalt. Require a base course of crushed aggregate and installation by experienced crews. | 6.6 |
| *Site Grading* | Using gentler slopes and concave areas to reduce runoff and encourage infiltration. | N/A |

**Table E-1**
**Infiltration Methods in Commonly-Used Stormwater Controls**

| **Stormwater Control** | **Description** | **Guidance in Section** |
|---|---|---|
| | ***Category A: Site Design Measures (continued)*** | |
| *Site Layout Practices* | Examples: Use compact, multi-story buildings to reduce building footprint, cluster buildings to reduce street length and protect sensitive areas, design narrow streets, use sidewalks on one side of street. | N/A |
| *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 |
| | ***Category B: Indirect Infiltration ("Infiltration Measures")*** | |
| *Bioretention Area* | Briefly ponds stormwater on the surface of a shallow depression and allows it to percolate through permeable soil. Underdrain is typically required, but is elevated to maximize infiltration to underlying soils, where conditions allow. | 6.1 |
| *Vegetated Buffer Strip* | Sloped area with low-growing vegetation that treats runoff by slowing the velocity so sediment and associated pollutants can settle, along with some infiltration. | N/A |
| *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* | 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 Devices")*** | |
| *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; ACCWP, 2006. | | |

# E.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 factors listed below that affect the feasibility of infiltration. These factors are grouped according to whether they apply to both indirect and direct infiltration, or whether they apply only to direct infiltration.

As indicated in Table E-1, "***infiltration measures***" are stormwater treatment measures that provide indirect infiltration. Examples of infiltration measures include bioretention areas, vegetated buffer strips, and pervious pavement.

"***Infiltration devices***" are stormwater treatment measures that 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. Infiltration measures and infiltration devices are referred to collectively as "***infiltration facilities***."

### E.2.1 Factors Affecting Feasibility of Both Indirect and Direct Infiltration

The following factors are used to determine the feasibility of any infiltration facility, whether it provides indirect infiltration (infiltration measures) or direct infiltration (infiltration devices):

- The permeability of the underlying soil;
- 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.

### E.2.2 Factors Affecting Feasibility of Direct Infiltration

Factors that specifically preclude the use of direct infiltration (infiltration devices) 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).

## E.3 Dealing with Common Site Constraints

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

- Where infiltration of the C.3.d amount of runoff is infeasible, bioinfiltration or bioretention areas may be used if drainage is sufficient or underdrains are provided. The design should maximize infiltration to the underlying soil, as shown in Section 6.1. Some indirect infiltration to groundwater will occur and will enhance the effectiveness of these treatment measures. Site design measures such as disconnected downspouts and pervious paving may be used if soils are amended and positively drained.
- Infiltration is generally infeasible on ***steep or unstable slopes***. Site design measures that limit impervious area may be appropriate if approved by a geotechnical engineer. Consider detaining runoff in green roofs and cisterns, or using stormwater treatment measures that do not infiltrate water into the natural ground, such as flow-through planters or tree well filters.
- Green roofs, cisterns, flow-through planters, tree well filters, and other stormwater controls that are isolated from underlying soils are also appropriate for areas with ***high ground water*** and/or ***groundwater contamination***.
- A variety of ***site design measures*** can often be used even on sites with the constraints described above, including (but not limited to) amended soils, structural soils, grading landscaping to a concave form, designing taller buildings with smaller footprints, and concentrating development on less sensitive portions of the site.

## E.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] Infiltration trenches are typically not considered Class V injection wells because they are longer than they are wide. The USEPA's regulations state that stormwater drainage wells are "authorized by rule" (40 CFR 144), which means they do not require a permit if they do not endanger ***underground sources of drinking water***, and they comply with federal UIC requirements. For more information, see 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

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

the regional office of the USEPA. Instructions for submitting this information are available on the USEPA Region 9 website at http://www.epa.gov/region09/water/groundwater/uic-classv.html. Project sponsors are responsible for constructing, operating and closing the drainage well in a manner that does not risk contaminating underground sources of drinking water. The USEPA may place additional requirements on the infiltration device. Project sponsors should contact the appropriate USEPA staff, identified on the Internet link provided above, to learn what inventory information should be submitted, and when the submittal should be made.

# Appendix F

# Mosquito Control Guidelines

This appendix presents guidance from the Countywide Program's Vector Control Plan for designing and maintaining stormwater treatment measures to control mosquitoes. Project sponsors are responsible for incorporating in their treatment measure designs and maintenance plans the design and maintenance guidance, presented below. Project plans that include stormwater treatment measures (and their maintenance plans) will be routed by the municipality to the San Mateo County Mosquito Abatement District for review. Project applicants may wish to consult with Mosquito Abatement District staff for guidance.

## F.1 Design Guidance for Mosquito Control

The following design considerations were adapted from guidance prepared by the California Department of Health Services,[1] and are provided for project sponsors to use when selecting, designing, and constructing stormwater treatment measures.

### General Design Principles

- Preserve natural drainage. Use site design measures to reduce the amount of stormwater runoff and provide for natural on-site runoff control. This will reduce the number of treatment measures required.
- In flat areas, where standing water may occur for more than 72 hours under existing conditions, consider grading to make minor increases in slope to improve surface drainage and prevent standing water.
- Select stormwater management measures based on site-specific conditions. Designs that take into account site conditions tend to improve drainage and limit the occurrence of stagnant water.
- Attend to ponds that temporarily impound water. Careful consideration should be made before intermittently flooded stormwater treatment measures are selected for

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

handling stormwater. Facilities that pond water for an extended period (e.g., extended detention basins and constructed wetlands) must 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, a selection of a type that does not require a wet pond or other permanent pool of water should be considered.
- Properly design storm drain systems. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe. Storm drains should be constructed so that the invert out is at the same elevation as the interior bottom to prevent standing water.
- Use grouted rock energy dissipaters instead of loose rock.
- In practice, many stormwater treatment measures, not only wet ponds, hold water for over 72 hours, sometimes due to their outdated designs, and possibly due to improper construction and maintenance. To ensure that public health and safety are maintained, the following suggestions should be considered 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 state or local public health or vector control agencies to determine whether local mosquito species and local factors may preclude rapid mosquito emergence, thus safely allowing water residence times to exceed 72 hours. In some areas this may require a detailed study that should be funded by the soliciting party.
    - Provide adequate funds necessary to support routine mosquito monitoring and control and maintenance.
- Per the Vector Control Plan, project plans that include stormwater treatment measures (and their maintenance plans), will be routed to the San Mateo County Mosquito Abatement District for review. Project applicants may wish to consult with Mosquito Abatement District staff for guidance.

## 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 devices to be easily and safely accessible without the need for special requirements (e.g., OSHA requirements for “confined space”).
- If utilizing covers, include in the design spring-loaded or light-weight access hatches that can be opened easily for inspection.

- Provide all-weather road access (with provisions for turning a full-size work vehicle) along at least one side of large above-ground structures that are less than 25 feet wide. For structures that have shoreline-to-shoreline distances in excess of 25 feet, a perimeter road is required for access to all sides.

### Dry System Design Principles for Mosquito Control

- Design structures so they do not hold standing water for more than 72 hours.
- 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 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 pump sumps.
- Use aluminum “smoke proof” covers for any vault sedimentation basins.
- Properly design storm drain systems. The sheltered environment inside storm drains can promote mosquito breeding. Pipes should be designed and constructed for a rate of flow that flushes the system of sediment and prevents water backing up in the pipe.

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

- Completely seal structures that retain water permanently or longer than 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 vector control personnel for surveillance and, if necessary, abatement activities.
- If the sump, vault, or basin is sealed against mosquitoes, with the exception of the inlet and outlet, use a design that will submerge the inlet and outlet completely to

reduce the available surface area of water for mosquito egg-laying (female mosquitoes can fly through pipes).

- Creative use of flapper or pinch valves, collapsible tubes and “brush curtains” may be effective for mosquito exclusion in certain designs.
- Design structures with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering of the unit, if necessary.

### Wet Ponds And Wetlands Design Principles for Mosquito Control

- If a wet pond or constructed, modified, or restored wetland must be built, appropriate and adequate funds must be allocated to support long-term site maintenance as well as routine monitoring and management of mosquitoes by a qualified agency.
- Before approving a wet pond or wetland system, evaluate the long-term costs and jurisdictional and maintenance issues associated with the potential establishment of special-status species. If any doubt exists, consider alternate stormwater treatment measures.
- Long-term management of mosquitoes in wet ponds and wetlands should integrate biological control, vegetation management and other physical practices, and chemical control as appropriate.
- Provide for regular inspection of sites for detection of developing mosquito populations. Local factors may influence the overall effectiveness of certain approaches for mosquito reduction.
- Wet ponds and wetlands should maintain water quality sufficient to support surface-feeding fish such as mosquito fish (*Gambusia affinis*), which feed on immature mosquitoes and can aid significantly in mosquito control.
- If large predatory fish are present (e.g., perch and bass), mosquito fish populations may be negatively impacted or eradicated. In this case, careful vegetation management remains the only nonchemical mosquito control measure.
- Where mosquito fish are not allowed, careful vegetation management remains the only nonchemical mosquito control measure. Other predators such as dragonflies, diving beetles, birds, and bats feed on mosquitoes when available, but their effects are generally insufficient to preclude chemical treatment.
- Perform routine maintenance to reduce emergent plant densities. Emergent vegetation provides mosquito larvae with refuge from predators, protection from surface disturbances, and increased nutrient availability while interfering with monitoring and control efforts.
- Whenever possible, maintain wet ponds and wetlands at depths in excess of 4 feet to limit the spread of invasive emergent vegetation such as cattails (*Typha* spp.). Deep, open areas of exposed water are typically unsuitable for mosquito immatures due to surface disturbances and predation. Deep zones also provide refuge areas for fish and beneficial macroinvertebrates should the densely vegetated emergent zones be drained.

- Build shoreline perimeters as steep and uniform as practicable to discourage dense plant growth.
- Use concrete or liners in shallow areas to discourage unwanted plant growth where vegetation is unnecessary.
- Eliminate floating vegetation conducive to mosquito production, such as water hyacinth (*Eichhornia* spp.), duckweed (*Lemna* and *Spirodela* spp.), and filamentous algal mats.
- Make shorelines accessible to maintenance and vector control crews for periodic maintenance, control, and removal of emergent vegetation, as well as for routine mosquito monitoring and abatement procedures, if necessary.
- Design and obtain necessary approvals for all wet ponds and wetlands to allow for complete draining when needed.
- Improve designs of permanent pools. Minimize shallow depths and increase circulation in ponds. Permanently flooded systems should be stocked with native *Gambusia* minnows to foster biological predation on mosquito larvae.
- Do not use stormwater structures to meet endangered species mitigation requirements. Aquatic habitat for endangered species should not be created near areas populated by humans.

## F.2 Maintenance Guidance for Mosquito Control

Routine and timely maintenance is critical for suppressing mosquito breeding as well as for meeting local water quality goals. If maintenance is neglected or inappropriate for a given site, even structures designed to be the least “mosquito friendly” may become significant breeding sites. Although general principles of vector control are described here, maintenance guidelines for individual treatment measures are often site-specific.

The maintenance principles given below are intended to reduce the mosquito population. These principles should be incorporated, as appropriate, in maintenance plans developed for stormwater treatment control measures and in the ongoing maintenance and inspection of treatment measures.

### General Maintenance Principles

- Minimize stagnant water (i.e., maintain constant exchange of water in systems).
- Minimize surface area (i.e., deeper water habitat is preferable).
- With the exception of certain treatment measures designed to hold permanent water, all treatment measures should drain completely within 72 hours to effectively suppress vector production.
- Build perimeter access roads or trails to access wet ponds. Without proper access avenues, the “barbed wire” effect can result where sharp vines prevent vector monitoring and abatement.

- Site inspections of newly constructed projects should be routinely conducted by municipalities to avoid the inadvertent approval of improperly constructed systems.
- Any circumstances that restrict the flow of water from a system as designed should be corrected. Debris or silt build-up obstructing an outfall structure should be removed. Under drains and filtration media should be inspected periodically and cleaned out or replaced as needed.
- Conduct maintenance activities regularly, in accordance with a municipality-approved maintenance plan.

### Vegetation Management Maintenance Principles

- Conduct annual vegetative management, such as removing weeds and restricting growth of aquatic vegetation to the periphery of wet ponds.
- Remove grass cuttings, trash and other debris, especially at outlet structures
- Avoid producing ruts when mowing (water may pool in ruts).

### Dry System Maintenance Principles for Mosquito Control

- Extended detention basins are usually designed to detain water for periods less than 72 hours. If they detain water for longer than five days, they are poorly maintained.
- If a detention basin has been installed at an inappropriate location (e.g., on a site where the water table is too close to the surface), if elimination 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.

### Underground Structure Maintenance Principles for Mosquito Control

- Prevent mosquito access to underground systems that may have standing water (i.e., seal openings that are 1/16-inch in diameter or greater).
- Provide SMCMAD access to underground systems that may have standing water.

### Infiltration and Filtration Device Maintenance Principles for Mosquito Control

- Infiltration trenches and sand filter structures should not hold water for longer than 24 hours. If they retain water for longer than 48 hours, they are poorly maintained.

Appendix

# G

# 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 Area (includes bioinfiltration area)
- Maintenance Plan for Flow-through Planter
- Maintenance Plan for Tree Well Filter
- Maintenance Plan for Vegetated Buffer Strip
- Maintenance Plan for Infiltration Trench
- Maintenance Plan for Extended Detention Basin
- Maintenance Plan for Media Filter
- Maintenance Plan for Rainwater Harvesting

Requirements vary from one municipality to the next. Contact the local jurisdiction to obtain electronic files for use in preparing these documents, and to obtain information on municipality-specific requirements.

# Stormwater Treatment Measure Operation and Maintenance Inspection Report to the [[== Insert Name of Municipality==]], California

This report and attached Inspection and Maintenance Checklists document the inspection and maintenance conducted for the identified stormwater treatment measure(s) subject to the Maintenance Agreement between the City and the property owner during the annual reporting period indicated below.

## I. Property Information:

Property Address or APN: ____________________________________________________

Property Owner: _________________________________________________________

## II. Contact Information:

Name of person to contact regarding this report:_________________________________

Phone number of contact person:________________ Email:________________________

Address to which correspondence regarding this report should be directed:

_____________________________________________________________________

_____________________________________________________________________

## III. Reporting Period:

This report, with the attached completed inspection checklists, documents the inspections and maintenance of the identified treatment measures during the time period from ______ ______ to __________.

## IV. Stormwater Treatment Measure Information:

The following stormwater treatment measures (identified treatment measures) are located on the property identified above and are subject to the Maintenance Agreement:

| Identifying Number of Treatment Measure | Type of Treatment Measure | Location of Treatment Measure on the Property |
|---|---|---|
| | | |
| | | |
| | | |

## V. Summary of Inspections and Maintenance:

Summarize the following information using the attached Inspection and Maintenance Checklists:

| Identifying Number of Treatment Measure | Date of Inspection | Operation and Maintenance Activities Performed and Date(s) Conducted | Additional Comments |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## VI. Sediment Removal:

Total amount of accumulated sediment removed from the stormwater treatment measure(s) during the reporting period: __________ cubic yards.

How was sediment disposed?

- ☐ landfill
- ☐ other location on-site as described in and allowed by the maintenance plan
- ☐ other, explain ____________________

## VII. Inspector Information:

The inspections documented in the attached Inspection and Maintenance Checklists were conducted by the following inspector(s):

| Inspector Name and Title | Inspector’s Employer and Address |
|---|---|
| | |
| | |

## VIII. Certification:

I hereby certify, under penalty of perjury, that the information presented in this report and attachments is true and complete:

______________________________________________ ____________________
Signature of Property Owner or Other Responsible Party Date

______________________________________________
Type or Print Name

______________________________________________
Company Name

__________________________________________________________________
Address

Phone number:____________________ Email:________________________________

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

[[== Insert Date =]]

*Bioretention areas function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants.*

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 and trash from bioretention area and dispose of properly. | Monthly, or as needed after storm events |
| 2 | Inspect bioretention area to ensure that it drains between storms and within five days after rainfall. | Monthly, or as needed after storm events |
| 3 | Inspect inlets for channels, soil exposure or other evidence of erosion. Clear obstructions and remove sediment. | Monthly, or as needed after storm events |
| 4 | Remove and replace all dead and diseased vegetation. | Twice a year |
| 5 | Maintain vegetation and the irrigation system. Prune and weed to keep bioretention area neat and orderly in appearance. | Before wet season begins, or as needed |

[1] Bioretention areas include linear treatment measures designed to filter water through biotreatment soils. A bioretention area that has no waterproof liner beneath it 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".
[2] Attached site plan must match the site plan exhibit to Maintenance Agreement.

| Table 1<br>Routine Maintenance Activities for Bioretention Areas | | |
|---|---|---|
| 6 | Check that mulch is at appropriate depth (3 inches per soil specifications) and replenish as necessary before wet season begins. | Monthly |
| 7 | Inspect bioretention area using the attached inspection checklist. | Monthly, or after large storm events, and after removal of accumulated debris or material |

## II. Prohibitions

The use of pesticides and quick release fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed:

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 preferable. Check with municipality for specific requirements.
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 five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Bioretention Area Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

## Bioretention Area
## Inspection and Maintenance Checklist

Property Address: ____________________________________________ Property Owner: ____________________________

Treatment Measure No.: __________ Date of Inspection: _________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season
☐ After heavy runoff ☐ End of Wet Season
Inspector(s): ______________________________ ☐ 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 bioretention area between storms and does not drain within five days 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 bioretention area, or added underdrains. |
| 2. Trash and 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 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. | | | Vegetation is healthy and attractive in appearance. |
| 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. | | | 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. Miscellaneous | Any condition not covered above that needs attention in order for the bioretention area to function as designed. | | | Meet the design specifications. |

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

[[== Insert Date =]]

*Flow-through planters are designed to treat and temporarily detain runoff without allowing seepage into the underlying soil. They typically receive runoff via downspouts leading from the roofs of adjacent buildings.*

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:

- **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 | Evaluate health of trees and groundcover. Remove and replace all dead and diseased vegetation. Treat vegetation using preventative and low-toxic methods. | Twice a year |
| 2 | Maintain vegetation and the irrigation system. Prune and weed to keep flow-through planter neat and orderly in appearance. | As needed |
| 3 | Check that mulch is at appropriate depth (3 inches per soil specifications) and replenish as necessary. | Monthly |
| 4 | Check that soil is at appropriate depth. Till or replace soil as necessary to maintain a minimum of 6 inches between top of mulch and overflow weir. | Before wet season and as necessary |
| 5 | Remove accumulated sediment, litter and debris from flow-through planter and dispose of properly. Confirm that no clogging will occur and that the box will drain within three to four hours. | Before wet season and as necessary |
| 6 | Inspect flow-through planter to ensure that there are no clogs. Test with garden hose to confirm that the planter will drain within three to four hours. | Monthly during the wet season, and as needed after storm events |

| Table 1<br>Routine Maintenance Activities for Flow-Through Planters | | |
|---|---|---|
| 7 | Inspect downspouts from rooftops and sheet flow from paved areas to ensure flow to planter box is unimpeded. Remove debris and repair damaged pipes. Check splash blocks or rocks and repair, replace and replenish as necessary. | Monthly during the wet season, and as needed after storm events |
| 8 | Inspect overflow pipe to ensure that it will safely convey excess flows to storm drain. Repair or replace any damaged or disconnected piping. | Before the wet season, and as necessary |
| 9 | Inspect flow-through planter to ensure that box is structurally sound (no cracks or leaks). Repair as necessary. | Annually |
| 10 | Inspect flow-through planter using the attached inspection checklist. | Monthly, or after large storm events, and after removal of accumulated debris or material |

## II. Prohibitions

The use of pesticides and quick release fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed:

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 preferable. Check with municipality for specific requirements.
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 five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Flow-Through Planter Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

## Flow-Through Planter
## Inspection and Maintenance Checklist

Property Address: ____________________________________________________ Property Owner: _________________________________

Treatment Measure No.: ____________ Date of Inspection: ___________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:__________________

Inspector(s): ____________________________________

| **Defect** | **Conditions When Maintenance Is Needed** | **Maintenance Needed? (Y/N)** | **Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done) | **Results Expected When Maintenance Is Performed** |
|---|---|---|---|---|
| 1. Vegetation | Vegetation is dead, diseased and/or overgrown. | | | Vegetation is healthy and attractive in appearance. |
| 2. Soil | Soil too deep or too shallow. | | | Soil is at proper depth (per soil specifications) for optimum filtration and flow. |
| 3. Mulch | Mulch is missing or patchy in appearance. Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth. | | | 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. |
| 4. Sediment, Trash and Debris Accumulation | Sediment, trash and debris accumulated in the flow-through planter. Planter does not drain as specified. | | | Sediment, trash and debris removed from flow-through planter and disposed of properly. Planter drains within 3-4 hours. |
| 5. Clogs | Soil too deep or too shallow. Sediment, trash and debris accumulated in the flow-through planter. Planter does not drain within five days after rainfall. | | | Planter drains per design specifications. |
| 6. Downspouts and Sheet Flow | Flow to planter is impeded. Downspouts are clogged or pipes are damaged. Splash blocks and rocks in need of repair, replacement or replenishment. | | | Downspouts and sheet flow is conveyed efficiently to the planter. |
| 7. Overflow Pipe | Does not safely convey excess flows to storm drain. Piping damaged or disconnected. | | | Overflow pipe conveys excess flow to storm drain efficiently. |
| 8. Structural Soundness | Planter is cracked, leaking or falling apart. | | | Cracks and leaks are repaired and planter is structurally sound. |
| 9. Miscellaneous | Any condition not covered above that needs attention in order for the flow-through planter to function as designed. | | | Meet the design specifications. |

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

[[== Insert Date =]]

*Tree well filters consist of one or multiple chambered pre-cast concrete boxes or hoops with a small tree or shrub planted in a filter bed filled with engineered media or other absorptive filtering media.*

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:

- **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 | Evaluate health of trees and groundcover. Remove and replace all dead and diseased vegetation. Treat vegetation using preventative and low-toxic methods. | Twice a year |
| 2 | Maintain vegetation and the irrigation system. Prune and weed to keep tree well filter neat and orderly in appearance. | As needed |
| 3 | Check that planting mix is at appropriate depth and replenish as necessary. | Before wet season and as necessary |
| 4 | Check that mulch is at appropriate depth (3 inches per soil specifications) and replenish as necessary. | Monthly |
| 5 | Remove sediment, litter and debris from tree well filter. Confirm that no clogging will occur and that the filter will drain per the design specifications. Dispose of sediment, litter and debris properly. | Before wet season and as necessary |

| Table 1<br>Routine Maintenance Activities for Tree Well Filters | | |
|---|---|---|
| 6 | Inspect Tree Well Filter to ensure that it drains between storms and within five days after rainfall. | Periodically or as needed after storm events |
| 7 | Inspect overflow pipe to ensure that it will safely convey excess flows to storm drain. Repair or replace any damaged or disconnected piping. | As necessary |
| 8 | Inspect tree well filter using the attached inspection checklist. | Monthly, or after large storm events, and after removal of accumulated debris or material |

## II. Prohibitions

The use of pesticides and quick release fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed:

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 preferable. Check with municipality for specific requirements.
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 five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592, FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Tree Well Filter Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

# Tree Well Filter
# Inspection and Maintenance Checklist

Property Address: ______________________________________________ Property Owner: _____________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________

Inspector(s): ________________________________

| **Defect** | **Conditions When Maintenance Is Needed** | **Maintenance Needed? (Y/N)** | **Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done) | **Results Expected When Maintenance Is Performed** |
|---|---|---|---|---|
| 1. Vegetation | Vegetation is dead, diseased and/or overgrown. | | | Vegetation is healthy and attractive in appearance. |
| 2. Planting Mix | Planting mix too deep or too shallow. | | | Planting mix is at proper depth for optimum filtration and flow. |
| 3. Mulch | Mulch is missing or patchy in appearance. Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth. | | | 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. |
| 4. Trash and Debris Accumulation | Trash and debris accumulated in the tree well filter. Filter does not drain as specified. | | | Trash and debris removed from tree well filter and disposed of properly. Filter drains per design specifications. |
| 5. Sediment | Evidence of sedimentation in tree well filter. | | | Material removed so that there is no clogging or blockage. Sediment is disposed of properly. |
| 6. Standing Water | When water stands in the tree well filter between storms and does not drain within five days 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, overflow pipe repaired. |
| 7. Overflow Pipe | Does not safely convey excess flows to storm drain. Piping damaged or disconnected. | | | Overflow pipe conveys excess flow to storm drain efficiently. |
| 8. Miscellaneous | Any condition not covered above that needs attention in order for the tree well filter to function as designed. | | | Meet the design specifications. |

# Vegetated Buffer Strip Maintenance Plan for
# [[== Insert Project Name ==]]

[[== Insert Date =]]

*Vegetated Buffer Strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. They function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils.*

Project Address and Cross Streets________________________________________________

_________________________________________________________________________

Assessor's Parcel No.: ______________________________________________________

Property Owner: ___________________________Phone No.:__________________________

Designated Contact: _____________________________Phone No.:_____________________

Mailing Address:____________________________________________________________

_________________________________________________________________________

The property contains [[== insert number ==]] vegetated buffer strip(s), located as described below and as shown in the attached site plan:

- **Vegetated Buffer Strip No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other buffer strips, if applicable. ==]]

## I. Routine Maintenance Activities

The principal maintenance objective for vegetated buffer strips is to achieve the pollutant removal efficiency of the buffer strip, as designed, by maintaining a dense, healthy vegetated cover. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

**Table 1**
**Routine Maintenance Activities for Vegetated Buffer Strips**

| No. | Maintenance Task | Frequency of Task |
|---|---|---|
| 1 | Mow turf grass to [[==indicate height ==]]. Remove grass cuttings. Avoid producing ruts when mowing. | [[== insert frequency ==]] |
| 2 | Irrigate during dry weather. | [[== insert frequency to maintain design height ==]] |
| 3 | Remove obstructions and trash from vegetated buffer strip and dispose of properly. | Monthly, or as needed |
| 4 | Inspect buffer strip to check for erosion and sediment and debris accumulation. Dispose of sediment and debris properly. | Twice a year: 1) one inspection at the end of the wet season in order to plan and schedule summer |

**Table 1**
**Routine Maintenance Activities for Vegetated Buffer Strips**

| | | |
|---|---|---|
| 4 (cont.) | | maintenance, 2) the other inspection after periods of heavy runoff |
| 5 | Remove sediment accumulating near culverts and in channels when it builds up to 75 millimeters (3 inches) at any spot, or if it covers vegetation. Dispose of sediment properly. | As needed |
| 6 | Inspect buffer strip using the attached inspection checklist. | Monthly, or as needed |

## II. Prohibitions

The use of pesticides and quick release fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed:

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 preferable. Check with municipality for specific requirements.
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 five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame, CA 94010
PH:(650) 344-8592 FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Vegetated Buffer Strip Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

**Vegetated Buffer Strip**
**Inspection and Maintenance Checklist**

Property Address: ______________________________________________ Property Owner: ____________________________

Treatment Measure No.: ___________ Date of Inspection: _________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season
☐ After heavy runoff ☐ End of Wet Season
Inspector(s): _________________________________ ☐ 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 Accumulation on Vegetation | Sediment accumulating near culverts and/or in channels builds up to 75 millimeters (3 inches) at any spot, or it covers vegetation | | | Remove accumulated sediment deposits. When finished, buffer strip should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased. Dispose of sediment properly. |
| 2. Standing Water | Water stands in the buffer strip between storms and does not drain within five days 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 buffer strip, removed clogged check dams, added underdrains or converted to a wet buffer strip. |
| 3. Flow spreader (if any) | Flow spreader uneven or clogged such that flows are not uniformly distributed through entire buffer strip width. | | | Spreader leveled and cleaned so that flows are spread evenly over entire buffer strip width. |
| 4. Constant Baseflow | When small quantities of water continually flow through the buffer strip, even when it has been dry for weeks, and an eroded, muddy channel has formed in the buffer strip bottom. | | | No eroded, muddy channel on the bottom. A low-flow pea-gravel drain may be added the length of the buffer strip. |
| 5. Poor Vegetation Coverage | When planted vegetation is sparse or bare or eroded, patches occur in more than 10% of the buffer strip bottom. | | | Vegetation coverage in more than 90% of the buffer strip bottom. Determine why growth of planted vegetation is poor and correct that condition. Replant with plugs of vegetation from the upper slope: plant in the buffer strip bottom at 8-inch intervals, or reseed into loosened, fertile soil. |

| **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** |
|---|---|---|---|---|
| 6. Vegetation | When the planted vegetation becomes excessively tall; when nuisance weeds and other vegetation start to take over. | | | Vegetation mowed per specifications or maintenance plan, or nuisance vegetation removed so that flow is not impeded. Vegetation should never be mowed lower than the design flow depth. Remove clippings from the buffer strip and dispose appropriately. |
| 7. Excessive Shading | Growth of planted vegetation is poor because sunlight does not reach buffer strip. | | | Healthy growth of planted vegetation. If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes. |
| 8. Inlet/Outlet | Inlet/outlet areas clogged with sediment and/or debris. | | | Material removed so that there is no clogging or blockage in the inlet and outlet areas. |
| 9. Trash and Debris Accumulation | Trash and debris accumulated in the buffer strip. | | | Trash and debris removed from buffer strip. Dispose of trash and debris properly. |
| 10. Erosion/ Scouring | Eroded or scoured buffer strip bottom due to flow channelization, or higher flows. | | | No erosion or scouring in buffer strip bottom. For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the buffer strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the buffer strip bottom at 8-inch intervals. |
| 11. Miscellaneous | Any condition not covered above that needs attention in order for the vegetated buffer strip to function as designed. | | | Meet the design specifications. |

# Infiltration Trench Maintenance Plan for
# [[== Insert Project Name ==]]

[[== Insert Date =]]

*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.*

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 5 days 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 five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## 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: ___________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season
☐ After heavy runoff ☐ End of Wet Season
Inspector(s): __________________________________ ☐ 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 5 days 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 =]]

*Extended detention ponds are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle.*

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 |

| **Table 1<br>Routine Maintenance Activities for Extended Detention Basins** | | |
|---|---|---|
| 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 shall be minimized, and the principles of integrated pest management (IPM) followed:

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 preferable. Check with municipality for specific requirements.
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.
11. Maintenance activities at the bottom of the extended detention basin shall not be performed with heavy equipment, which would compact the soil and limit infiltration.

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843

Email: info@smcmad.org

## 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: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:_________________

Inspector(s): _______________________________

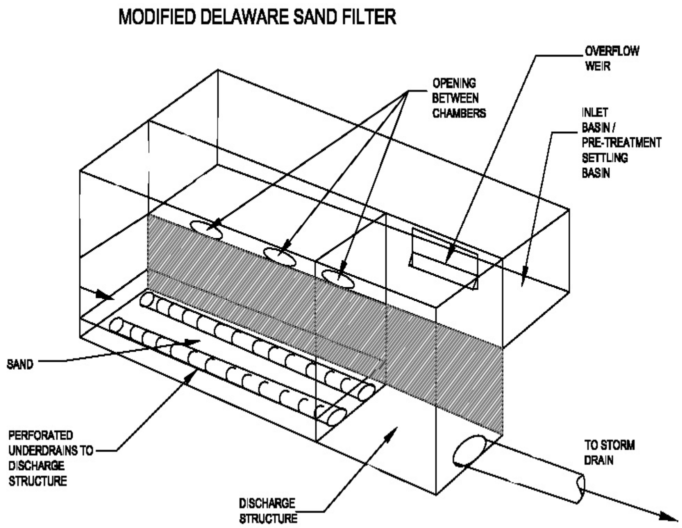
| Defect | Conditions When Maintenance Is Needed | Maintenance Needed? (Y/N) | Comments (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.) | Results Expected When Maintenance Is Performed |
|---|---|---|---|---|
| **General** | | | | |
| Trash & Debris | • Trash and debris accumulated in basin.<br>• 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.<br>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. |

| Defect | Conditions When Maintenance Is Needed | Maintenance Needed? (Y/N) | Comments (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.) | Results Expected When Maintenance Is Performed |
|---|---|---|---|---|
| Tree/Brush Growth and Hazard Trees | • Growth does not allow maintenance access or interferes with maintenance activity.<br>• Dead, diseased, or dying trees. | | | • Trees do not hinder maintenance activities.<br>• Remove hazard trees as approved by the City. (Use a certified Arborist to determine health of tree or removal requirements). |
| Drainage time | Standing water remains in basin more than five days. | | | Correct any circumstances that restrict the flow of water from the system. Restore drainage to design condition. If the problem cannot be corrected and problems with standing water recur, then mosquitoes should be controlled with larvicides, applied by a licensed pesticide applicator. |
| Outfall structure | Debris or silt build-up obstructs an outfall structure. | | | Remove debris and/or silt build-up 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.<br>• 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. |

| Defect | Conditions When Maintenance Is Needed | Maintenance Needed? (Y/N) | Comments (Describe maintenance completed and if any needed maintenance was not conducted, note when it will be done.) | Results Expected When Maintenance Is Performed |
|---|---|---|---|---|
| Tree Growth | Tree growth on berms or emergency spillway >4 ft in height or covering more than 10% of spillway. | | | • Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored.<br>• A civil engineer should be consulted for proper berm/spillway restoration. |
| Emergency Overflow/ Spillway | Rock is missing and soil is exposed at top of spillway or outside slope. | | | Rocks and pad depth are restored to design standards. |
| **Debris Barriers (e.g., Trash Racks)** | | | | |
| Trash and Debris | Trash or debris is plugging openings in the barrier. | | | Trash or debris is removed 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** | | | | |
| Miscellan-ous | Any condition not covered above that needs attention to restore extended detention basin to design conditions. | | | Meets the design specifications. |

**Non-Proprietary Media Filter Maintenance Plan for**
**[[== Insert Project Name ==]]**

[[== Insert Date =]]




*Non-proprietary media filters are usually two-chambered, including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber.*

Project Address and Cross Streets______________________________________________

__________________________________________________________________________

Assessor's Parcel No.: _____________________________________________________

Property Owner: ___________________________________________________________

Phone No.:_______________________

Designated Contact: _______________________________________________________

Phone No.:_______________________

Mailing Address:_____________________________________________________________

__________________________________________________________________________

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

- **Non-Proprietary Media Filter No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other non-proprietary 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 Non-Proprietary Media Filter failure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

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

| Table 1<br>Routine Maintenance Activities for Non-Proprietary 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 non-proprietary media filter drains completely within five days. | After major storm events and as needed. |
| 4 | For non-proprietary media filters with a filter bed, inspect media depth to ensure proper drainage. | Monthly during rainy season, or as needed after storm events |
| 5 | Inspect non-proprietary 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 non-proprietary media filter to prevent damage.

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Non-Proprietary 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.

# Non-Proprietary Media Filter
# Inspection and Maintenance Checklist

Property Address: ________________________________________________ Property Owner: ______________________________

Treatment Measure No.: ___________ Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season
☐ After heavy runoff ☐ End of Wet Season
Inspector(s): _________________________________ ☐ 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 | Non-proprietary media filter does not drain within five days after rainfall. | | | Clogs removed from sedimentation basin, riser pipe and filter bed. Filter drains per design specifications. |
| 3. Mosquitoes | Evidence of mosquito larvae in non-proprietary 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 non-proprietary media filter to function as designed. | | | Meet the design specifications. |

## Manufactured Stormwater Treatment Measure Maintenance Plan for [[== Insert Project Name ==]]

[[== Insert Date =]]

Manufactured Stormwater Treatment Measures are **PROPRIETARY** treatment devices that tend to be installed below ground and operate using some type of proprietary filter media, hydrodynamic separation, or sedimentation and screening. Common examples of manufactured treatment measures include manufactured media filters, inlet filters or drain inserts, oil/water separators and hydrodynamic separators. In August 2004, the Regional Water Board's Executive Office wrote a letter stating that a project relying on inlet filters or oil/water separators as the sole treatment measure would be unlikely to meet the maximum extent practicable standard of the National Polutant Discharge Elimination System Permit. See the Countywide C.3 Technical Guidance (www.flowstobay.org) for more information.

Project Address:_______________________________________________________________

Assessor's Parcel No.: ____________________________________________________

Property Owner: ___________________________ Phone No.:____________________

Designated Contact: ________________________ Phone No.:____________________

Mailing Address:________________________________________________________________

The property contains [[== insert number ==]], [[==insert device type/manufacturer==]] located as described below and as shown in the attached site plan[1].

- [[==device name ==]] is located at [[== describe location ==]].
- [[== Add descriptions of other products, 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 failure of the manufactured treatment measure. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

**Table 1**
**Routine Maintenance Activities for Manufactured Treatment Measures**

| 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, using vactor truck method. Dispose of sediment, trash, filters and debris properly. | As needed |
| 3 | Ensure that manufactured treatment measure drains completely within five days. | After major storm events and as needed. |
| 4 | Inspect outlets to ensure proper drainage. | Monthly during rainy season, or as needed after storm events |
| 5 | Follow manufacturer's guidelines for maintenance and cartridge replacement. | As per manufacturer's specifications. |
| 6 | Inspect manufactured treatment measure, using the attached inspection checklist. | Monthly, or after large storm events, and after removal of accumulated debris or material |

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

## II. Prohibitions

Trees and other large vegetation shall be prevented from growing adjacent to the manufactured treatment measure to prevent damage.

Standing water shall not remain in the treatment measures for more than five days, to prevent mosquito generation. Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Treatment Measure Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

## Manufactured Stormwater Treatment Measure
## Inspection and Maintenance Checklist

Property Owner: ________________________________________ Property Address: ______________________

Date of Inspection: __________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season

System Type: _________________________

Installer/Contractor:_______________________

Manufacturer: _________________________ Inspector(s): ____________________

| **Defect** | **Conditions When Maintenance Is Needed** | **Maintenance Needed? (Y/N)** | **Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done) | **Results Expected When Maintenance Is Performed** |
|---|---|---|---|---|
| 1. Sediment, trash and debris accumulation on Filter | Sediment, trash and debris accumulated in the sedimentation basin, riser pipe, retention pipes 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. Empty cartridge should be reassembled and reinstalled. |
| 2. Standing water | Manufactured treatment measure does not drain within five days after rainfall. | | | Clogs removed from filters, sedimentation basin, riser pipe and filter bed. Filter drains per design specifications. |
| 3. Mosquitoes | Evidence of mosquito larvae in manufactured treatment measure. | | | Clogs removed from sedimentation basin, riser pipe and filter bed. Filter drains per design specifications. |
| 4. Miscellaneous | Any condition not covered above that needs attention in order for the manufactured treatment measure to function as designed. | | | Meet the design specifications. |

**Rainwater Harvesting Systems 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 ==]] pervious paving area(s), located as described below and as shown in the attached site plan[1].

- **Rainwater Harvesting System No. 1** is located at [[== describe location ==]].
- [[== Add descriptions of other rainwater harvesting systems, if applicable. ==]]

## I. Routine Maintenance Activities

The principal maintenance objective is to prevent sediment buildup and clogging, which reduce rainwater harvesting capacity. Routine maintenance activities, and the frequency at which they will be conducted, are shown in Table 1.

**Table 1**
**Routine Maintenance Activities for Rainwater Harvesting Systems**

| No. | Maintenance Task | Frequency of Task |
|---|---|---|
| 1 | Inspect and clean filters and screens, and replace as needed. | Every 3-6 months |
| 2 | Inspect and clean debris from gutters, downspouts, first-flush devices and roof washers. | Every 3-6 months |
| 3 | Inspect and clean debris from roof or other collection surfaces. | Every 3-6 months |
| 4 | Inspect for and repair leaks. | Every 3-6 months |
| 5 | If rainwater is provided for indoor use, inspect and verify that treatment systems are operational and maintaining minimum water quality requirements as determined by local health officials. | Every 3-6 months |
| 6 | Inspect all components, including backflow prevention systems. | Annually |
| 7 | Inspect and clear debris from cisterns and verify operation. | Annually |
| 8 | Flush or vacuum cisterns to remove sediment as needed | Annually |
| 9 | Maintenance requirements specific to rain barrels:<br>• Inspect rain barrels twice per year and after major storms.<br>• Inspect screens and remove debris.<br>• Inspect spigots, downspouts, and rain leaders, and clean or replace as needed | Twice per year and as needed |
| 10 | Inspect rainwater harvesting systems using the attached inspection checklist. | Quarterly or as needed |

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

## II. Prohibitions

Should any mosquito issues arise, contact the San Mateo County Mosquito Abatement District (SMCMAD), as needed for assistance. Mosquito larvicides shall be applied only when absolutely necessary, as indicated by the SMCMAD, and then only by a licensed professional or contractor. Contact information for SMCMAD is provided below.

## III. Mosquito Abatement Contact Information

San Mateo County Mosquito Abatement District
1351 Rollins Road
Burlingame,CA 94010
PH:(650) 344-8592
FAX: (650) 344-3843
Email: info@smcmad.org

## IV. Inspections

The attached Treatment Measure Inspection and Maintenance Checklist shall be used to conduct inspections monthly (or as needed), identify needed maintenance, and record maintenance that is conducted.

## Rainwater Harvesting Systems
## Inspection and Maintenance Checklist

Property Address: ______________________________________________ Property Owner: _____________________________

Treatment Measure No.: ___________ Date of Inspection: _________ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ After heavy runoff ☐ End of Wet Season ☐ Other:________________

Inspector(s): ________________________________

| **Defect** | **Conditions When Maintenance Is Needed** | **Maintenance Needed? (Y/N)** | **Comments** (Describe maintenance completed and if needed maintenance was not conducted, note when it will be done) | **Results Expected When Maintenance Is Performed** |
|---|---|---|---|---|
| 1. Sediment and Debris Accumulation | Sediment or debris accumulated in filters, screens, gutters, downspouts, first-flush devices, or roof washers, or on roof or other collection surfaces. Sediment accumulated in cistern(s). | | | Sediment and debris removed and disposed of properly. Collection surfaces do not contribute sediment and debris. |
| 2. Leaks | Water leaking from system. | | | No leakage. |
| 3. Water Quality | Treatment system is not working properly. | | | Treatment system is operational and maintaining minimum water quality requirements. |
| 4. Miscellaneous | Any condition not covered above that needs attention in order for the rainwater harvesting system to function as designed. | | | Meets the design specifications. |

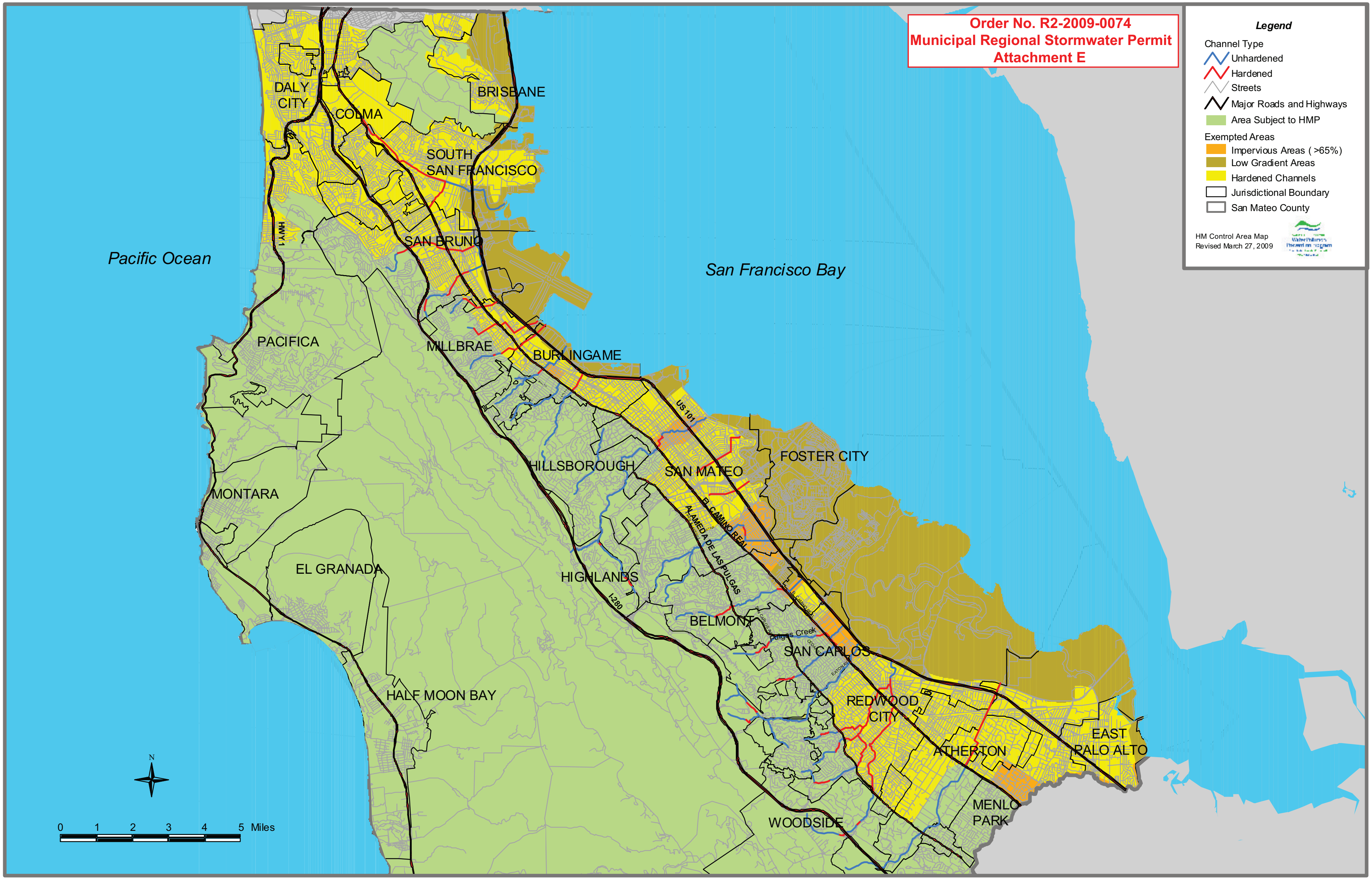
Appendix

# H

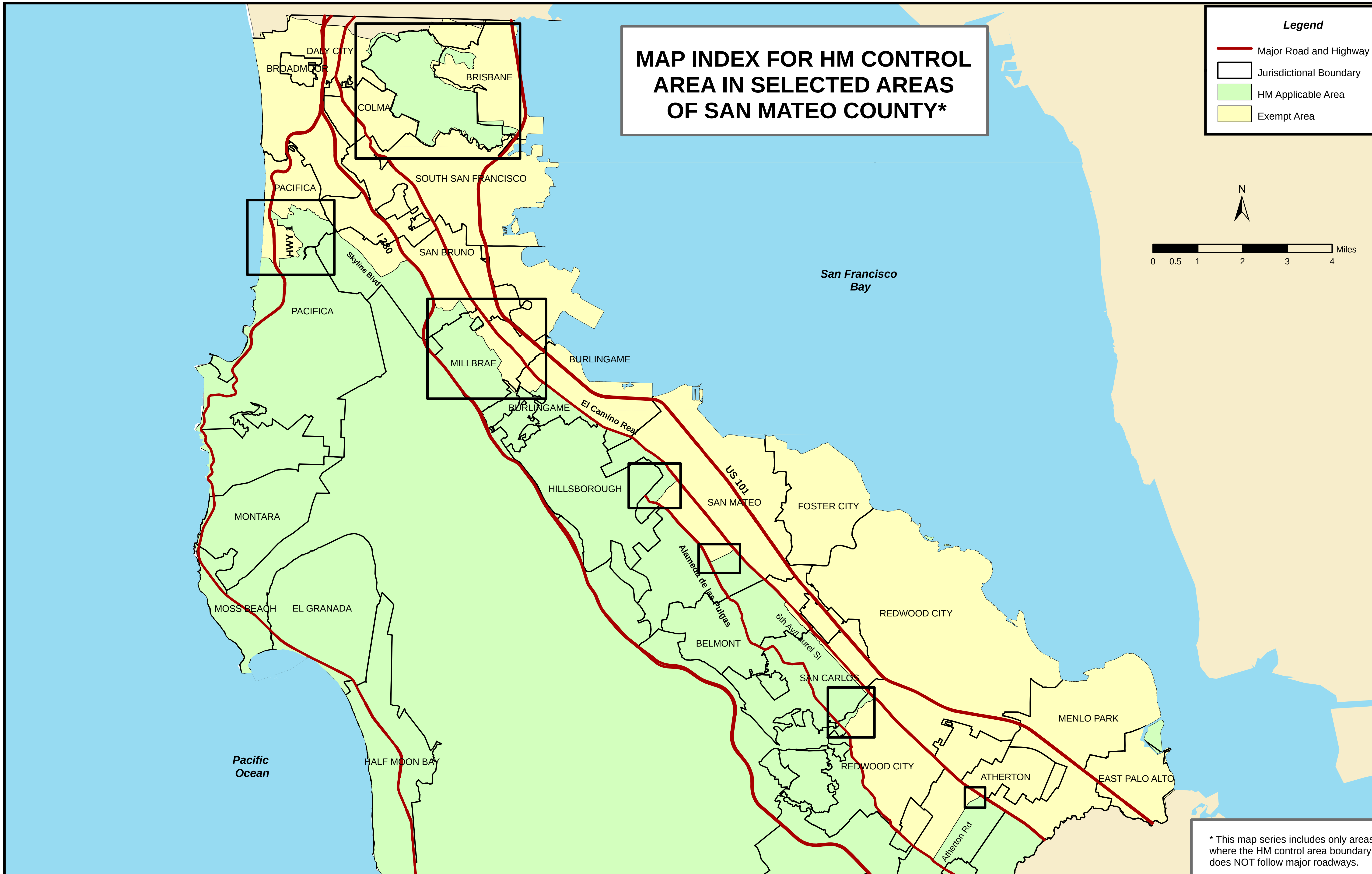
# Areas Subject to Hydromodification Management Requirements

This appendix presents the countywide Hydromodification Management (HM) Control Area Map, which identifies the geographical areas that are subject to hydromodification management (HM) requirements. The full countywide HM Control Area Map is followed by a series of maps that show detailed areas of the county in which the HM control area boundary does not follow major roadways.

**Table of Contents**



Order No. R2-2009-0074
Municipal Regional Stormwater Permit
Attachment E
Legend
Channel Type
Unhardened
Hardened
Streets
Major Roads and Highways
Area Subject to HMP
Exempted Areas
Impervious Areas ( >65%)
Low Gradient Areas
Hardened Channels
Jurisdictional Boundary
San Mateo County
HM Control Area Map
Revised March 27, 2009
Pacific Ocean
San Francisco Bay
DALY CITY
COLMA
BRISBANE
SOUTH SAN FRANCISCO
SAN BRUNO
PACIFICA
MILLBRAE
BURLINGAME
HILLSBOROUGH
SAN MATEO
FOSTER CITY
MONTARA
EL GRANADA
HIGHLANDS
BELMONT
SAN CARLOS
HALF MOON BAY
REDWOOD CITY
ATHERTON
EAST PALO ALTO
MENLO PARK
WOODSIDE
HWY 1
US 101
I-280
EL CAMINO REAL
ALAMEDA DE LAS PULGAS
N
0 1 2 3 4 5 Miles

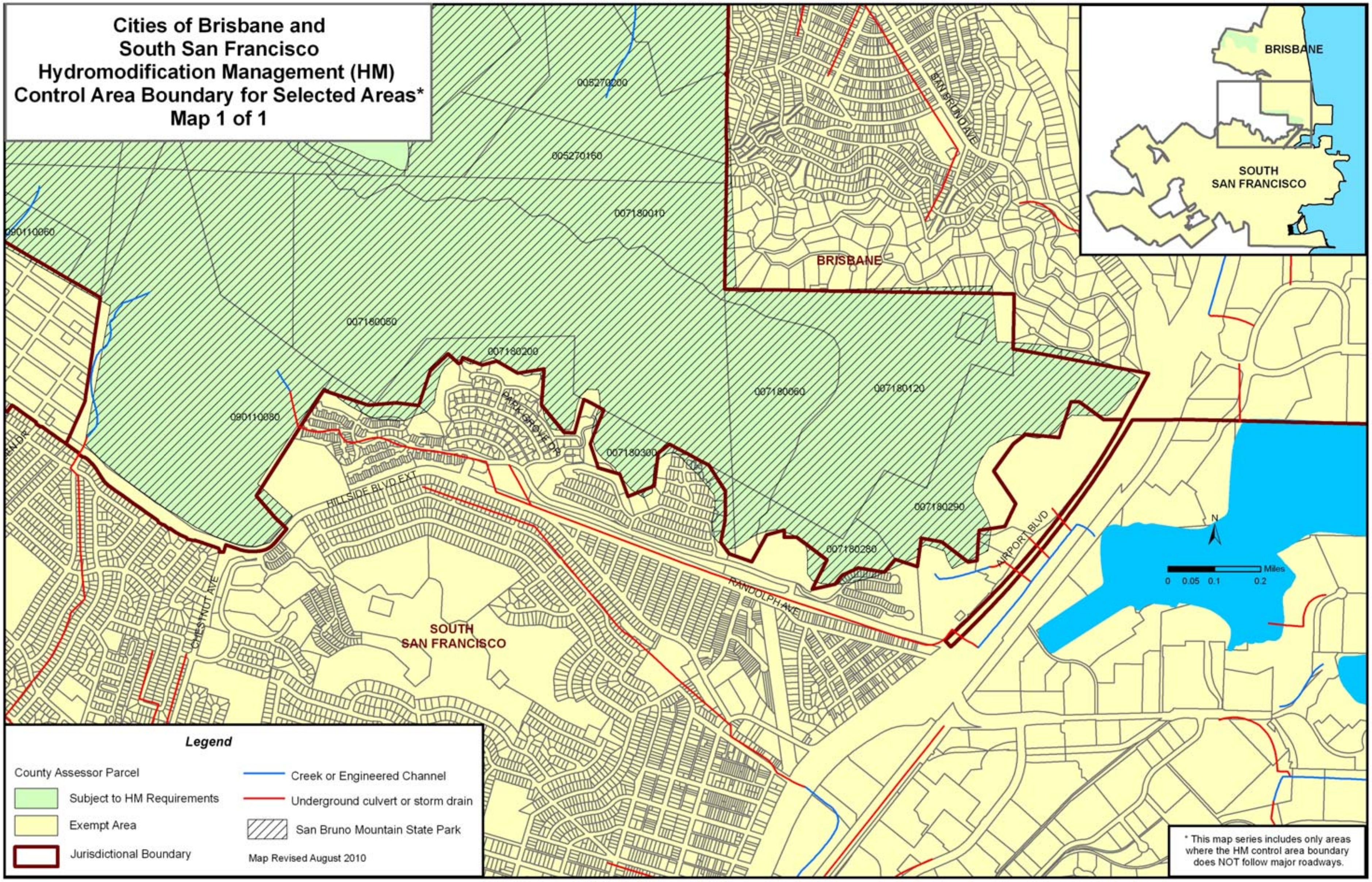


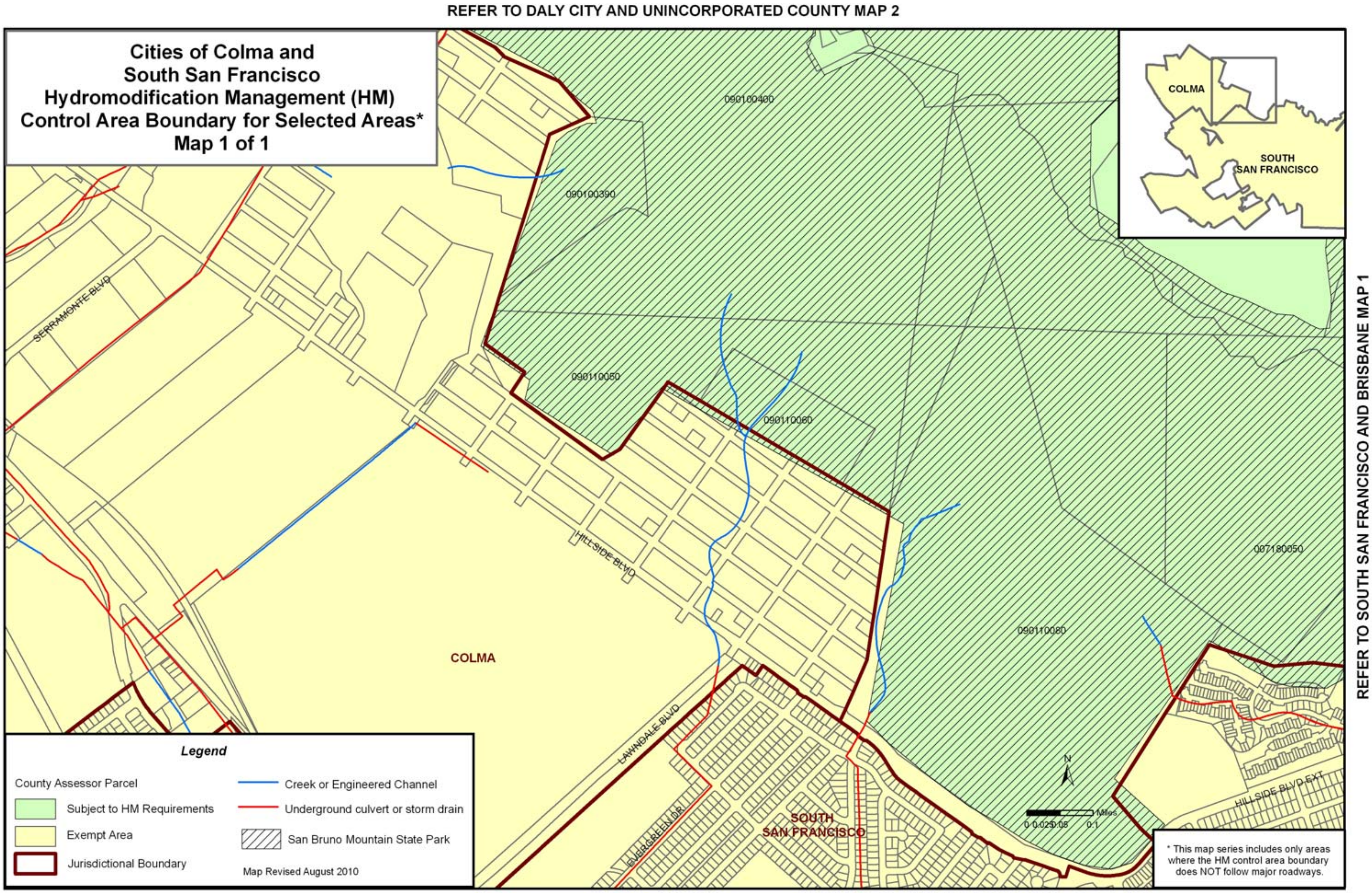
MAP INDEX FOR HM CONTROL AREA IN SELECTED AREAS OF SAN MATEO COUNTY*
Legend
Major Road and Highway
Jurisdictional Boundary
HM Applicable Area
Exempt Area
N
Miles
0 0.5 1 2 3 4
DALY CITY
BROADMOOR
BRISBANE
COLMA
SOUTH SAN FRANCISCO
PACIFICA
HWY 1
I 280
Skyline Blvd
SAN BRUNO
San Francisco Bay
PACIFICA
MILLBRAE
BURLINGAME
BURLINGAME
El Camino Real
US 101
HILLSBOROUGH
SAN MATEO
FOSTER CITY
MONTARA
Alameda de las Pulgas
REDWOOD CITY
MOSS BEACH
EL GRANADA
6th Av
Laurel St
BELMONT
SAN CARLOS
MENLO PARK
Pacific Ocean
HALF MOON BAY
REDWOOD CITY
ATHERTON
EAST PALO ALTO
Atherton Rd
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.

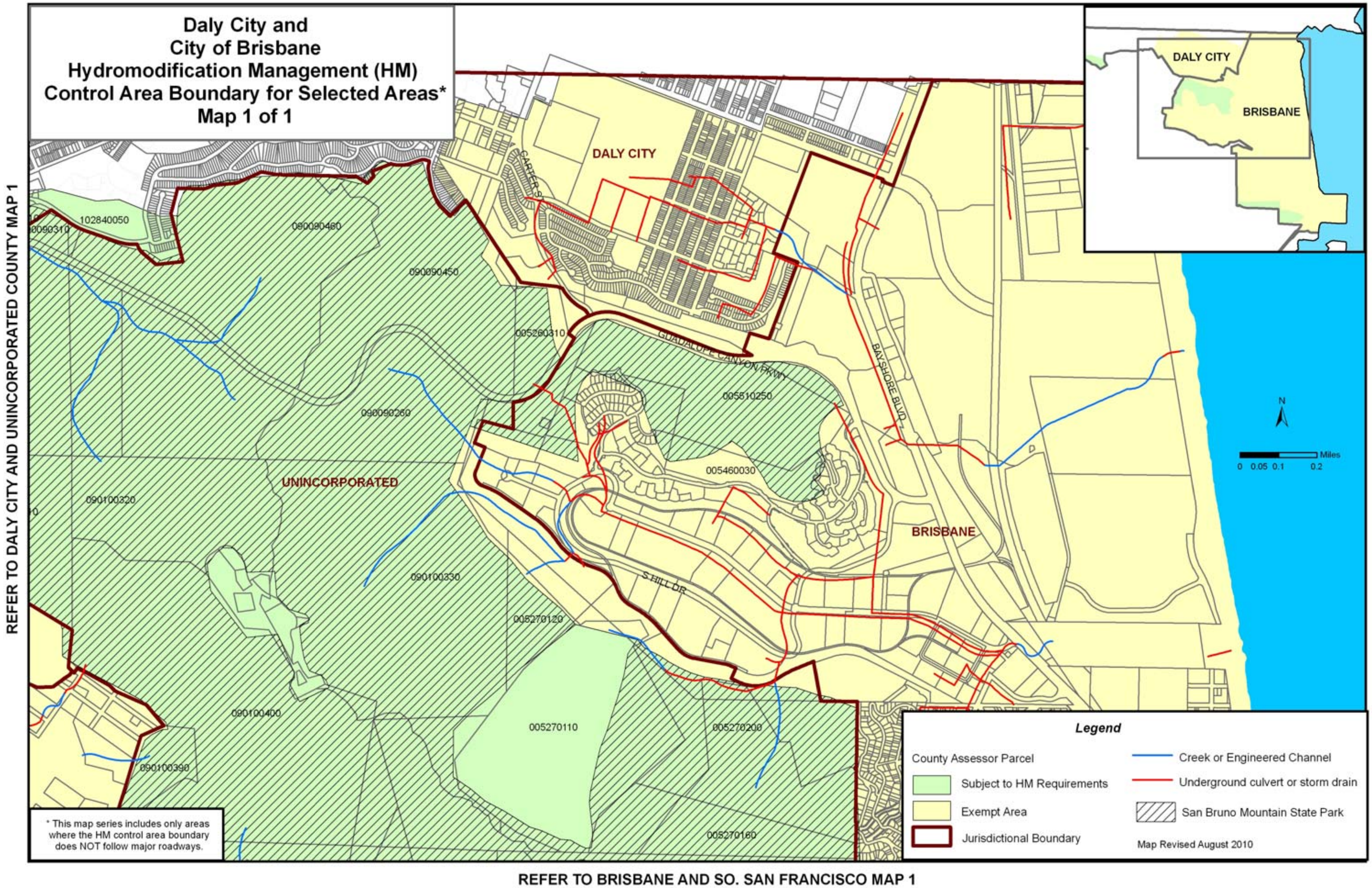

City of Atherton
Hydromodification Management (HM)
Control Area Boundary for Selected Areas *
Map 1 of 1
CITY OF ATHERTON
ATHERTON AVE
ALAMEDA DE LAS PULGAS
ASHFIELD RD
EL CAMINO REAL
MAPLE AVE
MERCEDES LN
WINCHESTER DR
ISABELLA AVE
SPENCER LN
INGLEWOOD LN
ATHERTON AVE
Atherton Channel
070222130
070222140
070222060
070222070
070222100
070230260
070230030
070230040
070230150
070230180
070230170
070230200
N
0
0.025
0.05
0.1
Miles
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.

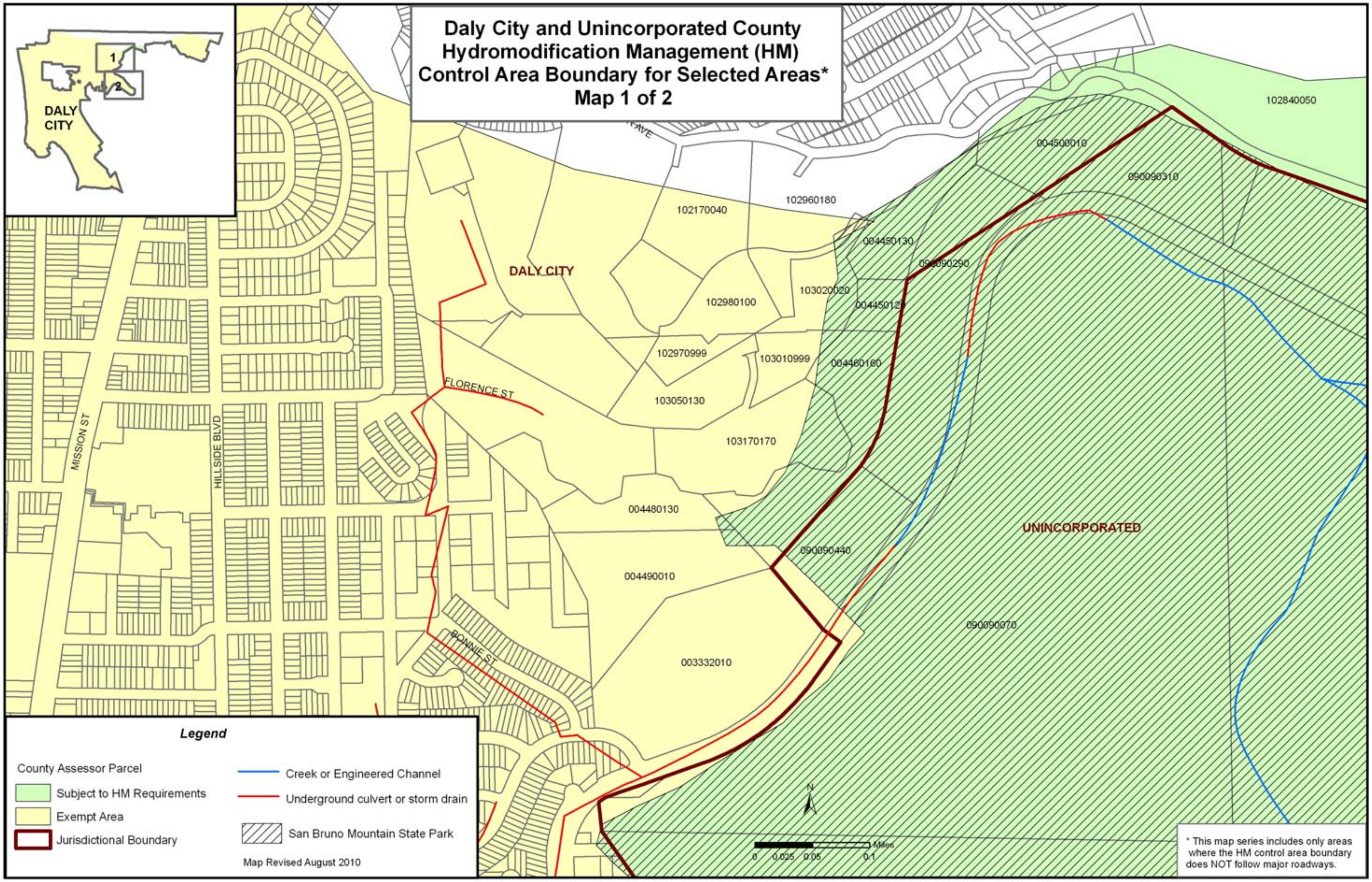
REFER TO BRISBANE AND DALY CITY MAP 1

REFER TO COLMA AND SOUTH SAN FRANCISCO MAP 1



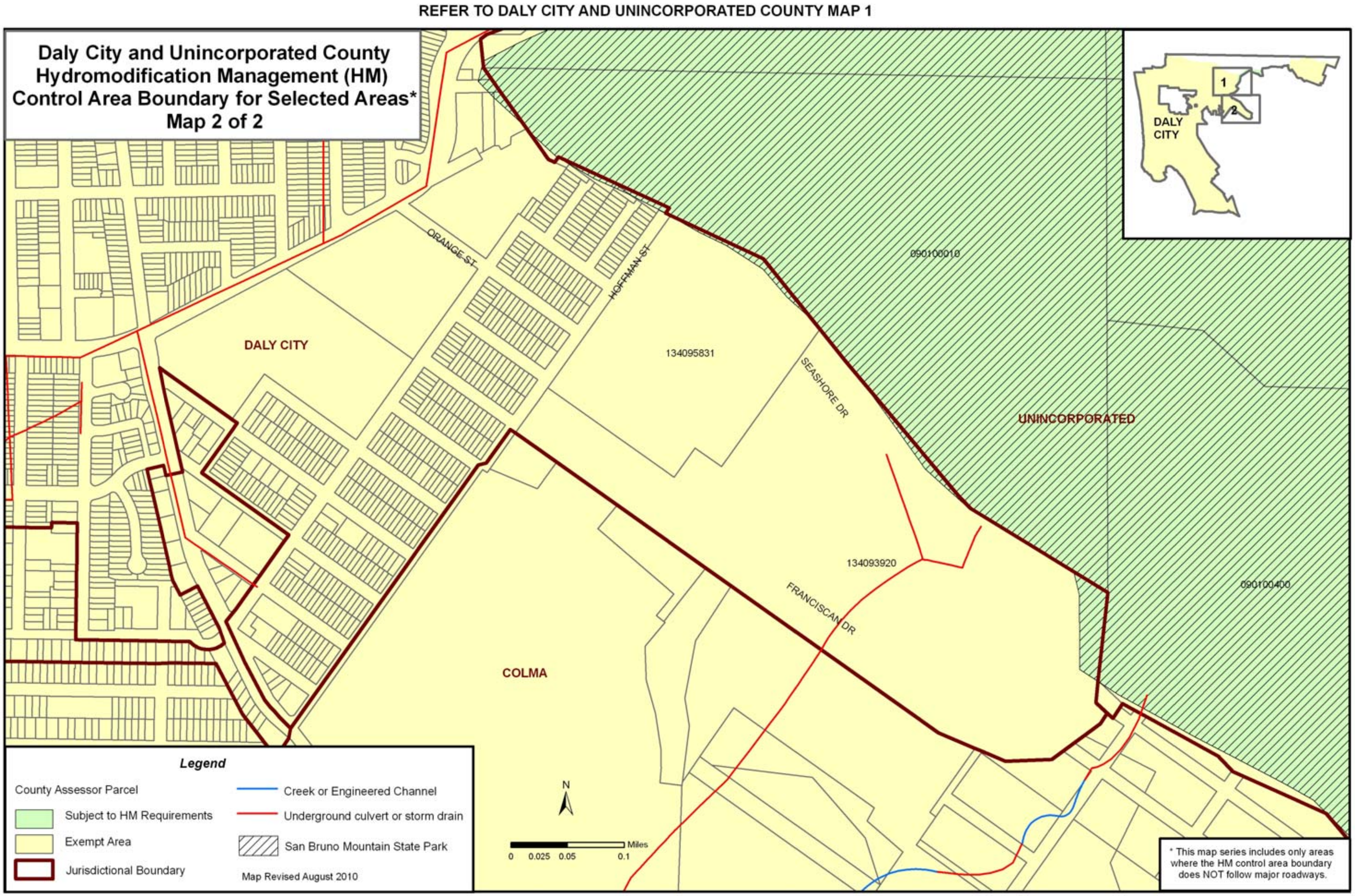

REFER TO DALY CITY AND UNINCORPORATED COUNTY MAP 2
Cities of Colma and
South San Francisco
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
COLMA
SOUTH SAN FRANCISCO
090100400
090100390
090110050
090110060
007180050
090110080
SERRAMONTE BLVD
HILLSIDE BLVD
LAWNDALE BLVD
EVERGREEN DR
HILLSIDE BLVD EXT
COLMA
SOUTH SAN FRANCISCO
N
0 0.025 0.05 0.1 Miles
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
San Bruno Mountain State Park
Map Revised August 2010
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.
REFER TO SOUTH SAN FRANCISCO AND BRISBANE MAP 1


Daly City and
City of Brisbane
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
DALY CITY
BRISBANE
UNINCORPORATED
CARTER ST
GUADALUPE CANYON PKWY
BAYSHORE BLVD
S HILL DR
102840050
090090460
090090450
005260310
090090260
005510250
005460030
090100320
090100330
005270120
090100400
005270110
005270200
090100390
005270160
N
0 0.05 0.1 0.2 Miles
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
San Bruno Mountain State Park
Map Revised August 2010
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.
REFER TO DALY CITY AND UNINCORPORATED COUNTY MAP 1
REFER TO BRISBANE AND SO. SAN FRANCISCO MAP 1

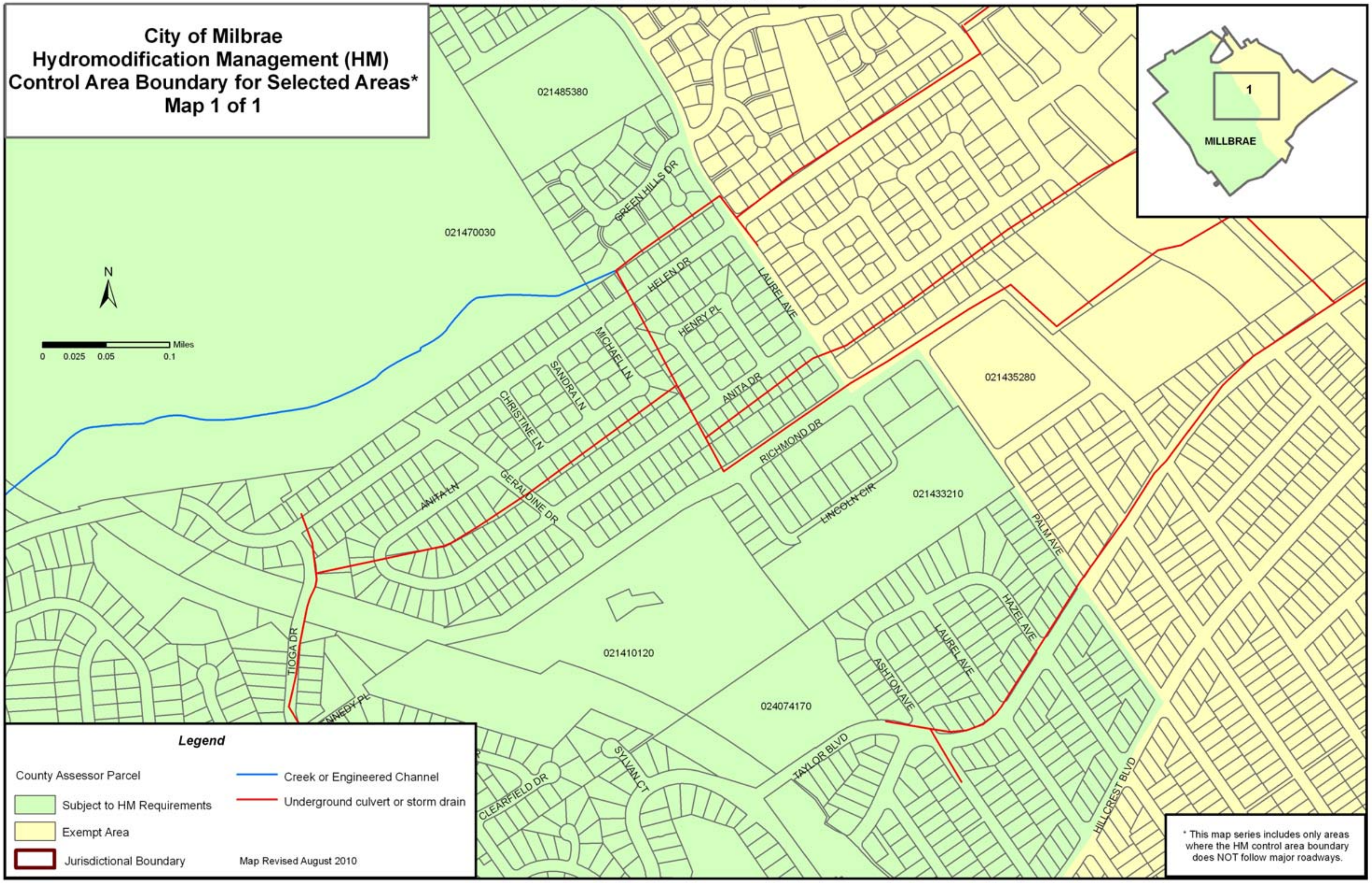



REFER TO DALY CITY AND BRISBANE MAP 1

REFER TO DALY CITY AND UNINCORPORATED COUNTY MAP 2


REFER TO DALY CITY AND UNINCORPORATED COUNTY MAP 1
Daly City and Unincorporated County
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 2 of 2
DALY CITY
CITY
1
2
ORANGE ST
HOFFMAN ST
SEASHORE DR
FRANCISCAN DR
DALY CITY
COLMA
UNINCORPORATED
090100010
134095831
134093920
090100400
REFER TO COLMA AND SOUTH SAN FRANCISCO MAP 1
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
San Bruno Mountain State Park
Map Revised August 2010
N
0 0.025 0.05 0.1 Miles
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.

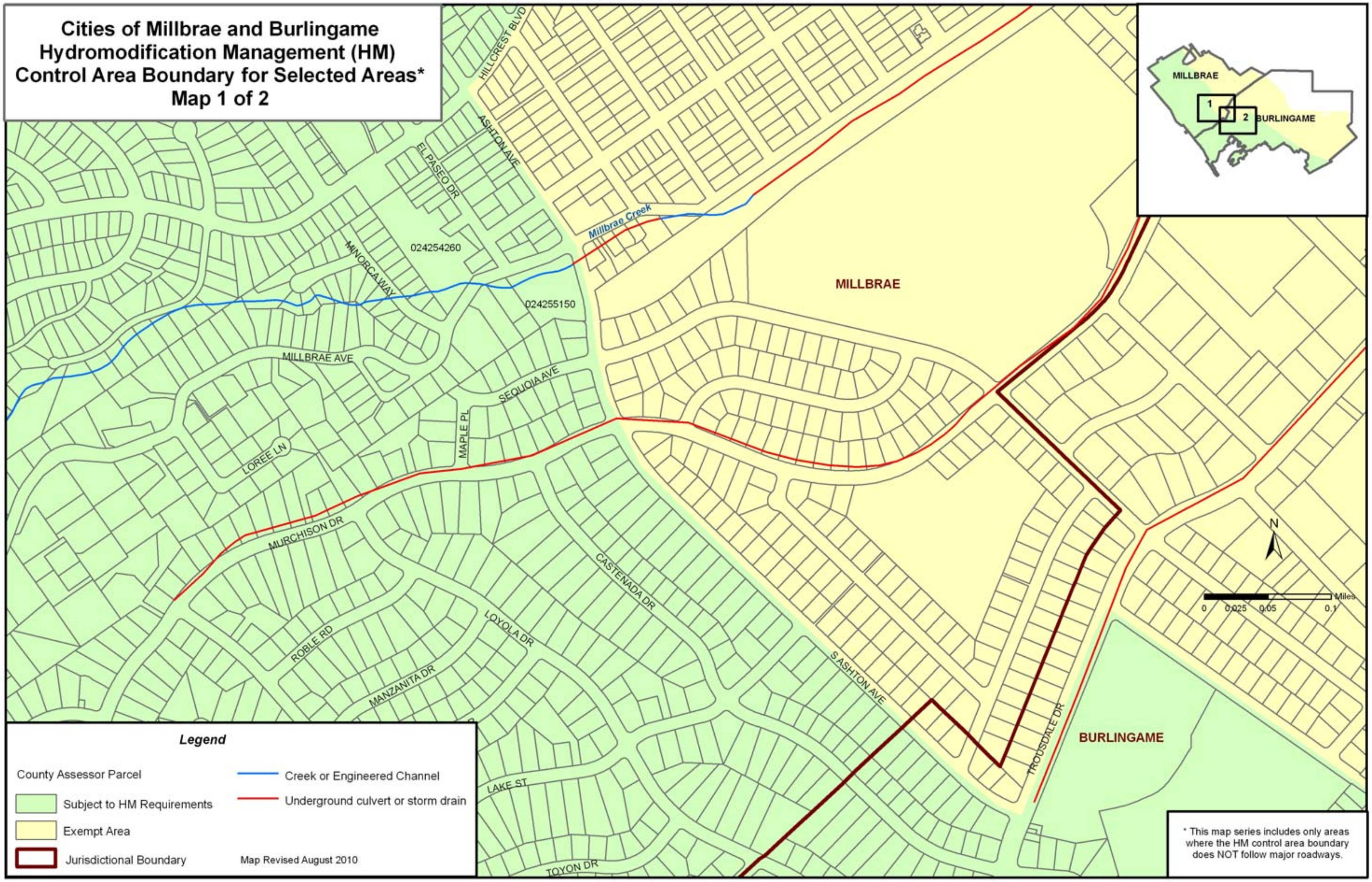
REFER TO SAN BRUNO AND MILLBRAE MAP 2




REFER TO MILLBRAE AND BURLINGAME MAP 1

REFER TO MILLBRAE MAP 1

# Cities of Millbrae and Burlingame Hydromodification Management (HM) Control Area Boundary for Selected Areas* Map 1 of 2



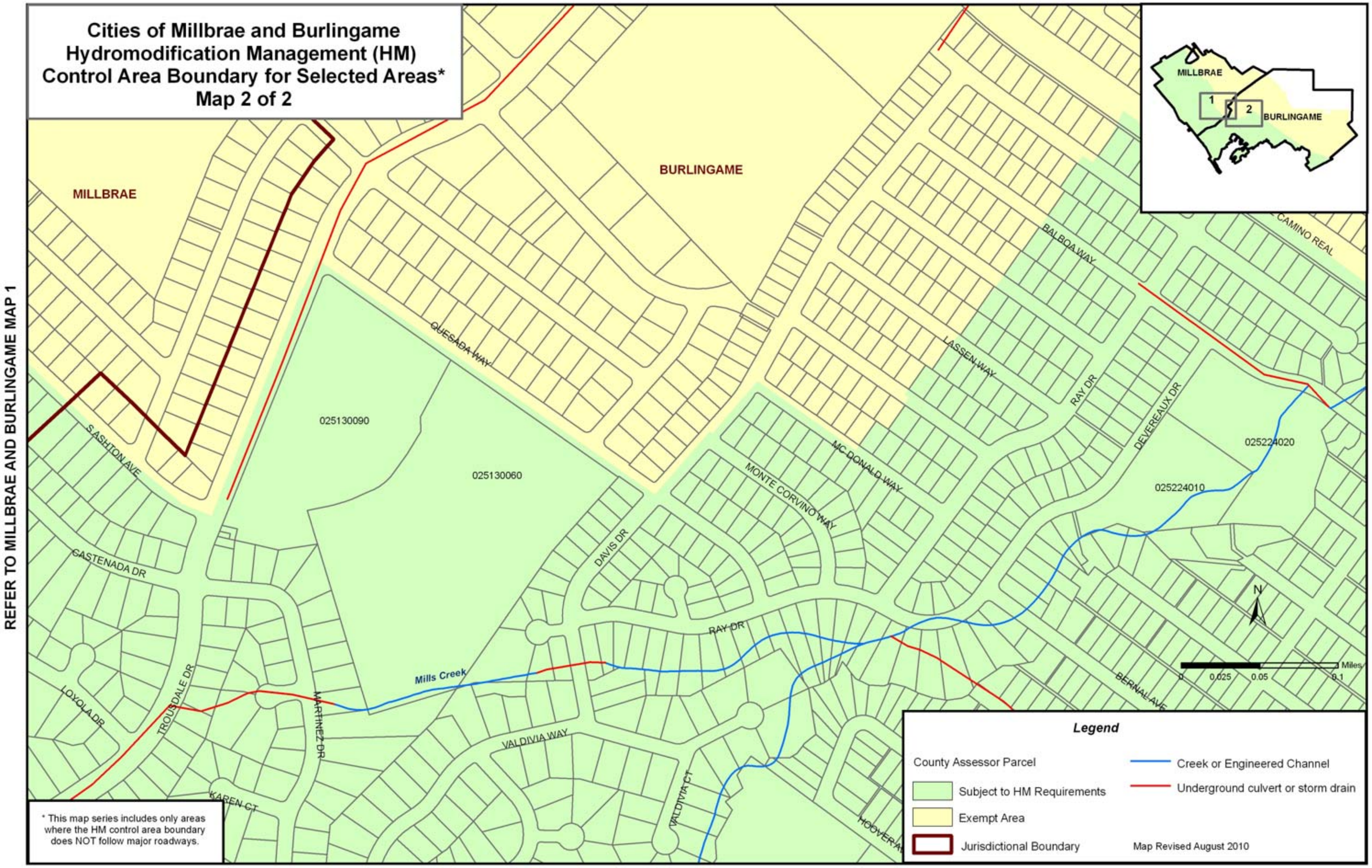

REFER TO MILLBRAE AND BURLINGAME MAP 2

**Legend**

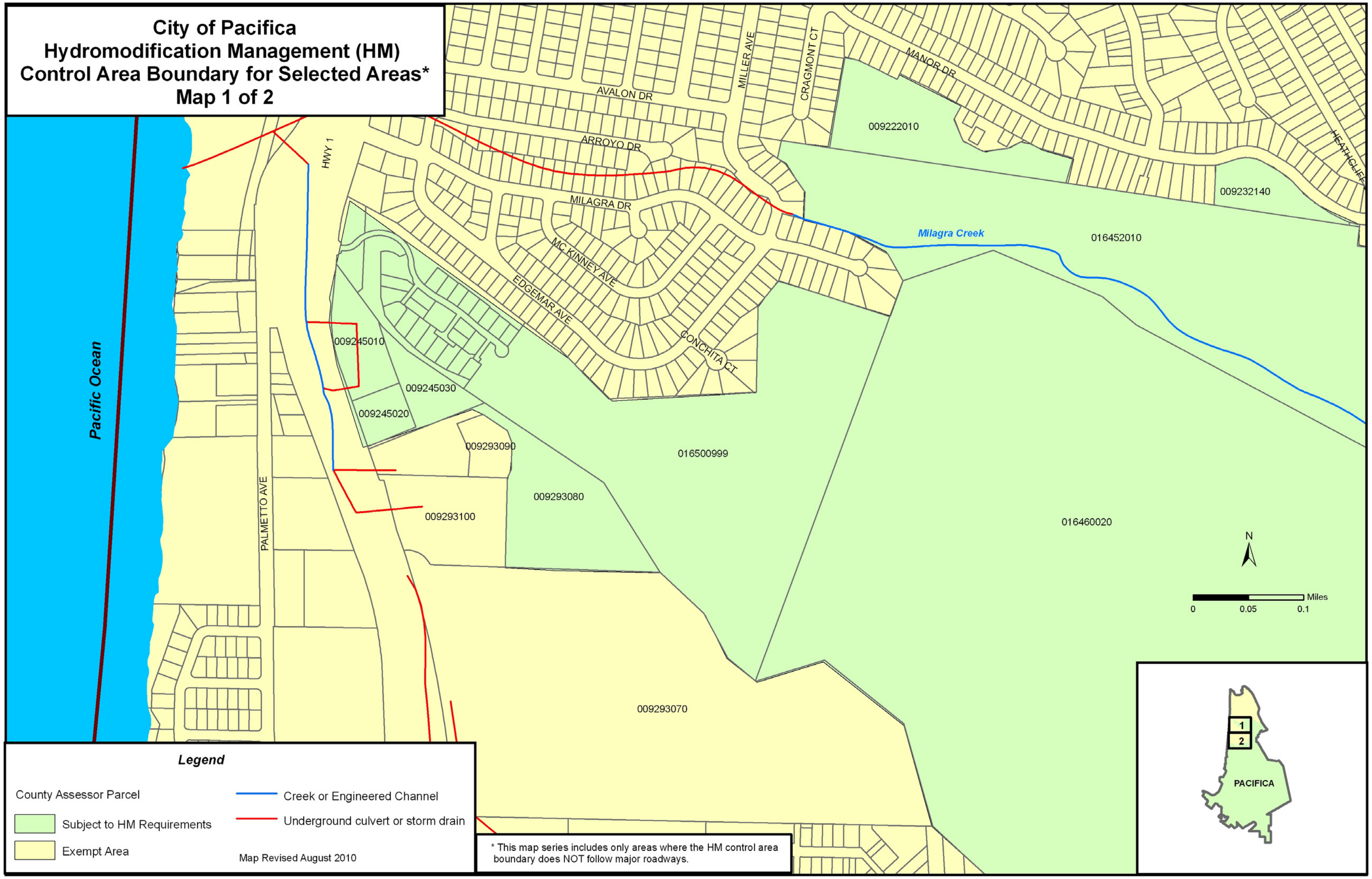
County Assessor Parcel
- Subject to HM Requirements
- Exempt Area
- Jurisdictional Boundary
- Creek or Engineered Channel
- Underground culvert or storm drain

Map Revised August 2010

* This map series includes only areas where the HM control area boundary does NOT follow major roadways.



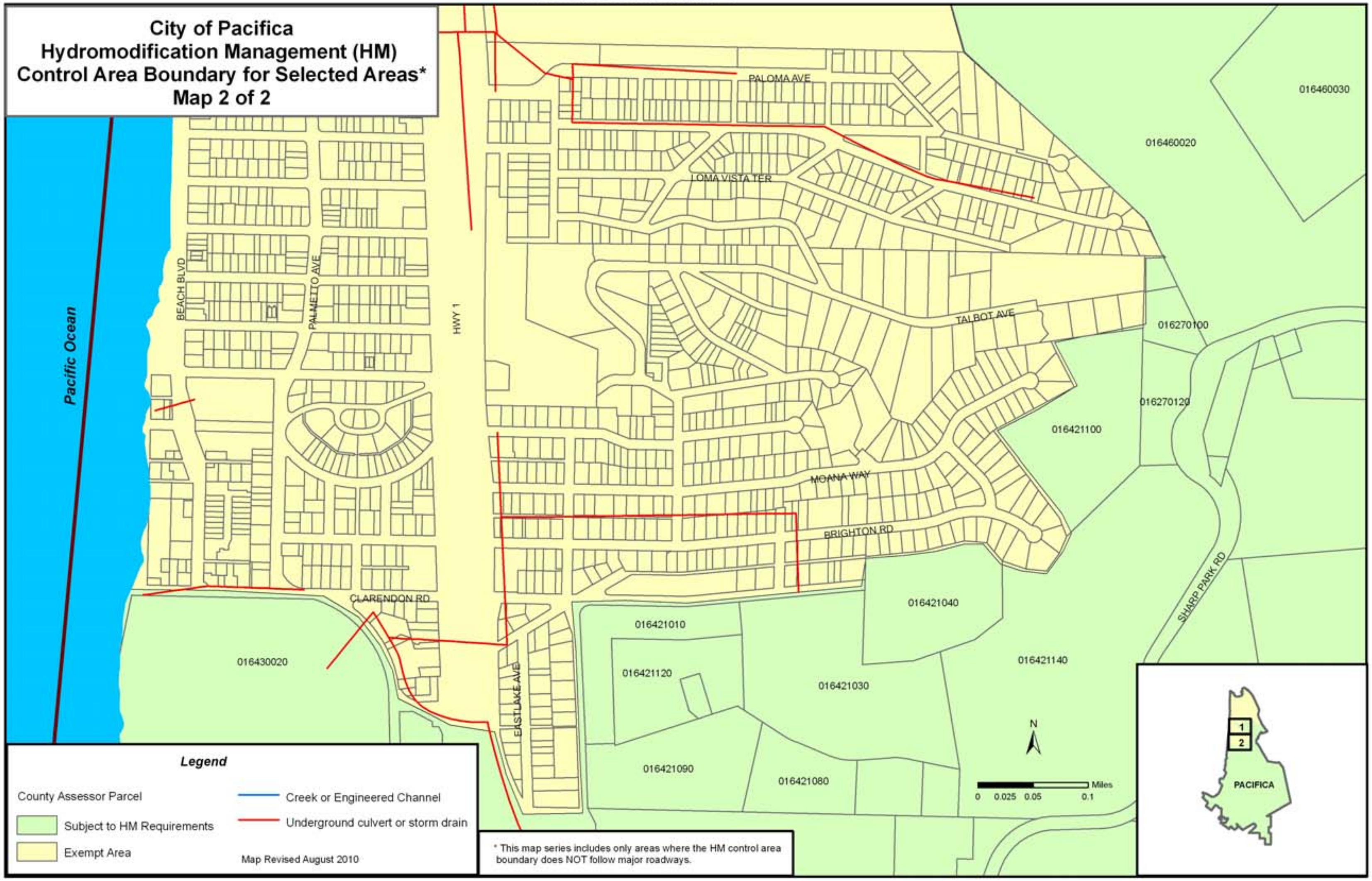
Cities of Millbrae and Burlingame
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 2 of 2
MILLBRAE
BURLINGAME
REFER TO MILLBRAE AND BURLINGAME MAP 1
QUESADA WAY
S ASHTON AVE
CASTENADA DR
LOYOLA DR
TROUSDALE DR
MARTINEZ DR
KAREN CT
VALDIVIA WAY
VALDIVIA CT
DAVIS DR
RAY DR
MONTE CORVINO WAY
MC DONALD WAY
LASSEN WAY
BALBOA WAY
DEVEREAUX DR
BERNAL AVE
HOOVER AVE
CAMINO REAL
Mills Creek
025130090
025130060
025224020
025224010
0 0.025 0.05 0.1 Miles
N
1
2
MILLBRAE
BURLINGAME
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.

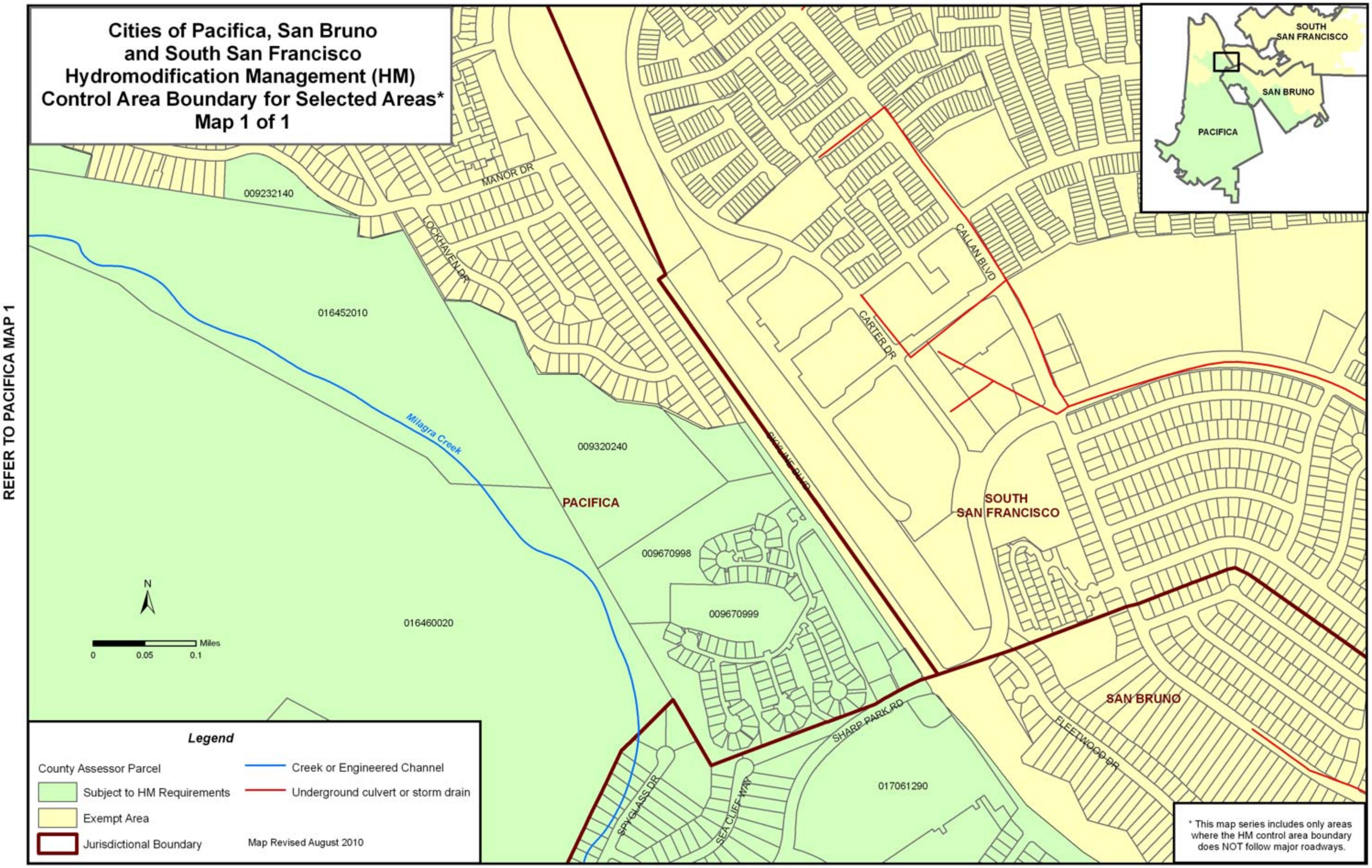



REFER TO PACIFICA, SAN BRUNO AND SOUTH SAN FRANCISCO MAP 1

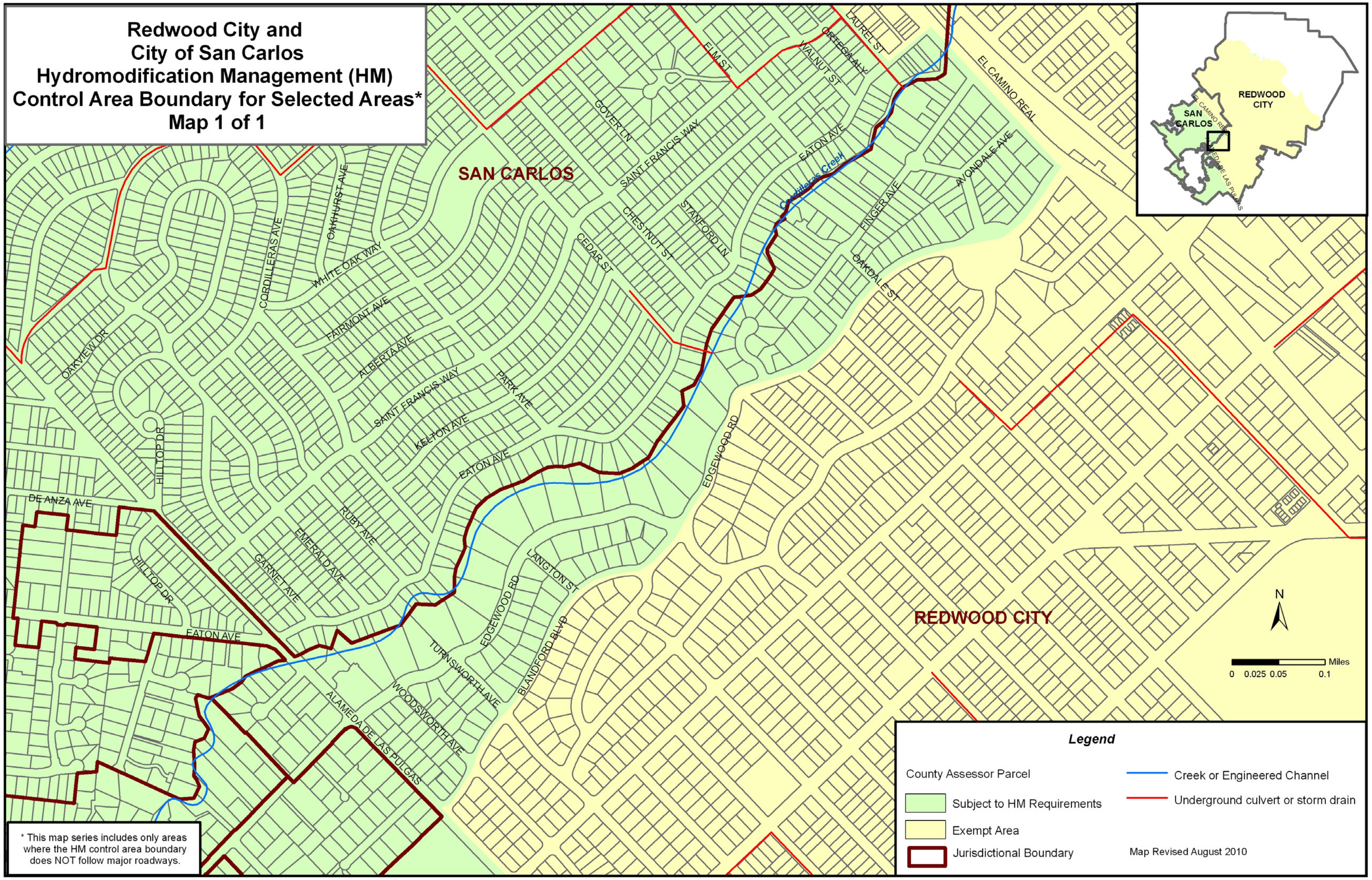
REFER TO PACIFICA MAP 2

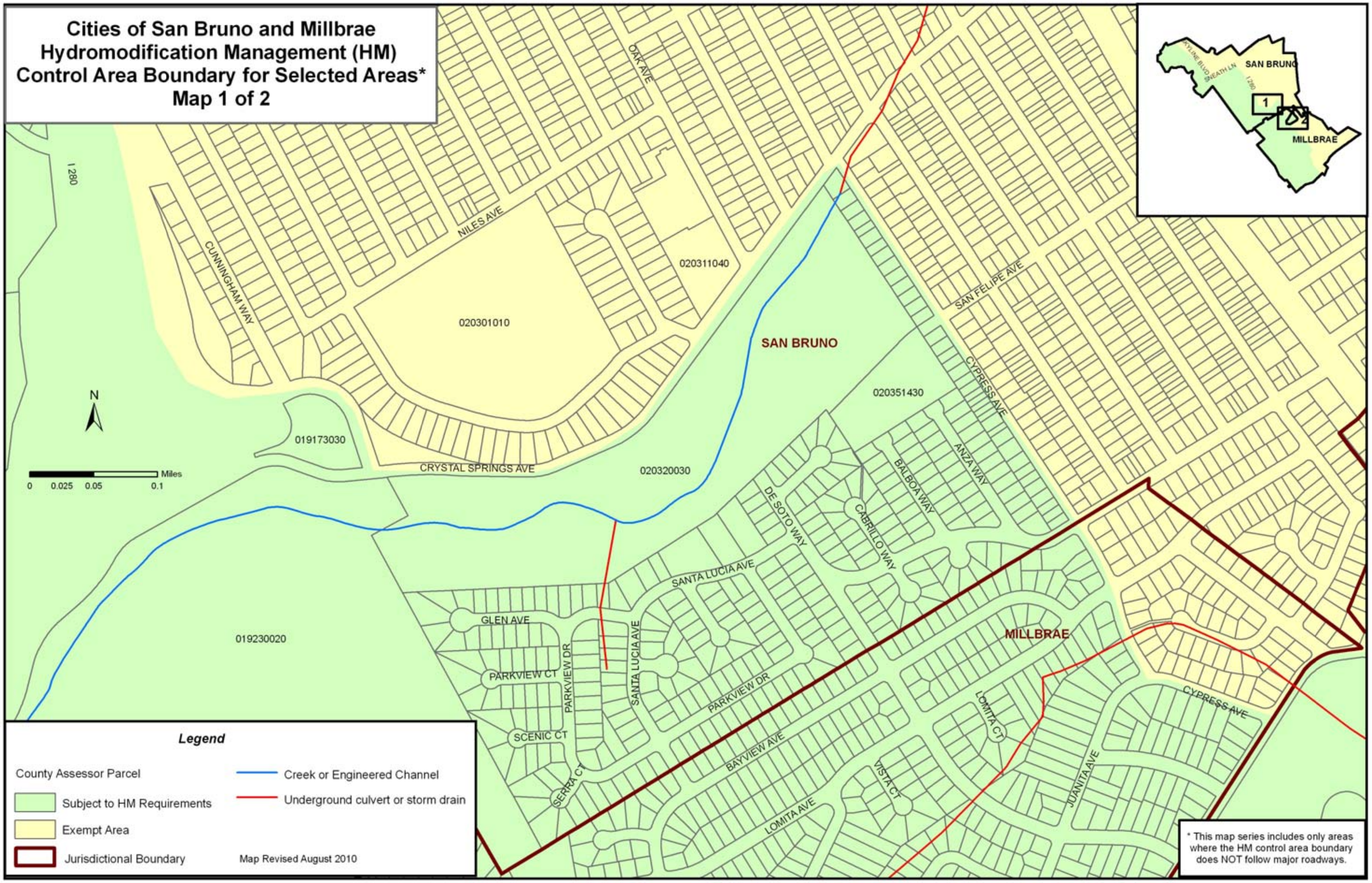
REFER TO PACIFICA MAP 1





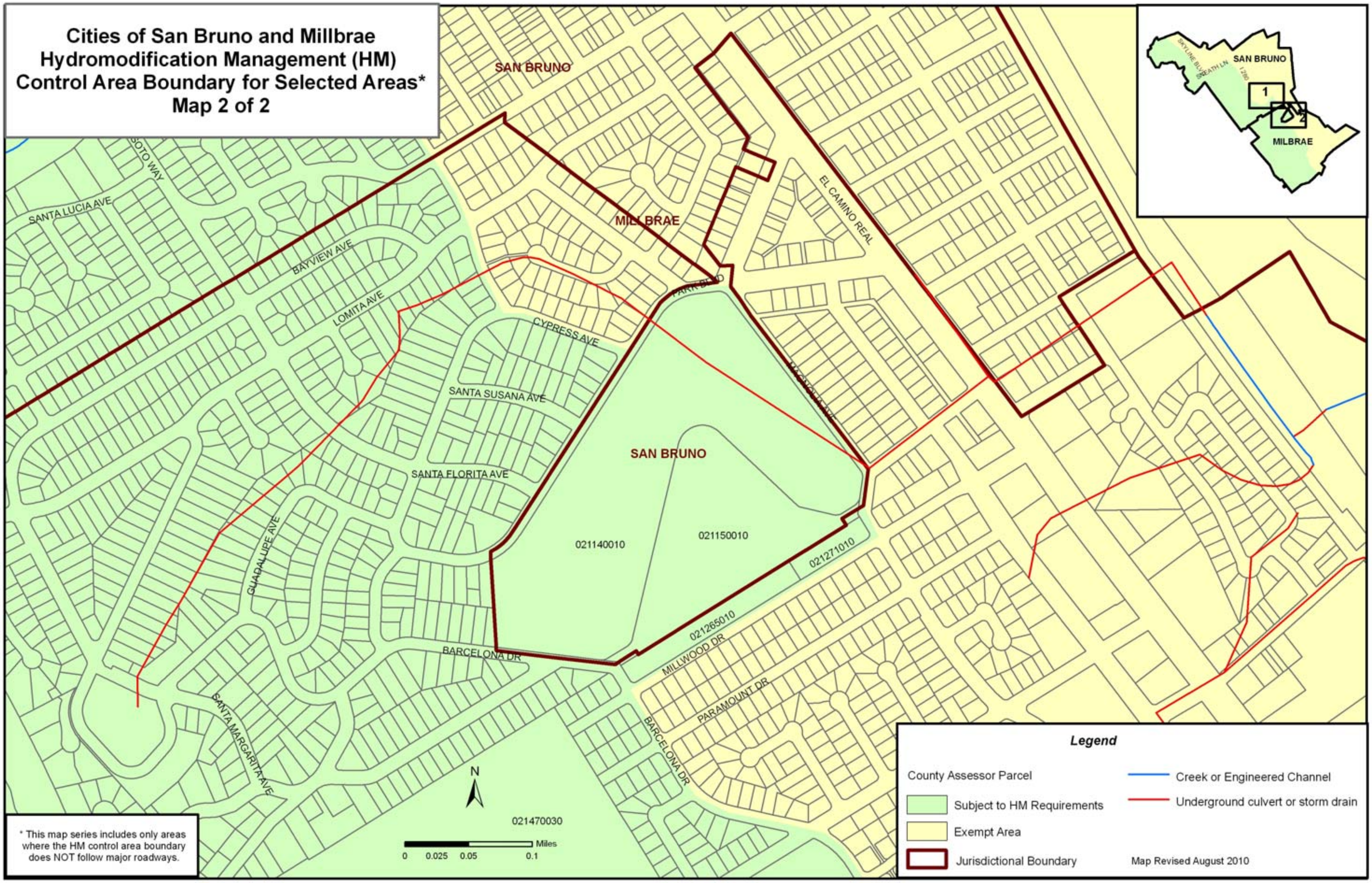
Cities of Pacifica, San Bruno
and South San Francisco
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
REFER TO PACIFICA MAP 1
MANOR DR
LOCKHAVEN DR
CALLAN BLVD
CARTER DR
SKYLINE BLVD
SHARP PARK RD
FLEETWOOD DR
SPYGLASS DR
SEA CLIFF WAY
Milagra Creek
009232140
016452010
009320240
009670998
009670999
016460020
017061290
PACIFICA
SOUTH SAN FRANCISCO
SAN BRUNO
N
0 0.05 0.1 Miles
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.


Redwood City and
City of San Carlos
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
SAN CARLOS
REDWOOD CITY
Cordilleras Creek
EL CAMINO REAL
LAUREL ST
ELM ST
WALNUT ST
GOVER LN
SAINT FRANCIS WAY
EATON AVE
CHESTNUT ST
STANFORD LN
CEDAR ST
FINGER AVE
AVONDALE AVE
OAKDALE ST
OAKHURST AVE
CORDILLERAS AVE
WHITE OAK WAY
FAIRMONT AVE
ALBERTA AVE
OAKVIEW DR
PARK AVE
KELTON AVE
HILLTOP DR
DE ANZA AVE
RUBY AVE
EMERALD AVE
GARNET AVE
EDGEWOOD RD
LANGTON ST
BLANDFORD BLVD
TURNSWORTH AVE
WOODSWORTH AVE
ALAMEDA DE LAS PULGAS
REDWOOD CITY
SAN CARLOS
N
0 0.025 0.05 0.1 Miles
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010

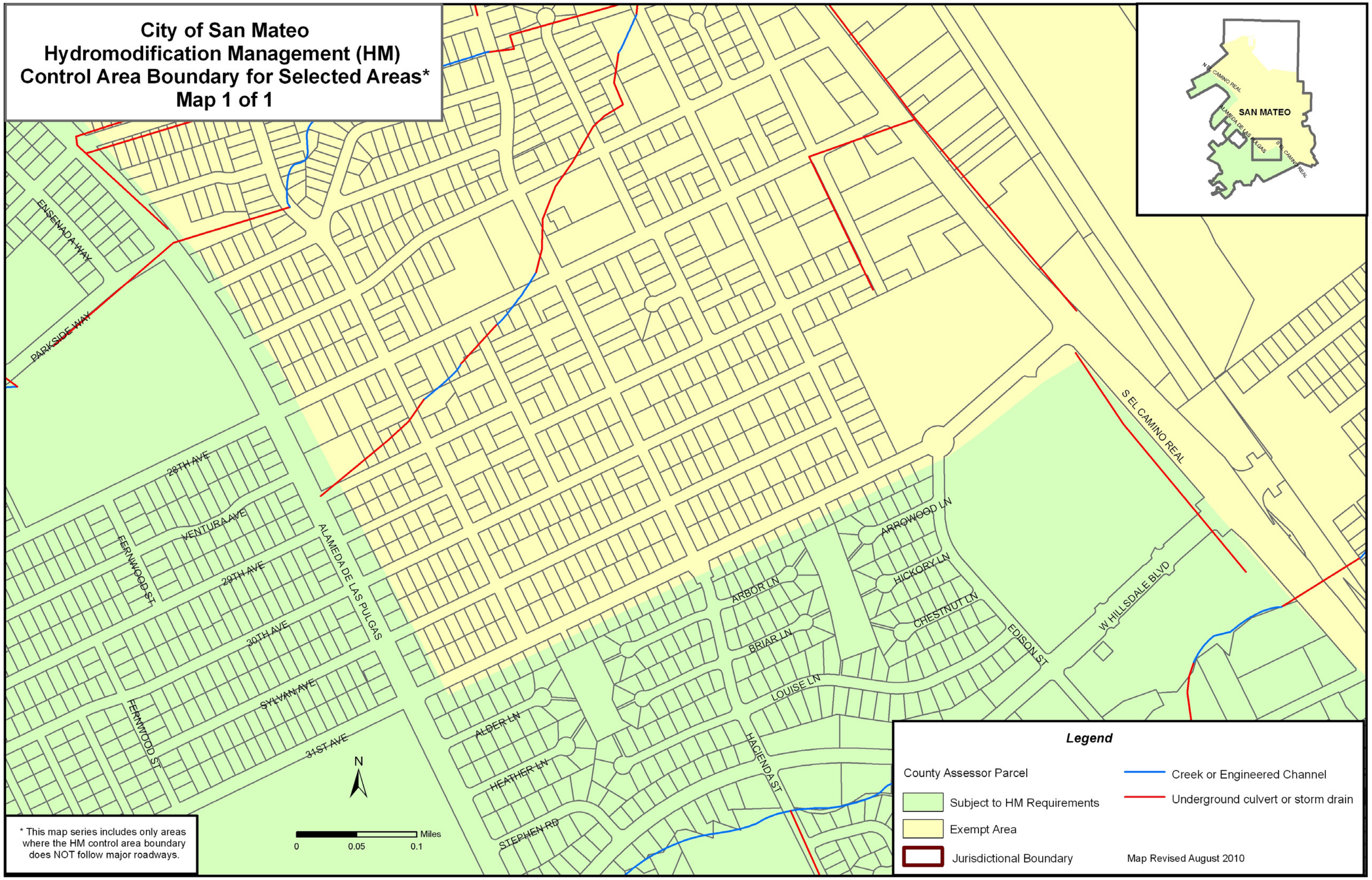


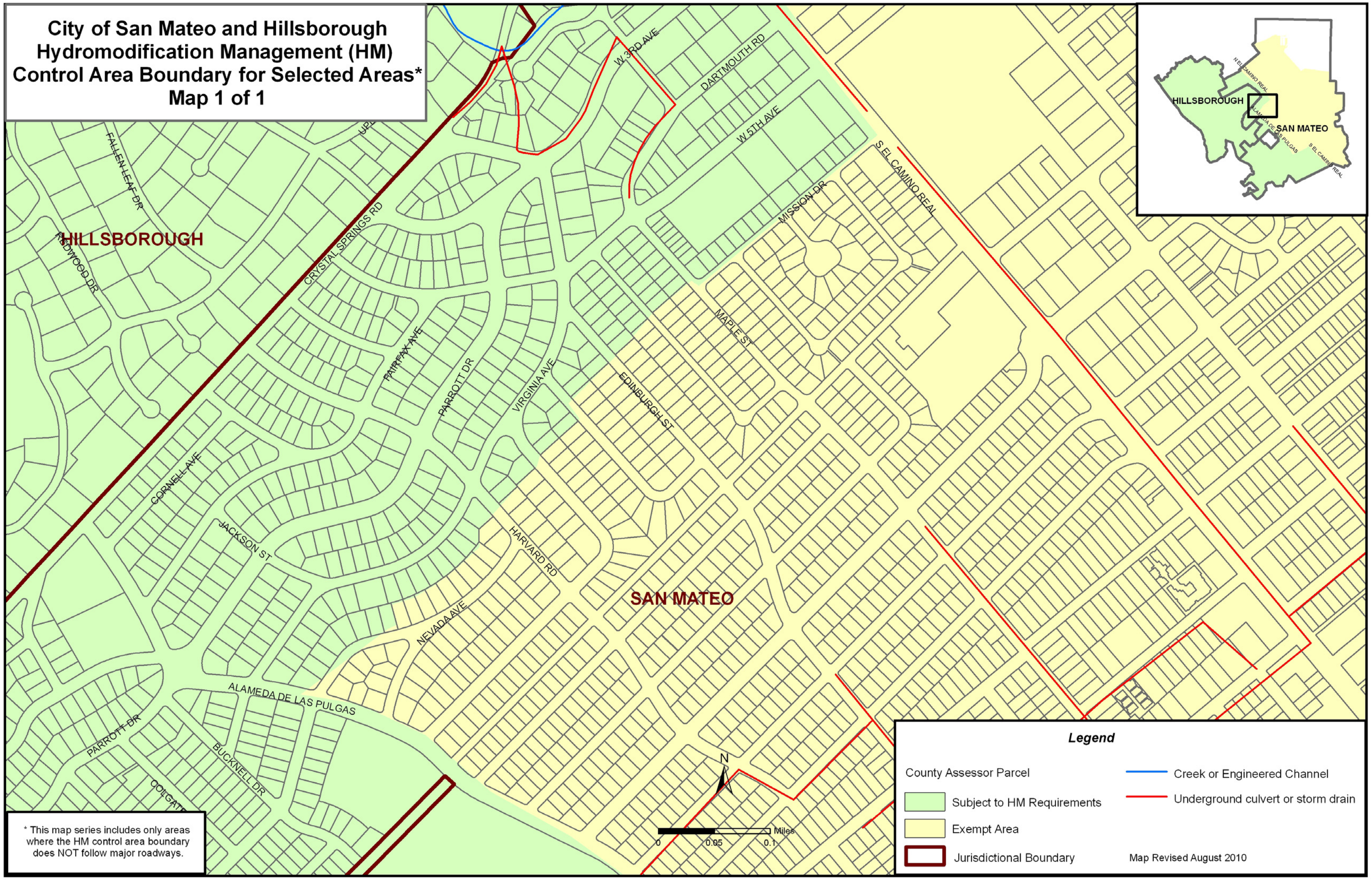

REFER TO SAN BRUNO AND MILLBRAE MAP 2

REFER TO SAN BRUNO AND MILLBRAE MAP 1




REFER TO MILLBRAE MAP 1


City of San Mateo
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
ENSENADA WAY
PARKSIDE WAY
28TH AVE
VENTURA AVE
FERNWOOD ST
29TH AVE
30TH AVE
SYLVAN AVE
31ST AVE
ALAMEDA DE LAS PULGAS
S EL CAMINO REAL
ARROWOOD LN
HICKORY LN
CHESTNUT LN
ARBOR LN
BRIAR LN
LOUISE LN
EDISON ST
W HILLSDALE BLVD
ALDER LN
HEATHER LN
STEPHEN RD
HACIENDA ST
SAN MATEO
N
Miles
0
0.05
0.1
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010


City of San Mateo and Hillsborough
Hydromodification Management (HM)
Control Area Boundary for Selected Areas*
Map 1 of 1
HILLSBOROUGH
SAN MATEO
FALLEN LEAF DR
CRYSTAL SPRINGS RD
FAIRFAX AVE
PARROTT DR
VIRGINIA AVE
CORNELL AVE
JACKSON ST
HARVARD RD
NEVADA AVE
EDINBURGH ST
MAPLE ST
MISSION DR
S EL CAMINO REAL
W 3RD AVE
DARTMOUTH RD
W 5TH AVE
ALAMEDA DE LAS PULGAS
PARROTT DR
BUCKNELL DR
* This map series includes only areas where the HM control area boundary does NOT follow major roadways.
N
0
0.05
0.1
Miles
Legend
County Assessor Parcel
Subject to HM Requirements
Exempt Area
Jurisdictional Boundary
Creek or Engineered Channel
Underground culvert or storm drain
Map Revised August 2010

# Appendix I

# Feasibility Evaluation: Infiltration and Rainwater Harvesting/Use

The purpose of this guidance is to assist project applicants and agency staff in determining whether it is feasible or infeasible for individual projects to treat the full water quality design flow or volume of stormwater runoff, as specified in MRP Provision C.3.d, using infiltration or rainwater harvesting and use[1]. Where this is infeasible, biotreatment will be allowed. The information presented in this guidance is based on the "Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report prepared by the Bay Area Stormwater Management Agencies Association (BASMAA) and submitted to the Regional Water Board on April 29, 2011.[2]

## Table of Contents



[1] Provision C.3.c of the MRP requires that the C.3.d amount or runoff be treated with infiltration, evapotranspiration, or harvesting and use, or, where this is infeasible, biotreatment. Evapotranspiration will occur in all landscape-based treatment and was incorporated in modeling of infiltration and rainwater harvesting/use conducted for the Feasibility Report.

[2] This report is available on the Countywide Program's website (www.flowstobay.org – click on "Business", then "New Development", then scroll down to the heading "Stormwater Requirements for New Development/ Redevelopment", and click on the link to the Feasibility Report.

## I.1 General Approach

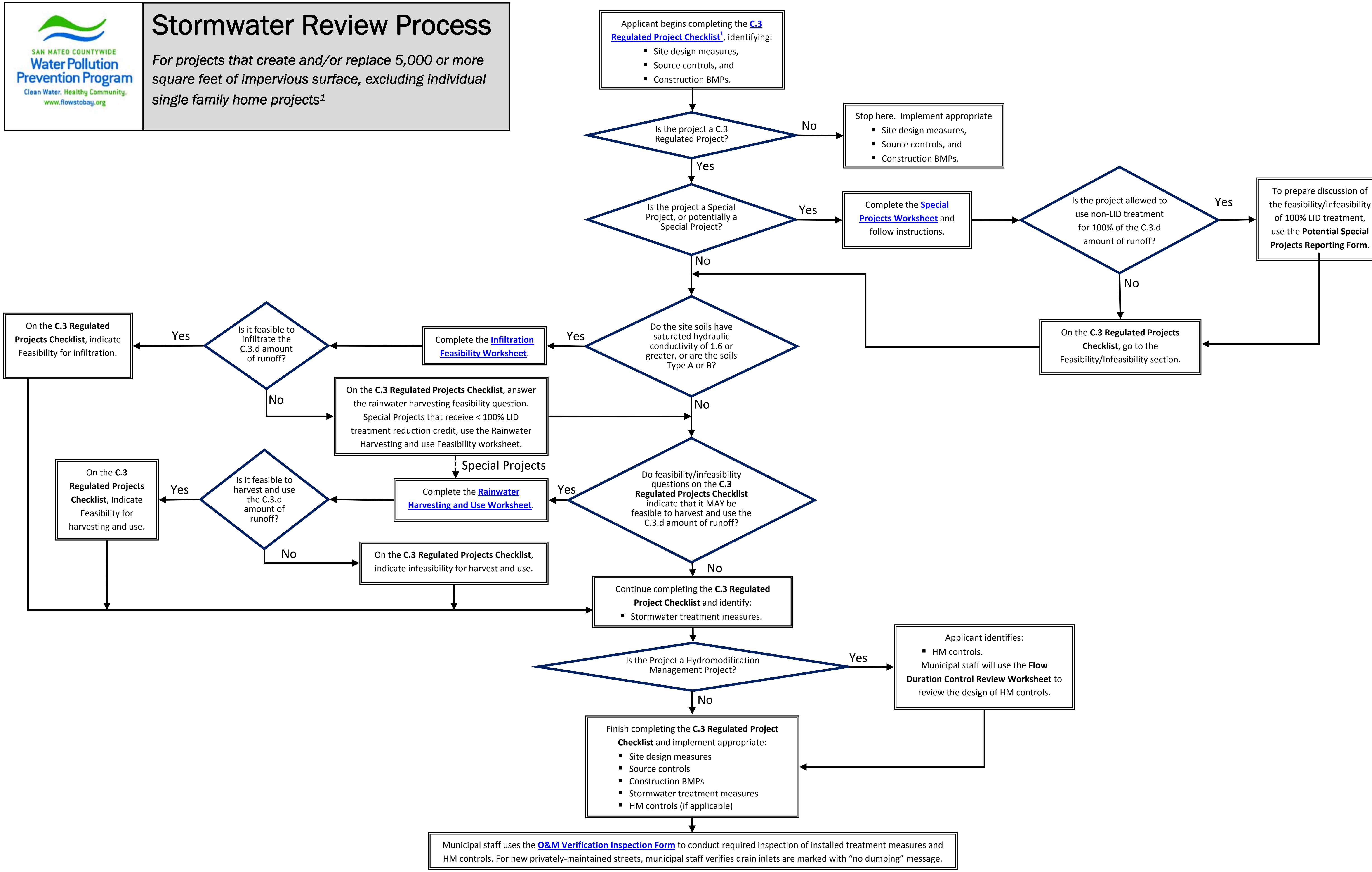
BASMAA's member agencies have collaborated to develop worksheets to assist project applicants and municipal staff in evaluating the feasibility and infeasibility of infiltration or rainwater harvesting and use, and determining the project's eligibility for Special Project LID treatment reduction credits. The steps in this process are shown in the flow chart (Figure I-1) and listed below:

- ***Step 1:*** Answer the Feasibility/Infeasibility of Infiltration and Rainwater Harvesting/Use section of the C.3 Regulated Projects Checklist, to evaluate whether the project may potentially fall into one of the following categories:
  a. Is it potentially a Special Project? (If so, complete the Special Projects Worksheet in Step 2)
  b. Is it infeasible to infiltrate the full C.3.d amount of runoff? (If not, complete the Infiltration Feasibility Worksheet in Step 2.)
  c. Is it infeasible to harvest and use the full C.3.d amount of runoff? (If not, complete the Rainwater Harvesting Feasibility Worksheet in Step 2.)
- ***Step 2:*** Either complete the applicable worksheet(s) or, if no further analysis is needed, go to Step 3d.
- ***Step 3:*** Depending on which additional worksheet(s) is/are completed, any of the following outcomes may result:
  a. If the project is a Special Project that receives 100 percent LID treatment reduction, up to 100 percent of the C.3.d amount of stormwater runoff may be treated with media filters and/or manufactured tree well filters. See Appendix J for more information about Special Projects.
  b. If infiltration of the C.3.d amount of runoff (or the remainder after deducting any Special Projects LID treatment reduction credit) is found to be feasible, then the project must infiltrate the required amount of runoff, unless it is harvested and used.
  c. If rainwater harvesting and use of the C.3.d amount of runoff (or the remainder after deducting any Special Projects LID treatment reduction credit) is found to be feasible, then the project must harvest and use the required amount of runoff, unless it is infiltrated.
  d. If the required amount of runoff cannot be infiltrated or harvested and used, implement biotreatment, except for any Special Project LID treatment reduction that may be allowed. Where conditions allow, the biotreatment measures should maximize infiltration.

SAN MATEO COUNTYWIDE Water Pollution Prevention Program
Clean Water. Healthy Community.
www.flowstobay.org

# Stormwater Review Process

*For projects that create and/or replace 5,000 or more square feet of impervious surface, excluding individual single family home projects[1]*




[1] Projects that create/replace less than 5,000 square feet of impervious surface should complete the Stormwater Checklist for Small Projects to select appropriate site design measures, source controls and construction BMPs. Individual single family home projects that are not part of a large plan of development are NOT considered C.3 Regulated Projects and should complete the Stormwater Checklist for Small Projects regardless of project size.

# I.2 Rainwater Harvesting/Use and Infiltration Feasibility Screening Analysis Guidance

All C.3 Regulated Projects need to answer the screening questions on the municipality's C.3 Regulated Projects Checklist (or comparable form). The screening questions screen out from further evaluation projects that clearly cannot infiltrate or harvest and use the C.3.d amount of runoff. If the answers to the screening questions show that it is infeasible to infiltrate or harvest and use the C.3.d amount of runoff, you will not have to complete the other worksheets related to feasibility. The screening questions are organized around the following topics:

- Special Projects pre-screening,
- Infiltration feasibility screening,
- Recycled water use,
- Calculate the potential rainwater capture area for rainwater harvest and use calculation,
- Rainwater harvest/use feasibility screening,
- Identify and attach additional feasibility analyses,
- Finding of infiltration feasibility/infeasibility
- Finding of rainwater harvesting/use feasibility/infeasibility, and
- Use of biotreatment.

**Screening Question 1: Special Projects**

Question E.1 in the Feasibility/Infeasibility section of the C.3 Regulated Projects Checklist asks whether the project is a Special Project. If the project may meet the Special Projects criteria, complete the Special Projects Worksheet (download from www.flowstobay.org, click on "Businesses", then "New Development" and scroll down to the heading, "Forms and Checklists for Implementing Stormwater Requirements"). If the project qualifies as a Special Project LID treatment may be required for a specified percentage of the C.3.d amount of stormwater runoff from the project, as described in Appendix J. The following guidance applies if the project is found to be a Special Project:

- If the Special Project receives 100 percent LID treatment reduction, the project is allowed to treat the entire C.3.d amount of stormwater runoff with high flow-rate tree box filters or high flow rate media filters. The remaining screening questions will need to be answered, in order to prepare a required narrative discussion of the feasibility or infeasibility of 100 percent LID treatment for the Special Project.
- If the Special Project receives less than 100 percent LID reduction, the project must evaluate the feasibility of infiltrating or harvesting and using the remaining C.3.d amount of stormwater runoff. To do this, answer the screening questions regarding infiltration and recycled water. Then fill out the Rainwater Harvesting and Use Feasibility Worksheet to evaluate the feasibility of treating the remaining percentage of the C.3.d amount of runoff with harvesting and use. Information about how to use the Rainwater Harvesting and Use Feasibility Form is provided in Section I.4 of this Appendix.

- As required in Provision C.3.e.vi.(2), for each Special Project, a narrative discussion must be provided of the feasibility or infeasibility of 100 percent LID treatment.

**Screening Question 2: Infiltration Feasibility**

Question E.2 in the Feasibility/Infeasibility section of the C.3 Regulated Projects Checklist evaluates how efficiently soils at the project site can infiltrate water. Where possible, base your response to this question on information in a project-specific soils report.

- If the soils report includes the saturated hydraulic conductivity (Ksat) for onsite soils, use this as the basis for determining feasibility of infiltration. The Feasibility Report found that infiltration of the C.3.d amount of runoff is infeasible where soils have a Ksat of less than 1.6 inches/hour.
- If the site-specific soil report does not include the Ksat, but does include the soil type, then base the feasibility determination on soil type. If the soils at the project site consist of Type C or Type D, then infiltration of the C.3.d amount of runoff is infeasible.
- If the above information is unavailable for the project site, then base the feasibility screening on the Ksat value shown on the map included in Attachment 3. You can also obtain Natural Resource Conservation Service soil survey data (the basis for the attached maps) at the following website: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. Where possible, this information should be confirmed with site-specific data.

**Screening Question 3: Recycled Water Use**

Question E.3 in the Feasibility/Infeasibility section of the C.3 Regulated Projects Checklist asks whether the project will install and use a recycled water system for non-potable water use. If this type of system will be used, then rainwater harvesting is considered to be infeasible, and you can skip to Section E.9. It would not be cost effective for a project to be required to install two plumbing systems for non-potable water. Recycled water is given priority over rainwater for non-potable water use because of the year-round availability and consistent quality of recycled water, the municipalities' investments in recycled water infrastructure, and the requirement for wastewater treatment facilities to find reliable uses for recycled water.

**Screening Question 4: Calculate Potential Rainwater Capture Area**

If a recycled water system is not used, further evaluation of rainwater harvesting/use feasibility is based on whether there is sufficient demand for the amount of rainwater that would potentially be captured by the project. The first step in this evaluation is to identify the potential rainwater capture area for the entire project area, by answering questions E.4.a through E.4.c on the C.3 Regulated Projects Checklist.

Please note that this part of the screening analysis should not be completed for Special Projects that receive less than 100 percent LID treatment reduction. The Feasibility/Infeasibility section of the C.3 Regulated Projects Checklist is not designed to take Special Projects treatment reductions into account. The Rainwater Harvesting and Use Feasibility Form does account for these reductions and should be used to evaluate the feasibility of harvest and use based on demand.

After the feasibility screening questions are completed for the entire project, if rainwater harvesting and use of the C.3.d amount of runoff is infeasible, AND, if the project includes one or more buildings with a roof area of 10,000 square feet or more, then the potential rainwater capture area should be identified for each individual roof that has an area of 10,000 square feet or more.[3]

- ***Potential Rainwater Capture Area and the "50 Percent Rule."*** When evaluating the entire project, indicate in Question E.4.b whether the amount of any impervious surface that is replaced by the project is at least 50 percent, but less than 100 percent, of the existing impervious surface at the project site.
  - If the area of impervious surface to be replaced is at least 50 percent but less than 100 percent of the existing impervious surface, then the stormwater runoff from all of the existing impervious surface will be included in the Potential Rainwater Capture Area. (This is referred to as "the 50 percent rule.") In this case, add to the amount of impervious surface created and/or replaced by the project the amount of existing impervious surface that will remain in place. Enter the total in the space provided.
  - If the amount to be replaced is less than 50 percent of the existing impervious surface, then only the stormwater runoff from the new and/or replaced impervious surface will need to be treated. . In this case, enter "not applicable" in the space provided.
  - If 100 percent of the existing impervious will be removed, then there will be no pre-project impervious surface remaining on the site, and the 50 percent rule does not apply. In this case, enter "not applicable" in the space provided.

- ***Calculate the Potential Rainwater Capture Area:*** After taking the "50 percent rule" into consideration, convert from square feet to acres the total area that will need to receive stormwater treatment. This is the amount in 4a, unless 4b (50% Rule) is applicable, in which case it is the amount in 4b. It needs to be converted to acres, since some criteria that will be used to evaluate rainwater harvesting feasibility are per acre of impervious surface.

**Screening Question 5: Rainwater Harvest/Use Feasibility - Irrigation**

Respond to Question E.5 in the C.3 Regulated Projects Checklist if the project includes landscaping. This is based on a screening criterion derived from Table 11 in the Feasibility Report (included in Attachment 3 of this appendix), which presents ratios of "Effective Irrigated Area to Impervious Area" (EIATIA) for each of the rain gauge areas that were evaluated in the report. The multiplier provided in this

[3] The Feasibility Report indicated that rainwater harvesting/use feasibility would be determined on a drainage management area (DMA) basis. BASMAA has identified roofs of this size as the appropriate level of analysis for determining rainwater harvesting feasibility on a DMA basis.

question on the checklist applies to areas of turf landscaping in the Palo Alto rain gauge area, which is the lowest EIATIA for the county.

**Screening Question 6: Rainwater Harvest/Use Feasibility – Indoor Non-potable Use**

Answer only the question(s) that apply to your project's land use type.

- ***Residential toilet flushing.*** Answer Question E.6.a in the C.3 Regulated Projects Checklist only for projects that consist entirely of residential use, and for the residential portion of mixed use projects that include some residential use. This question is based on a screening criterion derived from Attachment 2: Toilet-Flushing Demand for Harvested Rainwater. The threshold number of dwelling units per acre shown provided for residential toilet flushing specifically applies to toilet flushing demand in the Palo Alto rain gauge area, which is the lowest demand threshold for residential toilet flushing feasibility in the county.

- ***Commercial/Institutional/Industrial Toilet Flushing.*** Answer Question E.6.b only for projects that consist entirely of commercial and/or institutional and/or industrial use, and for the commercial portion of mixed commercial and residential use projects. This question is based on screening criteria derived from California Plumbing Code building occupancy load factors and Table 10 in the Feasibility Report, which identifies the required toilet flushing demand based on employees per impervious acre (Table 10 is included in Attachment 3). The feasibility threshold for toilet flushing for commercial, institutional and industrial projects is provided in terms of square feet of interior floor area per acre of impervious surface. This threshold indicates that, at this ratio of interior floor area to impervious surface, rainwater harvesting and use for non-residential and non-school toilet flushing is feasible in the Palo Alto rain gauge area. The Palo Alto rain gauge threshold is the lowest demand threshold for non-residential and non-school toilet flushing feasibility in the county.

- ***School Toilet Flushing.*** Answer Question E.6.c only for school projects. This question is based on screening criteria derived from California Plumbing Code building occupancy load factors and Table 10 in the Feasibility Report (see Attachment 3), which identifies the required toilet flushing demand based on employees per impervious acre. The feasibility threshold for school toilet flushing is provided in terms of square feet of interior floor area per acre of impervious surface. This threshold indicates that, at this ratio of interior floor area to impervious surface, rainwater harvesting and use for school toilet flushing is feasible in the Palo Alto rain gauge area. The Palo Alto rain gauge threshold is the lowest demand threshold for school toilet flushing feasibility in the county.

- ***Industrial Non-Potable Uses Other than Toilet Flushing.*** Answer Question E.6.d only for industrial projects. If the project will include an industrial processing use for non-potable water, identify the demand for this use. This question is based on the required cistern volume and demand, for the maximum allowable drawdown time, to capture the C.3.d amount of runoff shown in Table 9 of the Feasibility Report (see Attachment 3). The required demand in gallons per day per acre of impervious area of the industrial project applies to the required demand in the Palo Alto rain gauge area, the lowest industrial non-potable water demand threshold for harvesting and use feasibility in the county.

If the project's industrial non-potable water demand is MORE than 2,900 gallons a day, refer to the curves from Appendix F of the Feasibility Report (see Attachment 3) to evaluate the feasibility of harvesting and using the C.3.d amount of runoff for industrial use. Find the page that shows curves corresponding to the closest rain gauge to your project. The applicant can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. The required demand in gallons per day per impervious acre is calculated by dividing the cistern volume by the drawdown time (converted to days).

- ***Toilet Flushing Demand for Mixed Commercial and Residential Use Projects.*** *Question E.6.e* provides instructions to separately evaluate the commercial and residential portions of a mixed use project, as described above in the sections on Residential Toilet Flushing and on Commercial/Institutional/Industrial toilet flushing.

**Screening Question 7: Additional Feasibility Analysis**

Question E.7 in the C.3 Regulated Projects Checklist lists possible additional analyses that may be required, based on the results of the screening analysis. If further analysis is required, check all boxes that apply, based on the responses to the previous questions.

**Screening Question 8: Finding of Infiltration Feasibility/Infeasibility**

Question E.8 in the C.3 Regulated Projects Checklist provides a list of possible outcomes of the infiltration feasibility screening analysis. Check all boxes that apply to determine whether, based on the screening analysis, infiltration of the C.3.d amount of runoff is feasible or infeasible.

**Screening Question 9: Finding of Rainwater Harvesting and Use Feasibility/Infeasbility**

Question E.9 in the C.3 Regulated Projects Checklist provides a list of possible outcomes of the rainwater harvesting and use feasibility screening analysis. Check all boxes that apply to determine whether, based on the screening analysis, harvesting and use of the C.3.d amount of runoff is feasible or infeasible.

**Screening Section 10: Use of Biotreatment**

Section E.10 of the checklist states that biotreatment may be used if findings of infeasibility are made for both infiltration of the C.3.d amount of runoff and rainwater harvesting and use of the C.3.d amount of runoff.

# I.3 Infiltration Feasibility Worksheet Guidance

Fill out this worksheet if soils at the project site have a Ksat of 1.6 or greater, or are Type A or B soils. This worksheet will help determine if conditions at the site would prohibit infiltration.

**Feasibility of Infiltration Facilities**

A “yes” answer to any of the questions from 2.1 through 2.3 indicates that site conditions prohibit the use of both infiltration measures (indirect infiltration, including unlined bioretention areas and infiltration trenches that are wider than they are deep) and infiltration devices (direct infiltration, including infiltration trenches and basins that are deeper than they are wide). A “yes” answer to any of these questions means that infiltration must be avoided altogether. In these situations, appropriate biotreatment systems may consist of a concrete-lined flow through planter, or a bioretention area with a waterproof liner. As soon as you answer “yes” to any of these questions, stop filling out the form, and indicate in Section 3 that infiltration is infeasible. If the answers to Questions 2.1 through 2.3 are all “no”, then the use of infiltration measures (indirect infiltration) is feasible. Continue filling out the form to determine whether the use of infiltration devices (direct infiltration) is feasible.

**Feasibility of Infiltration Devices**

A “yes” answer to any of the questions from 2.4 through 2.8 indicates that the use of infiltration devices (direct infiltration) is infeasible. Examples of infiltration devices include any infiltration trench or basin, dry welll, or French drain that is deeper than it is wide. Requirements for infiltration devices (direct infiltration) are more stringent, because the design of infiltration devices causes stormwater runoff to bypass surface soils. This means that groundwater resources are more vulnerable to contamination than would be the case if infiltration measures (indirect infiltration) were used.

A “yes” answer for any question from 2.4 through 2.8 would not change the feasibility of infiltration measures (indirect infiltration); it would mean only that the use of infiltration devices (direct infiltration) is prohibited.

# I.4 Rainwater Harvesting/Use Feasibility Worksheet Guidance

Complete this worksheet if the project’s answers to the feasibility screening questions in the C.3 Regulated Projects Checklist (or comparable form) indicated that further analysis of rainwater harvesting and use is needed. Section 7 of the screening worksheet will indicate whether further analysis is needed, and, if so, whether it is needed for the entire project, or just one or more roofs that each individually have an area of 10,000 square feet or more. As needed, fill out the rainwater harvesting and use worksheet separately for either the entire project, or for just one roof. The worksheet is organized around the following topics:

- Enter project data;
- Calculate area of self-treating areas, self-retaining areas, and areas contributing to self-retaining areas;
- Subtract credit for self-treating/self-retaining areas from area requiring treatment;
- Determine feasibility of use for toilet flushing based on demand;
- Determine feasibility of harvesting and use based on factors other than demand; and
- Results of feasibility determination.

The worksheet is provided in Excel, with pre-set formulas that perform various calculations automatically. The open cells shaded in blue are for you to enter data. Open cells without shading include the pre-set formulas.

**RWH Feasibility Worksheet Section 1: Enter Project Data**

Data must be entered in this section and will form the basis for evaluating the feasibility of using the full C.3.d amount of runoff for toilet flushing. Requested data include:

- Project type,
- Number of dwelling units (for a residential or mixed use project),
- Square footage of non-residential interior floor area (for a non-residential or mixed use project), and
- Total area being evaluated.

If you are filling out this form for a project with a potential non-potable use of stormwater other than toilet flushing, skip sections 2 through 4, and go directly to Section 5.

**RWH Feasibility Section 2: Calculate self-treating and self-retaining areas**

You may exclude the following from the calculation of the potential rain capture area: 1) runoff from self-treating areas; 2) runoff from self-retaining areas; 3) the areas of impervious surface that drain to self-retaining areas. This is because, if the project includes such areas, they have been designed to infiltrate the C.3.d amount of runoff. In Section 2 of the form, enter the area (in square feet) of the project that consists of self-treating or self-retaining areas, and the impervious surface area that drains to self-retaining areas.

**RWH Feasibility Section 3: Subtract self-treating and self-retaining areas**

This section includes pre-set formulas that will automatically subtract from the area that is being evaluated (adjusted to account for any Special Project LID treatment reduction) the total square footage of self-treating and self-retaining areas, as well as the square footage of impervious surface that drains to self-retaining areas. The result is the potential rainwater capture area. A pre-set formula then converts the potential rainwater capture area from square feet to acres.

**RWH Feasibility Section 4: Feasibility of use for toilet flushing based on demand**

- ***Steps 4.1 and 4.2: Identify project density:*** In these steps, you will identify (for residential projects) the dwelling units per acre of potential rainwater capture area. For non-residential projects, you will identify the non-residential interior floor area (in square feet) per acre of potential rain capture area. These ratios will be used to represent the anticipated toilet flushing demand for the project. The worksheet includes pre-set formulas to help you do this. Please note: ***If you are evaluating a mixed use project***, do not use these pre-set formulas. For mixed use projects, evaluate the residential toilet flushing demand based on the dwelling units per acre for the residential portion of the project (using a prorated acreage, based on the percentage of the project dedicated to residential use). Then evaluate the commercial toilet flushing demand per acre for the commercial portion of the project (using a prorated acreage, based on the percentage of the project dedicated to commercial use).

- ***Steps 4.3 and 4.4: Identify applicable density thresholds.*** In these steps, you will identify the density thresholds at which there would be sufficient toilet flushing demand to use the full C.3.d amount of stormwater runoff, for the applicable rain gauge area. Refer to the tables in Attachment 2 to locate the applicable density threshold for the rain gauge that is located nearest to your project. The density threshold for residential projects is in terms of dwelling units per impervious acre. The density threshold for non-residential projects is in terms of interior floor area (in square feet) per acre of impervious surface.

- ***Steps 4.5 and 4.6: Feasibility of use based on toilet flushing demand.*** In these steps, you will compare the project density(ies) from steps 4.1 and/or 4.2 with the density thresholds from steps 4.3 and 4.4. If the project density(ies) is/are LESS than the threshold(s), then there is sufficient demand to harvest and use the C.3.d amount of runoff for toilet flushing. If the answer to the applicable question(s) is yes, then rainwater harvesting and use is infeasible, and you can skip to Section 6. If either question results in a “no” answer, then continue to Section 5 to see if there are other constraints that would make harvesting and use infeasible.

**RWH Feasibility Worksheet: Section 5: Factors other than demand**

Complete this section if there was a “yes” answer to Questions 4.5 and/or 4.6, or if you are evaluating non-toilet flushing uses of rainwater. The questions in this section will help you determine whether there are site-specific factors, such as steep slope or lack of available space for a cistern, which would make rainwater harvesting and use infeasible.

# I.5 Worksheets and Attachments

The following pages include the worksheets and attachments listed below. To download electronic versions of the worksheets, visit www.flowstobay.org, click on "Business", then "C.3 Technical Guidance", and scroll down to Appendix I.

- Infiltration Feasibility Worksheet
- Rainwater Harvesting and Use Feasibility Worksheet
- Attachment 1: Glossary
- Attachment 2: Toilet-Flushing Demand for Harvested Rainwater
- Attachment 3: Excerpts from the Feasibility Report (Map of Soil Hydraulic Conductivity and Rain Gauge Areas, Tables 8 through 11 and curves from the report's Appendix F)

Appendix

# J

# Special Projects

## Table of Contents



## J.1 Introduction

On November 28, 2011, the San Francisco Bay Regional Water Quality Control Board (Water Board) amended the MRP to allow 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.5, documentation must be provided to show why the use of LID treatment is considered infeasible.

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 <u>all</u> 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.5.

## 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 <u>all</u> 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 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 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 and mixed-use development projects and in Dwelling Units per Acre (DU/Ac) for residential development projects. 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.5. 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 or Mixed Use | Floor Area Ratio 2:1 |
| 50% | Residential | 50 dwelling units/acre |
| 75% | Commercial or Mixed Use | Floor Area Ratio 3:1 |
| 75% | Residential | 75 dwelling units/acre |
| 100% | Commercial or Mixed Use | Floor Area Ratio 4:1 |
| 100% | Residential | 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 or mixed-use 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.

### *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.5. 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

[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 SF Bay Area.

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 or ½ 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 |

***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 and mixed-use development projects and in Dwelling Units per Acre (DU/Ac) for residential development projects. 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**<br>**Density Credits for Category C, Transit Oriented Development**<br>(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 or Mixed Use | Floor Area Ratio 2:1 |
| 10% | Residential | 30 dwelling units/acre |
| 20% | Commercial or Mixed Use | Floor Area Ratio 4:1 |
| 20% | Residential | 60 dwelling units/acre |
| 30% | Commercial or Mixed Use | Floor Area Ratio 6:1 |
| 30% | Residential | 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**<br>**Minimized Surface Parking Credits for Category C, Transit Oriented Development**<br>(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 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. The municipality may require submittal of the Special Projects Worksheet, or a similar worksheet, as part of project submittals. To download an electronic version of the worksheet, visit the Program's website www.flowstobay.org and click on "Business", then "New Development", then "Forms and Checklists".

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 Applying the LID Treatment Reduction Credits to Special Projects

The following steps should be used to develop a project-specific stormwater management plan for a Special Project, and apply the LID treatment reduction credits allowed for the project.

1. Determine the total amount of impervious surface created and/or replaced on site that is subject to C.3 treatment requirements, and the associated C.3.d volume of runoff. This is the area and volume for which the LID treatment reduction credits will be applied to determine the maximum amount of runoff that can be treated using non-LID treatment measures.

2. Conduct the feasibility evaluation for infiltration and rainwater harvesting/use, using the worksheets described in Appendix J, for the portion of runoff that must be treated using LID treatment measures. The results of this evaluation will determine which LID practices can be used.

3. Define drainage management areas on the site, and identify self-treating and self-retaining areas, if any (see Chapter 4).

4. Adjust drainage management areas as needed to route the amount of runoff that needs to be treated with LID treatment measures and as much of the rest of the C.3.d amount of runoff as possible to LID treatment measures.

5. For the portion of runoff that must be treated with non-LID treatment measures (up to the allowable LID treatment reduction credit), document the reasons why LID treatment measures cannot be used (see Section J.7).

## J.7 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, you must provide a narrative discussion of the feasibility or infeasibility of using 100 percent LID treatment onsite and offsite, for review by municipal staff. Both technical and economic feasibility or infeasibility should be discussed, as applicable. 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.

The narrative discussion should address each area of the site for which runoff will be treated with non-LID treatment measures, and must identify the basis for infeasibility. The following issues should be considered:

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).

In addition, you 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 at a regional project or on other property owned by the project proponent in the same watershed (in other words, demonstrate 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 (when this Appendix was prepared in 2013, there were none in San Mateo County).

Attachment J-1, on the following page, provides a template for preparing a narrative discussion on the feasibility or infeasibility of providing 100 percent LID treatment.

Appendix

# K

# Soil Specifications

The regional biotreatment soil specifications, approved by the Regional Water Board on November 28, 2011, are provided on the following pages. The soil specifications are included in Attachment L of the Municipal Regional Stormwater Permit (MRP), as amended. Effective December 1, 2011, stormwater biotreatment measures are required to use the Water Board-approved specifications. 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".

To assist permittees and others in complying with this requirement, the program has produced several documents including a guidance memorandum and a Biotreatment Soil Mix Supplier List. To see the documents, please log into the password protected page of the program website and go to the New Development page: flowstobay.org/privatend

Then scroll down to the section titled, "**Materials for use by Municipal Staff"** and click on the desired document. The documents can also be seen on the public webpage: flowstobay.org/newdevelopment under the section "**Forms and Checklists**."

# ATTACHMENT L

## Provision C.3.c.i.(1)(b)(vi)

## 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 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.
   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 STA, ASTM, 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, #30, #16. #8, #4, and 3/8 inch sieves (ASTM D 422 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 | 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. Compostеd 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 – 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 Evaluation of Composting and Compost (TMECC). The lab report shall verify:

(1) Feedstock Materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues.

(2) Organic Matter Content: 35% - 75% by dry wt.

(3) Carbon and Nitrogen Ratio: C:N < 25:1 and C:N >15:1

(4) Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120F) upon delivery or rewetting is not acceptable. In addition 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 /

(iii) Respiration test < 8 C / unit VS / day

(iv) Dewar test < 20 Temp. rise (°C) e.

(v) Solvita® > 5 Index value

(5) Toxicity: any one of the following measures is sufficient to indicate non-toxicity.

(i) NH4- : NO3-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

(6) 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; Soluble shall be <2.5 ppm

(7) Salinity: Must be reported; < 6.0 mmhos/cm

(8) pH shall be between 6.5 and 8. May vary with plant species.

b. 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 | 2 | 10 |

c. Bulk density shall be between 500 and 1100 dry lbs/cubic yard

d. Moisture content shall be between 30% - 55% of dry solids.

e. Inerts – compost shall be relatively free of inert ingredients, including glass, plastic and paper, < 1 % by weight or volume.

f. 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.

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 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

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 two 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.